Detection and Measurement of Sales Cannibalization in Information Technology Markets

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Zusammenfassung

Gegenstand der vorliegenden Dissertation ist die Untersuchung des Forschungsproblems der Identifizierung und Quantifizierung des Kannibalisierungseffekts in innovativen Märkten der Informationstechnologie (IT). Hierbei wird der Absatz eines Produktes als „kannibalisiert“ bezeichnet, falls sich dieser Absatz zugunsten eines anderen Produktes des gleichen Unternehmens reduziert. Dieser Effekt entsteht dadurch, dass die nachfragenden Kunden bei Nichtvorhandensein des bevorzugten Produktes – unter sonst gleichen Bedingungen – ein anderes Produkt desselben Unternehmens kaufen würden. Dabei handelt es sich nicht um ein direkt beobachtbares Merkmal eines Kunden oder einer Transaktion, sondern um ein hypothetisches Kaufverhalten, welches eingeschätzt und mit tatsächlich getätigten Käufen verglichen werden muss.

Im Kontext informationstechnologischer Produkte und Dienstleistungen stellt die Identifikation und Quantifizierung von Kannibalisierungseffekten eine besondere Herausforderung dar. Insbesondere der hohe Grad technologischer Innovation und Komplexität von IT-Lösungen erschweren die Anwendung herkömmlicher Methoden zur Erfassung und Bemessung derartiger Effekte, da diese, wie beispielsweise Laborexperimente und Testvermarktung, vorwiegend zur Anwendung im Zusammenhang mit undifferenzierten Konsumgütern entworfen wurden. Eine Ermittlung von Konsumentenpräferenzen und ihre Umwandlung in prognostizierte Marktanteile kann ebenso nicht angewendet werden, da derartige analytische Schritte nur durchführbar wären, falls die Präferenzstrukturen als wohlgeformt und stabil angenommen werden können – was jedoch in innovativen IT-Märkten nicht gegeben ist. Eine quasi-experimentelle Evaluierung, bei der als „natürliches Experiment“ die Markteinführung des potentiell kannibalisierenden Produktes gewählt würde, wäre nur vor dem Hintergrund des Vorhandenseins historischer Verkaufsdaten anwendbar. Aber auch in diesem Fall wäre das Quasi-Experiment für den Fall anzufechten, dass Innovation die kannibalisierende Wirkung des Produktes im Laufe seines Lebenszyklus verändert hat.

Vor diesem Hintergrund manifestiert sich das Forschungsproblem in der folgenden zentralen Forschungsfrage: Wie kann man Kannibalisierungseffekte identifizieren und quantifizieren, welche von innovativen, informationstechnologischen Produkten und Dienstleistungen erzeugt werden, deren Kannibalisierungspotential sich möglicherweise im Laufe der Zeit aufgrund technologischer Innovation verändert, oder deren Design und die daraus folgenden Verbraucherpräferenzen noch nicht vollständig ausgeprägt und stabil geworden sind? Um dieser Forschungsfrage nachzugehen, werden im Rahmen dieser Dissertation unterschiedliche operationale Definitionen von Kannibalisierung vorgeschlagen und in vier Fallstudien eingehend untersucht. Hierbei werden sowohl quantitative als auch qualitative Forschungsmethoden verwendet und aufgezeigt wie diese im Kontext des Erkenntnisinteresses kombiniert werden können.

Die erste Fallstudie befasst sich mit einer eingehenden Untersuchung des Absatzes im Produktportfolio des IT-Anbieters Apple. Dabei wird der gegenseitige Einfluss unterschiedlicher Modelle der iPod-Produktlinie untereinander, sowie der Einfluss zwischen dieser und den Produktlinien iPhone und iPad untersucht, welche eine vergleichbare Funktionalität zur Musikwiedergabe anbieten. Mithilfe einer Zeitreihenanalyse wird nachgewiesen, dass die Einführung von iPhone und iPad Mini das iPod-Absatzvolumen negativ beeinflusst hat – d.h. iPhone und iPad Mini haben teilweise den iPod-Absatz kannibalisiert. Formell wird hierfür ein angepasstes ökonometrisches Prüfverfahren (basierend auf dem sogenannten „Perron Test“) verwendet, welches vorgegebene Strukturbrüche in dem absatzgenerierenden stochastischen Prozess identifiziert, bevor ihre Effekte quantifiziert werden.

In der zweiten Fallstudie wird gezeigt, wie eine auf spezifische Bedürfnisse ausgerichtete IT-Plattform durch eine generische IT-Plattform mit einem Ökosystem an hochwertigem Zubehör kannibalisiert wird. Die erstgenannte IT-Plattform ist hierbei ein eigenständiges GPS-Navigationsgerät, welches dem Wettbewerb eines Smartphone standhalten muss, sobald dieses mit einer spezialisierten Navigations-App ausgestattet wird. Betrachtet werden die Absatzvolumina der beiden weltweit führenden Hersteller

von GPS-Navigationsgeräten - die Unternehmen Garmin und TomTom. Mittels einer Zeitreihenanalyse wird ein Zusammenhang zwischen dem Absatzeinbruch klassischer Navigationsgeräte sowie der Einführung von modernen Smartphone-Ökosystemen (Apple iTunes „App Store“ und Google „Playstore“) mit der Verfügbarkeit von Navigations-Apps nachgewiesen. Der Absatz wurde hierbei stärker von anderen Navigationssoftwareherstellern in den Smartphone-Ökosystemen beeinflusst, als die spätere Markteinführung eigener Navigations-Apps durch die klassischen Anbieter Garmin und TomTom, die keine weitere, statistisch verifizierbare Beeinflussung erzeugen konnte. Formell wird hier ein auf dem „Zivot-Andrews Test“ basierendes ökonometrisches Prüfverfahren verwendet, um die unbekannten Strukturbrüche im absatzgenerierenden stochastischen Prozess zu datieren.

In der dritten Fallstudie wird eine Analyse der Kannibalisierung von Vertriebskanälen im Unternehmenssoftwaremarkt vorgenommen. Hierbei wird die Auswirkung der Einführung eines Online-Vertriebskanals auf traditionelle Vertriebskanäle untersucht, die stark auf persönliche Interaktion angewiesen sind. Eine qualitative Untersuchung, in deren Verlauf halbstrukturierte Interviews aufgenommen und durch Inhaltsanalyse ausgewertet wurden, ermöglichte es ein Channel-Adoption-Modell zu erstellen, welches die wichtigsten Aspekte des Erwerbs von Unternehmenssoftware berücksichtigt. Diese umfassen die direkten und indirekten Barrieren und Treiber der Rezeption des Kanals, die Phasen des Kaufprozesses sowie die Hauptkategorien von Unternehmenssoftwareprodukten und -dienstleistungen. Im Gegensatz zum Privatanwenderbereich, in dem die Unterstützung von „Offline-Vertriebskanälen“ eher die Ausnahme geworden ist, benötigen Unternehmenskunden wegen der spezifischen Charakteristiken von Unternehmenssoftware (z.B. Komplexität, hohe Anfangsinvestitionen, usw.) diese Unterstützung weiterhin. Online-Vertriebskanäle wirken daher nicht kannibalisierend auf die gesamte Kaufprozesskette und für das ganze Portfolio, sondern allein auf die Anfangsphasen des Kaufprozesses oder auf Käufe von einfachen Produkten (wie Lizenzen und eigenständige On-Demand-Anwendungen). Die Untersuchung legt nahe, dass Unternehmenssoftwareanbieter ein Multikanalvertriebssystem gestalten sollten, in dem Online- und Offline-Kanäle einander unterstützen und ergänzen.

Gegenstand der vierten Fallstudie ist Kannibalisierung zwischen Geschäftsmodellen. Auf dem Softwaremarkt ließ sich in den letzten zehn Jahren der Trend beobachten, dass Anbieter Softwareanwendungen zunehmend in Form von Onlinediensten als „Software as a Service“ (SaaS) vermarkten, die „on demand“ gegen Entrichtung einer für den Nutzungszeitraum festgelegten Abonnementgebühr, oder einer von der Intensität der Nutzung abhängigen Nutzungsgebühr genutzt werden. Als Pioniere in diesem Bereich können reine On-Demand-Anbieter wie beispielsweise Salesforce.com oder NetSuite gesehen werden. Bereits etablierte On-Premise-Kontrahenten müssen in diesem Kontext entscheiden, wann und in welchem Ausmaß sie dieses neue On-Demand-Modell aufgreifen und umsetzen sollen – eine äußerst kritische Entscheidung für Anbieter in marktführenden Positionen, welche mit On-Demand-Angeboten das Risiko eingehen, ihre On-Premise-Produktpalette zu kannibalisieren. In der Fallstudie werden zwei der mittlerweile immer noch sehr wenigen Fälle untersucht, in denen Softwarehersteller den Übergang von „on premise“ zu „on demand“ vollständig vollzogen haben. Gegenstand der Betrachtung sind die Unternehmenssoftwareanbieter Ariba und Concur Technologies, die in den Neunzigerjahren On-Premise-Anbieter waren und ihr Geschäftsmodell im Laufe der Zeit auf ein reines On-Demand-Angebot umgestellt haben. Methodologisch wird für diese Fallstudie eine „mixed methods“-Forschungsstrategie verwendet, in welcher qualitative und quantitative Forschungsmethoden integriert sind. Hierbei wird zunächst eine qualitative Inhaltanalyse von Dokumenten (u.a. Geschäfts- und Quartalsberichte, Transkriptionen der Telefonkonferenzen zu den Finanzergebnissen, Interviews aus der Presse) verwendet, um die Meilensteine des Geschäftsmodellwandels zu identifizieren. Eine nachgelagerte Zeitreihenanalyse wird verwendet, um deren finanzielle Auswirkungen zu quantifizieren.

Summary

Characteristic features of Information Technology (IT), such as its intrinsic modularity and distinctive cost structure, incentivize IT vendors to implement growth strategies based on launching variants of a basic offering. These variants are by design substitutable to some degree and may contend for the same customers instead of winning new ones from competitors or from an expansion of the market. They may thus generate intra-organizational sales diversion – i.e., *sales cannibalization*.

The occurrence of cannibalization between two offerings must be verified (the *detection* problem) and quantified (the *measurement* problem), before the offering with cannibalistic potential is introduced into the market (*ex-ante* estimation) and/or afterwards (*ex-post* estimation). In IT markets, both detection and measurement of cannibalization are challenging. The dynamics of technological innovation featured in these markets may namely alter, hide, or confound cannibalization effects.

To address these research problems, we elaborated novel methodologies for the detection and measurement of cannibalization in IT markets and applied them to four exemplary case studies. We employed both quantitative and qualitative methodologies, thus implementing a *mixed-method multi-case research design*.

The first case study focuses on *product cannibalization* in the context of continuous product innovation. We investigated demand interrelationships among Apple handheld devices by means of econometric models with *exogenous* structural breaks (i.e., whose date of occurrence is given a priori). In particular, we estimated how sales of the iPod line of portable music players were affected by new-product launches within the iPod line itself and by the introduction of iPhone smartphones and iPad tablets. We could find evidence of expansion in total line revenues, driven by iPod line extensions, and inter-categorical cannibalization, due to iPhones and iPads Mini.

The second empirical application tackles *platform cannibalization*, when a platform provider becomes complementor of an innovative third party platform thus competing with its own proprietary one. We ascertained whether the diffusion of GPS-enabled smartphones and navigation apps affected sales of portable navigation devices. Using a unit-root test with *endogenous* breaks (i.e., whose date of occurrence is estimated), we identified a negative shift in the sales of the two leaders in the navigation market and dated it at the third quarter of 2008, when the iOS and Android mobile ecosystems were introduced. Later launches of their own navigation apps did not significantly affect these manufacturers' sales further.

The third case study addresses *channel cannibalization*. We explored the channel adoption decision of organizational buyers of business software applications, in light of the rising popularity of online sales channels in consumer markets. We constructed a qualitative channel adoption model which takes into account the relevant drivers and barriers of channel adoption, their interdependences, and the buying process phases. Our findings suggest that, in the enterprise software market, online channels will not cannibalize offline ones unless some typical characteristics of enterprise software applications change.

The fourth case study deals with *business model cannibalization* – the organizational decision to cannibalize an existent business model for a more innovative one. We examined the transition of two enterprise software vendors from on-premise to on-demand software delivery. Relying on a mixed-method research approach, built on the quantitative and qualitative methodologies from the previous case studies, we identified the transition milestones and assessed their impact on financial performances. The cannibalization between on-premise and on-demand is also the scenario for an illustrative simulation study of the cannibalization.

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1. Introduction

Only the foolish visit the land of the cannibals

Maori proverb

Wise as it may sound, only tribe members and Western tourists venturing in a wild, unfamiliar territory ought to act in accordance with the Māori proverb quoted above. Information Technology (IT) companies, instead, may be foolish *not* to visit the land of the cannibals (when the competitive setting makes it a profitable move, as it recurrently seems to do). In fact, particular attributes of IT artifacts facilitate the implementation of growth strategies based on introducing multiple variants of the same basic offering. Such variants are by design substitutable to some degree. They may compete for the same customers and thus generate intra-organizational sales diversion – the phenomenon of *sales cannibalization*. However, addressing the advisability of dwelling in the land of the cannibals is a merely speculative exercise if one does not know its relative position. Indeed, the cautious traveler will exploit cartography and GPS technology to carry on his journey safely. On which instruments should an economic agent in an IT market rely instead?

1.1. Information Technology Portfolios and Substitutability

What do the most valuable Information Technology companies have in common – apart from the tautological fact that they sell IT products and services? Indeed, they are all *multiproduct* and/or *multiservice* companies. That is, each of them offers several different products and/or services in the market simultaneously. As a case in point, let us consider the portfolios of four renowned IT vendors, reported in Table 1.1.

All of the vendors we considered are engaged in different markets and market segments. Microsoft sells, for example, in markets as diverse as videogame consoles and business applications. They also serve different segments within one market with distinct and segment-specific offerings. Microsoft, SAP, and Salesforce.com, for instance, provide solutions tailored to the size of the buying organization. All four vendors also support multiple software delivery models (on-premise[1]/on-demand) and computing platforms (desktop/mobile). Their offerings may target several proprietary platforms: own ones (Microsoft Office *for Windows*) and by third parties, even by direct competitors (Microsoft Office *for Mac*). Moreover, they occupy multiple levels of relevant technology stacks – e.g., in the case of on-demand solutions, at the Infrastructure-as-a-Service (IaaS), Platform-as-a-Service (PaaS), and/or Software-as-a-Service (SaaS) levels.[2] Salesforce.com, for instance, has offerings at the PaaS level ("Force.com") and at the SaaS level (among others, the "Sales Cloud" application).

Albeit lengthy, the portfolios in Table 1.1 are already a simplification of the complex assortments of products and services actually offered to customers. Revealing the full depth of each product line would have required listing also every available version of each individual item – such as alternative releases

[1] We employ the wording on-*premise*, which has established itself both in trade and academia, although the correct English form would be on-*premises*, since the noun "premise" demands the plural to convey the meaning of land and buildings (cf. http://www.merriam-webster.com/dictionary/premise).

[2] Our target audience is probably familiar with this terminology. For the more casual reader we briefly define on-demand, cloud computing, and *aaS here; further details, formal references, and a historical contextualization are provided in Sections 6.2, 6.3, and 7.5. "On-demand" and "cloud" are roughly interchangeable terms for the delivery of computing resources and/or processing capabilities via a network, as a service, dispensing users with most installation, operation, and maintenance activities otherwise needed to own and operate equivalent resources and capabilities at their premises ("on-premise"). Such services are commonly classified according to a layered, tripartite "cloud stack": infrastructural resources such as processing power and data storage are the bottom layer (*Infrastructure*-as-a-Service or IaaS), standalone applications are the top layer (*Software*-as-a-Service or SaaS), and a middle layer provides development resources for the creation and customization of SaaS applications (*Platform*-as-a-Service or Paas).

(e.g., Microsoft Windows *8* and *8 Pro*) or customized variants for specific industries (SAP alone has 26 "Industry Solutions") – and all the possible bundles of items. IT products and services may namely be bundled in several ways. On the one hand, different software products may be packaged together as a software suite (e.g., Microsoft Office or SAP Business Suite). On the other hand, a software product or suite may be combined with other non-software items: services (for instance, a maintenance plan) and/or hardware equipment (e.g., Microsoft SQL Server on a DELL server, or the in-memory enterprise appliance SAP HANA).

Salesforce.com seems to have the simplest product mix among the four examples in Table 1.1. In point of fact, the complexity of its portfolio is merely masked by the simple product classification. This vendor also offers each product in several "editions" (a common way to market SaaS solutions, Lehmann & Buxmann 2009), depending on the features/functionalities a customer is willing to pay for. Table 1.2 illustratively presents the Salesforce.com CRM editions currently in the market. Five are available, whereby larger sets of functionalities are sold at correspondingly higher monthly fees. Each edition includes the full capabilities of cheaper editions and offers some additional ones at a premium.

Table 1.1 Exemplary product portfolios of four renowned IT vendors

Microsoft[3]	**Google**[4]
Windows products	Web
• Windows 8	• Web Search
• Internet Explorer	• Google Chrome
• Windows Media Player	• Toolbar
• Windows Movie Maker	
• Windows Photo Gallery	Mobile
	• Android
Office products	• NEXUS
• Office for home	
• Office for business	Media
• Office for Mac	• YouTube
	• Books
Devices	• Image Search
• Surface	• News
• Small hardware & accessories	• Video Search
• Xbox	• Picasa
• Xbox LIVE	
• Xbox Music	Geo
• Xbox Video	• Maps
• Windows Phone	• Earth
	• Panoramio
Services	• SketchUp
• Outlook.com	
• SkyDrive cloud storage	Specialized Search
• Skype	• Blog Search
• MSN	• Google Shopping
• Bing	• Scholar
• HealthVault	• Alerts
• Microsoft PhotoSynth	
• Microsoft Tag	Home & Office
	• Drive
Server and Tools	• Gmail
• Windows Server	• Calendar
• Windows Server 2012 Essentials	• Sites
• SQL Server	• Translate
• Exchange Server	• Google Cloud Print
• BizTalk Server	
• Visual Studio	Social
• Windows Azure	• Blogger

[3] Adapted from www.microsoft.com/en-us/sitemap.aspx#Products and http://www.microsoft.com/en/us/sitemap.aspx [accessed on 1 September 2013]

[4] Adapted from www.google.de/intl/en/about/products/ and http://www.google.com/intl/en/services/ [accessed on 1 September 2013]

• Windows Intune • Forefront • SharePoint • System Center Developers & IT Pros • Training & certification • Microsoft Developer Network • TechNet for IT professionals Business and enterprise • Microsoft Dynamics • Small and midsize business • Enterprise and industry solutions • Pinpoint • Resources for Microsoft Partners • Microsoft Mediaroom IPTV platform • Windows Embedded	• Groups • Hangouts Advertising • AdWords • AdWords Express • Learn with Google • Google Offers • Google Engage Publishing • AdSense • DoubleClick • +1 Button • Webmaster Central • Website Optimizer Managing • Chrome for Business • Google Payments Business essentials • Google+ for Business • Google Ads • Google Apps for Business • Google Analytics
SAP[5]	**Salesforce.com**[6]
Business Applications • Business Suite • CRM • Enterprise Asset Management • Enterprise Resource Planning • Financial Management • Human Capital Management • Procurement • Product Lifecycle Management • Supply Chain Management • Sustainability Database &Technology • Application Foundation, Security • Business Process Management and Integration • Cloud Computing • Content Management, and Collaboration • Database • Data Warehousing • Information Management • In-Memory Computing (SAP HANA) • Mobile • Real-Time Data Platform (RTDP) Analytics • Applied Analytics • Business Intelligence • Data Warehousing • Enterprise Performance Management • Governance, Risk, Compliance Cloud • Analytics • Business Applications • Collaboration • Platform	• Sales Cloud • Service Cloud • Marketing Cloud • Force.com • Chatter • Data.com • Work.com • Products for Small Businesses

[5] Adapted from http://www54.sap.com/pc/index.html [accessed on 1 September 2013]

[6] Adapted from http://www.salesforce.com/products [accessed on 1 September 2013]

- Virtualization

Mobile
- Mobile Apps
- Mobile Apps Platform
- Mobile Commerce Solutions
- Mobile Device Management
- Managed Mobility
- Mobile Services

Note: The (sometimes inconsistent) categorizations used in this table are those employed by the vendors.

Table 1.2 Available editions of the Salesforce.com CRM application[7]

Edition	**Price** [USD/user/month]	**Functionalities**	
Contact Manager	5	Accounts & contacts Task & event tracking Email integration Outlook, Gmail Google Apps	Mobile access Content library Customizable reports
Group	25	All Contact Manager features plus: Opportunity tracking Customizable sales process Email templates & tracking Web-to-lead capture Lead scoring, routing & assignment	Dashboards Search Data.com contacts and accounts Salesforce-to-Salesforce collaboration
Professional	65	All Group Edition features plus: Mass email Campaigns Product tracking Real-time quotes Ideas community	Contract management Customizable forecasts Customizable dashboards Analytics snapshots
Enterprise	125	All Professional Edition features plus: Workflow & approval automation Sales teams Territory management Offline access Visual workflow Enterprise analytics	Call scripting Profile layouts and field-level security Custom apps & websites Developer sandbox Integration via Web Services API
Unlimited	250	All Enterprise Edition features plus: Unlimited customizations Unlimited custom apps Unlimited access to 100+ administration services Unlimited access to Premier online training catalog	Assigned success resource Mobile customization & administration Increased storage limits Multiple sandboxes 24x7 toll-free support

The complexity of IT product portfolios we have just shown is a consequence of the challenges faced by an IT vendor to serve its potential market successfully. These challenges, as hinted at by the above examination, entail supporting multiple market entities (technological artifacts and economic agents) simultaneously. They are pursued to maximize the potential market, to strengthen network effects, and to drive economies of scale and economies of scope. We have listed these challenges in Table 1.3. One challenge is supporting different platforms, thus requiring the development or adaptation of products and services for each supported platform. Moreover, the vendor may have to occupy multiple levels of a technological stack. IT vendors may also have to serve different market sides with appropriate products and services. For example, offering a software application to end-users and a development kit to developers. Other members of the supply chain or value network to which the vendor belongs may also

[7] Adapted from http://www.salesforce.com/crm/editions-pricing.jsp [accessed on 1 September 2013]

demand tailored products and services (e.g., training for consultants, customized development projects with integrators and resellers). Finally, IT vendors should take into account the specificities of different market segments.

Table 1.3 Challenges faced by an IT vendor to successfully serve its market

Entities to be supported simultaneously	Examples
Platforms	Control: own; third-party Ownership: proprietary; open Operating systems: Linux; Windows; OSX Computing platforms: cloud; desktop; mobile
Levels of a technological stack	Cloud computing stack: IaaS; PaaS; SaaS IT stack: hardware; operating system; middleware; applications
Market sides, or members of the value network or supply chain	Users & developers Persons & organizations Complementors; platform providers System integrators; Value-added resellers; consultancies
Market segments	Demographics: age classes Company size: small & medium companies; large enterprises Industries: healthcare; manufacturing; retail

If we further reflect on the portfolios in Table 1.1 under the aforementioned perspectives, we notice something else as well: many items within each portfolio are actually related to each other. They are related from a technological point of view, of course, but we are rather interested in their possible interactions in the markets here. The presence of one item, its attributes, performances, and pricing, may influence the demand which another item will enjoy. The possible interdependences in the market are called complementarity and substitutability, depending on the sign of this influence: positive for complements and negative for substitutes.

Substitutability may be defined functionally – as the degree to which two products perform the same function for a customer (Porter 1980, p.23) – or economically – as the degree to which one product's price change will impact the demand for the other (Bain 1952, p.52). When two of the vendor's own products or services are, at least to some degree, substitutable, they will appeal to overlapping customer segments and their demand functions will be interdependent. In other words, these products and services will partly compete with each other for the same customers.

Substitutes have variable degrees of substitutability with one another. We may readily identify several examples of close substitutes within the portfolios in Table 1.1. Packaged software applications and their "cloud" counterparts is an exemplary pair. For instance, Microsoft Windows Azure (Microsoft's IaaS/PaaS solution) may indeed replace installed instances of its own flagship operating system, servers, and development tools. Analogously, SAP on-demand business applications may compete with its flagship on-premise ones: the SaaS offering "SAP By-Design", for example, supports some of the same business processes for which the on-premise "SAP Business Suite" was originally conceived and has gained its fame. Serving both desktop and mobile computing platforms is another way of introducing substitutability in the portfolio: Google map and navigation functionalities, for example, are provided both as web applications accessible from any browser and as standalone "apps" for smartphones and tablets.

Salesforce.com multi-edition marketing strategy also generates substitutes. The alternative subscription plans (the "editions") are by definition substitutes, inasmuch as the cheaper plans merely enable a subset of features or a more restricted usage-allowance than the more expensive ones. This is evident looking at the functionality sets offered by the various CRM editions in Table 1.2. Different editions share some core functionalities. The same customers may thus consider them for purchasing in alternative to one another.

When two substitutable products or services are present in the market simultaneously, sales diversion between them may occur, whereby one wins customers at the expense of the other, instead of generating incremental sales. In other words, the potential customers of one product become a *source of demand* for the other. When this is the case, we must distinguish two scenarios. If the two offerings belong to competing organizational entities, one is actually winning customers who would have otherwise bought from the rival– an instance of sales diversion called *competitive draw*. Instead, if the two offerings are sold by the same organization, purchasers of one offering have bought another item from the same product portfolio – an intra-organizational instance of sales diversion referred to as *sales cannibalization*. Whenever an organization concurrently offers products or services with some degree of substitutability towards each other, these are direct alternatives to one another for some purchasers and sales cannibalization may occur.

1.2. Sales Cannibalization in IT Markets

1.2.1. Ubiquity of the Phenomenon

IT vendors regularly implement growth strategies based on product proliferation, that is, increasing the breadth of offerings available simultaneously in the market. The peculiar nature of IT artifacts namely allows and incentivizes them to generate several offerings more or less derivatively from a common core of elements or functionalities. However, this inherent commonality may beget some degree of substitutability among products. That is the reason why the presence of substitutes within an IT vendor's product mix is the rule rather than the exception and, consequently, sales cannibalization is a phenomenon recurrently observable in IT markets.

A distinctive attribute of both hardware and software is modularity, and the typical architecture of IT solutions is namely that of a layered system (Messerschmitt & Szyperski 2003, pp.24–25). This allows IT vendors to readily exploit the engineering concept of product platforms, whereby an array of derivative products can be developed by plugging/unplugging modules into a core set of subsystems (Meyer & Lehnerd 1997, chap.7). In enterprise software solutions, distinct modules are dedicated to the automation of different business processes and thus targeted solutions can be generated by activating a specific subset of the available ones. Another example, which will be at the heart of Case I, is the latest generation of portable music players by Apple (the iPod Touch) which is equivalent to the smartphone by the same vendor (the iPhone) in all aspects except for the missing cellular telecommunication capability.

Another distinctive characteristic of IT products is the cost structure: fixed costs for their creation (e.g., investments in research and development, specialized plants, etc.) are high in comparison with variable costs for manufacturing and distribution. Specifically, the latter are the lower the more relevant the software component is in the IT artifact, since the cost of replicating and distributing software is negligible (Shapiro & Varian 1999, pp.20–22). The initial fixed costs for the development of an IT artifact are largely sunk and represent risky investments, so that portfolio diversification becomes a way of mitigating that risk (Messerschmitt & Szyperski 2003, p.324). Moreover, the behavior of marginal costs hampers cost-based pricing and invites vendors to pursue price discriminatory tactics through versioning and bundling (Messerschmitt & Szyperski 2003, pp.330–336), both of which entail product proliferation.

Versioning means offering different variants (in terms of quality and price) of the same basic product or service to appeal to different customer types (Hal & Carl 1998). It produces by definition multiple substitutes of the original product or service, whose quality and corresponding price are either lowered or raised in each variant. In the case of the Apple portable devices, for instance, each product is available in various memory levels (e.g., the Apple iPhone with 16, 32, or 64 GB of memory) and display configurations (regular or with "Retina" technology). Such segmentation practices have been addressed by IS scholars. Among others, Jing (2003) has investigated segmentation policies for

information goods in the presence of network externalities, while Raghunathan (2000) has extended the generic segmentation model of Moorthy & Png (1992) to software product lines.

Bundling consists of combining different products and/or services into one single package or transaction (Adams & Yellen 1976). We have already highlighted the modular nature of IT technology. Computer systems may themselves be defined as bundles of hardware and/or software components, where the exact contour of the artifact is determined by business and design decisions (Evans et al. 2005, p.194). IT artifacts can be bundled with goods or service of a different nature as well, such as digital content, services, etc. The form of bundling relevant to our discussion is *mixed* bundling, when the vendor offers both the bundle and its individual constituents separately. In this situation, the bundle and its parts are substitutable to some extent. An individual component namely offers a subset of the bundle benefits. Smartphones, for example, are sold as standalone products or in combination with cellular subscription services. Both the device alone and the package of device plus subscription may appeal to the same customers.

The embodiment of innovation is another characteristic of IT. However, the innovative degree of the newly launched product may differ. It is low in the context of a market penetration strategy (i.e., introducing new variants to increase the market shares of current products), and higher for a product development strategy (i.e., introducing new products in current markets) or for a diversification strategy (i.e., introducing new products in new markets). Moreover, due to technological innovation and the diffusion process thereof, successive generations of any given IT artifact will probably exist and possibly be in the market at the same time. At time of writing, for example, two generations of the Apple iPhone (the fourth and the fifth) are sold simultaneously in the market.

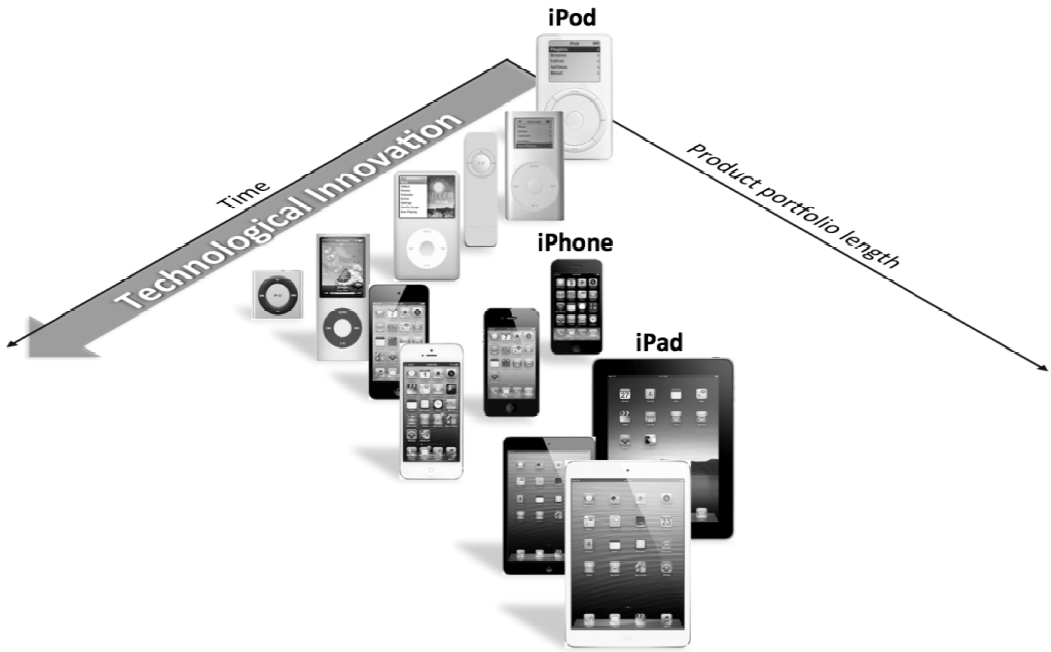


Figure 1.1 Apple handheld computing platforms as an exemplary illustration of the explosion of portfolio items driven by technological innovation and growth strategies based on product proliferation

The joint effect of accelerating technological innovation cycles and the incessant exploitation of growth strategies based on product proliferation is an explosion in the total number of items in a vendor's portfolio – or, couched in marketing terminology, an ever-increasing portfolio length. Thus, IT vendors confront their potential customers with a growing number of substitutable offerings and may engender sales cannibalization within their portfolios. An exemplary case is depicted in Figure 1.1, where the proliferation of portable consumer devices by Apple is illustrated.

This manufacturer of consumer IT has originally entered the market for portable music players with the iPod, and has since introduced the first touchscreen-based smartphones and tablet computers – the

iPhone and the iPad (diversification strategy). In each product category, Apple has launched several products over time, for example, the iPod "Mini", "Nano", and "Shuffle" (product development strategy). Multiple memory and screen configurations are available for all devices (market penetration through versioning). Packages including the device plus a contract with a telecommunication carrier are offered for the iPhones and the iPads with 3G capabilities (market penetration through bundling).

1.2.2. Importance of the Phenomenon

Sales cannibalization is not a merely ubiquitous feature of the IT industry – it can determine the fate of individual offerings and vendors, whole ecosystems, or even entire markets and industries.

Strategically, cannibalization plays a fundamental role in determining the outcome of the competitive game for market leadership. The willingness to cannibalize own successful offerings and their underlying assets is namely a distinctive organizational trait of enduring market leaders (Tellis & Golder 2002, pp.48–56). On the contrary, the fear of cannibalization hinders innovation to protect established products from obsolescence and to avoid sacrificing specialized assets which would not be transferable to the new products (Chandy & Tellis 1998). Hindering innovation leads to market share erosion at the advantage of competitors, and, in the case of disruptive innovations, ultimately to the dismay of even once-dominant firms (Christensen 1997). In full accordance with the strategic role of cannibalization, cannibalization rates in the software industry have been found to be "*one of the strongest and most distinguishing differences between successful and unsuccessful companies*", and the best-performing software vendors are those which introduce a new product in the growth phase of the previous one already (Hoch et al. 2000, pp.146–147).

Evidently, whenever the sales diversion takes place between portfolio items with different economics, cannibalization has financial and competitive consequences. Cannibalization of software applications delivered on-premise by those delivered on-demand is a case in point. Costs and revenues which these two delivery models generate differ in nature, magnitude, and timing (Buxmann et al. 2008). The software value chain itself must be configured in a different way for on-demand than it is for on-premise (Schief & Buxmann 2012), and the software vendor may vertically integrate or instead search appropriate new partners. Cannibalization can therefore affect a software vendor's financial performances as well as deeply alter its partnership constellation.

As the last remark lets imagine, not only sales cannibalization within one's own portfolio is relevant. Sales cannibalization experienced (or avoided) by competitors and complementors is an important strategic factor to consider. Depending on the specific context, it may either signal an intra-organizational struggle or be part of a deliberate move, but it may always present repercussions for other companies. Moreover, sales cannibalization occurring at a specific step of an IT value chain, or at a specific node of an IT value network, may have consequences for other steps or nodes, for an entire ecosystem, or for the industry as a whole. To recall one topical instance, cannibalization of notebooks by tablets is having heavy repercussions in the personal computer market for PC manufacturers, such as HP or Dell, for incumbent platform providers, such as Microsoft and Intel, and for complementors, such as the digital content providers from the infotainment industry.

Given the importance of the phenomenon, IT decision makers and decision influencers need (or ought to demand) sales cannibalization estimates in order to be able to take or sponsor the right course of action. The literature lists several users of sales cannibalization data (Mahajan & Wind 1988, p.342). Among internal stakeholders: the top management and managers of other brands affected by the cannibal product. Among external stakeholders: security analysts, competitors, and economic media reporters.

We believe that institutional investors, whether public or private, and regulatory bodies should also be considered two key external users of that information. With regard to the former, whether observed or projected sales represent an incremental component or not is obviously a factor affecting the rate of return of an investment. With regard to the latter, whether observed or projected sales represent an

incremental component or not will determine the overall effects on the wealth growth of the administrative perimeter considered. Therefore, the optimal degree of market concentration (for antitrust decisions) or penetration (for licensing decisions) cannot ignore cannibalistic relationships among the products or services in that market (e.g., Elliott & Navin 2002; Walker & Jackson 2008).

1.2.3. The Detection and Measurement Problem

As we have shown up to now, sales cannibalization has a nearly ubiquitous and strategically important role in IT markets. Yet, it is challenging to detect and measure its occurrence. We have previously defined sales cannibalization as *one* possible source of demand for a product (cf. end of Section 1.1). It is thus necessary to distinguish and isolate it from the other sources of demand, in order to detect and measure it. In principle, this requires examining the customers' hypothetical behavior in absence of the alleged cannibal product. A cannibalistic purchase occurs whenever the purchaser would have bought another item from the same firm, had the cannibal not been available, *ceteris paribus*. A simple imaginary scenario will help to clarify this working definition and the challenges it poses to detection and measurement.

A subsidiary of an international corporation has planned to acquire a CRM application to support its local sales activities. Let us assume that the corporation headquarters already relies on an on-premise CRM system by the fictional enterprise software vendor "*Pico* Inc.", but the IT strategy for the whole corporation is a decentralized one, so that the choice of a CRM solution is taken anew and independently for each subsidiary. A group of relevant decision makers and influencers would screen the offerings in the market and select one to be acquired and deployed. This is the so-called "buying center", which could include, for instance, the CIO, CFO, and marketing division leaders from the headquarters and equivalent functional roles from the subsidiary. Possible decision criteria could be the required investment, the level of integration attainable with the central CRM system, and the deployment time required to have the subsidiary system live. Let us now consider two alternative realizations of this buying process.

In one scenario, the decision makers/influencers with IT expertise recommend an on-demand solution, in order to minimize the deployment time.[8] The CFO agrees because this would require a lower initial investment in a time of economic instability.[9] The buying center initially considers the market leader in on-demand CRM, the fictitious vendor "*Bello* Inc.". However, they later discover from a sales representative that Pico also offers an on-demand CRM solution. This could guarantee a seamless integration with their central CRM system, provided by the same vendor. Therefore, they opt for the Pico on-demand offering instead of the one by Bello.

Let us now consider a slightly different course of events. In this alternative scenario, the buying center initially agrees that the level of integration with the headquarter system by Pico has the highest priority. The favored solution is thus the acquisition of a CRM system from the same vendor. Subsequently, the IT decision makers and influencers select the on-demand CRM application among the CRM solutions in the Pico portfolio, in order to minimize the deployment time for the subsidiary system.

The two scenarios are identical with regard to the initial context (need of acquiring a CRM system for a subsidiary) and to the buying decision eventually taken (acquisition of a Pico on-demand CRM system).

[8] On-demand solutions are operated by the software vendor and provided "as a service" via Internet. Therefore, they usually require less preliminary steps of installation/implementation/deployment/etc. before being delivered to the end-users than their on-premise counterpart.

[9] On-demand solutions are commonly priced per seat per subscription period. Under the assumption that the vendor does not constrain the minimum number of users and the minimum length of the subscription – an assumption which we will maintain here – an on-demand solutions should allow a potential customer to acquire the solution with a lower upfront investment than an on-premise application.

Yet, they are intrinsically different. In the first scenario, the rival system by Bello would have been bought, had Pico lacked any on-demand offering in its portfolio. The Pico on-demand offering is thus actually diverting a potential customer from Bello, that is, from the competition (competitive draw). In the second scenario, instead, if Pico had lacked any on-demand solution, the buying organization would still have acquired a Pico system anyway (the on-premise one). This second case is a case of cannibalization, since the on-demand Pico offering is not winning a new customer for Pico but instead merely diverting one from its on-premise product.

From the point of view of Pico Inc., the two scenarios are observationally equivalent unless *very* detailed information on the customer's own internal decision-making is available. As a matter of fact, vendors rarely have access to such information. This is what we call the problem of "*ex-post* estimation" of cannibalization: estimating the share of cannibalistic purchases which *have occurred*. "Ex post" since the estimation takes place after the market launch of the alleged cannibal product. In order to judge if a realized sale was cannibalistic or not, it is necessary to identify the hypothetical customer's purchase decision in a state of the world without the cannibal item. In other words, we want to find out what the customer response would have been in a hypothetical purchase situation where we have removed the cannibal from the market landscape.

If the estimation problem is tackled before the product or service with cannibalization potential is launched into the market ("*ex-ante* estimation"), we aim at forecasting the share of cannibalistic purchases which *will occur* once the allegedly cannibalistic offering goes into the market. We are interested in knowing how the appearance of the cannibal will alter the customer's response. We need to estimate the hypothetical customer's response to the introduction of the cannibal in his choice set. Table 1.4 recapitulates the two problems of cannibalization estimation.

Table 1.4 The cannibalization detection and measurement problems

		States of the world to be compared	
		Actual state of the world	*Hypothetical* state of the world
Estimation of cannibalization	Ex ante	Only the victim is present (the cannibal has not been launched yet)	Both the victim and the cannibal are present
	Ex post	Both the victim and the cannibal are present	Only the victim is present (the cannibal has been "removed")

Verifying whether cannibalization has occurred or will occur is the problem of *detection* of cannibalization. One further step in uncovering the true nature of the phenomenon would then be to estimate its magnitude over a certain interval of time – the problem of cannibalization *measurement*. It may be helpful to think of the detection and measurement problems in terms of hypothesis testing. The cannibalization detection problem can be seen as testing a null hypothesis of no cannibalization against no particular alternative hypothesis. A methodological solution to this problem should be capable of rejecting the null hypothesis whenever sales cannibalization is actually occurring in the market. A methodological solution to the cannibalization measurement problem, instead, cannot be limited to the rejection of the null hypothesis but must be able to provide evidence for the acceptance of an alternative hypothesis corresponding to a specific level of sales cannibalization.

1.2.4. Lack of IT-specific Detection and Measurement Methods

The challenge of detecting and measuring sales cannibalization, whose inherent difficulty already arose in the previous section, is even higher in the case of IT products and services. This is due to the fundamental role played in IT markets by technological innovation.

Since cannibalization is related to the degree of substitutability between cannibal and victim entities, the cannibalization potential of an offering depends on its attributes and performances, those of the victim offering, and the customers' preferences and expectations. In an IT market, all three elements

are subject to change over time under the influence of technological innovation and the diffusion thereof. The dynamics of innovation are such that, until a dominant design emerges and establishes itself in the market, the performance criteria which serve as a basis for competition are neither well articulated by buyers nor known to sellers (Utterback 1996, p.81). In the presence of innovation, consumers' attitudes and expectations on features, forms, and capabilities are not a given but instead develop and mature as the technology itself develops and matures, stabilizing over time around the dominant design. Radical innovations even require changes in the customers' current mode of behavior (Moore 1999, p.10). Markets actually grow around innovations (Utterback 1996, p.93) and not the other way around.

However, cannibalization measurement approaches from the Marketing Science and Management Science disciplines have been conceived mostly in the context of non-innovative or undifferentiated products. We thoroughly review the detection and measurement models proposed in the literature in Section 2.3.4 but provide here an overall critique of extant approaches, from the point of view of the IT industry and the place of technological innovation therein.

The detection and measurement problem formulated as the comparison of a real state of the world versus a hypothetical one naturally lends itself to an experimental design with the presence of the cannibal product as treatment. Recording customers' behavior in an experimental setting where the presence of any offering can be controlled is one possible implementation. Laboratory experiments with simulated shopping environments and field experiments in test markets have been proposed and employed to conduct ex-ante assessments in the case of repeatedly-purchased consumer goods (Urban & Hauser 1980, chap.14–15).

The practicability of this solution for innovative IT products and services is debatable. On the one hand, in an industry where the secrecy of technological expertise and of its strategic deployment is a key competitive factor, an experiment in a real – though circumscribed – market could disseminate confidential information and destroy competitive advantage. On the other hand, such experiments may be too costly, time-consuming, or altogether impossible to be implemented for some IT buying situations. With regard to the enterprise software market, for instance, organizational buying processes involve too many functional roles and are too complex and variable to be reproduced in a laboratory setting (Case III will provide an example thereof).

When an experimental design is not feasible, one alternative is to perform preference analysis, since preference measures can subsequently be transformed into purchase and market share predictions (Urban & Hauser 1980, pp.285–289). Alternative market scenarios with and without the cannibal are then simulated based on the preference order ranks. If the estimated victim's market shares are lower in the presence of the cannibal, cannibalization is detected (Page & Rosenbaum 1987). Technological innovation may hamper this approach by acting as a discontinuity in the customers' preferences, as explained above. If the consumers are still forming their attitudes and expectations about the products' features, form, and capabilities, how is a preference measurement supposed to quantify them?

A third possibility exists for ex-post estimation when historical sales data is available: a quasi-experimental design. The market launch of the cannibal is the "natural experiment", that is, the instant in which the naturally occurring manipulation of the dependent variable (i.e., the victim's sales) is supposed to take place. Econometric models can detect and quantify sales cannibalization based on historical sales and the timing of the natural experiment. For example, time series econometric models can test the presence of a structural break in the sales-generating process due to the quasi-experiment.

Unfortunately, because of technological innovation, the assumptions underlying the quasi-experimental design may be questioned. The natural experiment occurrence does not necessarily correspond to the cannibal's market launch. That is to say, assuming that the cannibalization phenomenon simply manifests itself (or not) at product launch may lead to spurious inferences. An IT entity may become a cannibal later than market introduction, i.e., cannibalization may be engendered later in the product

lifecycle, as a consequence of the innovation process altering its performances and the market expectations and attitudes towards them.

1.3. Research Questions

In light of the peculiarity of the cannibalization estimation problem in the context of IT products and services, sketched in the previous sections, we formulate the following research questions on the issue of sales cannibalization detection and measurement in IT markets in the presence of innovations:

Research Question 1 (*RQ1*)
How can sales cannibalization be detected and measured with regard to innovative IT products and services whose attributes and performances as perceived by the market – and thus whose cannibalization potential – have changed over time due to innovation?

Research Question 2 (*RQ2*)
How can potential sales cannibalization be detected and measured with regard to innovative IT products and services whose design is not yet fully developed and toward which marketplace expectations are still being formed?

RQ1 and RQ2 are particular instances of respectively the ex-post and ex-ante detection and measurement problems (cf. Table 1.4) in which technological innovation intervenes to act as a confounding factor peculiar to IT markets. In *RQ1*, we aim at estimating the cannibalization phenomenon as it *has* developed in an IT market, taking into consideration how innovation have altered product attributes and performances, and customers' preferences towards them, over time. In *RQ2* we aim at estimating the cannibalization phenomenon as it may be supposed it *will* develop, taking into consideration that innovation is still shaping product attributes and performances, and customers' expectations towards them.

Both *RQ1* and *RQ2* are methodological in nature. They state the research issue of finding valid ways to detect and measure cannibalization among IT offerings in the presence of innovation. The answers ought to be methodologies which allow the researcher to tackle the positive question of whether cannibalization has occurred or will occur in a specific innovative context. One way of rephrasing these research questions would be in terms of hypothesis testing (a perspective we already introduced in Section 1.2.3). How should we design and perform a test which allows us to assess the plausibility of a null hypothesis of no cannibalization against an alternative of significant cannibalization (ex-post or ex-ante)? Fundamentally, we deal with the research issue of conceiving and implementing valid *operational definitions* of the cannibalization phenomenon, in a context where technological innovation determines the evanescence of product attributes, performances, and the related customers' expectations.

Since a rigorous operationalization of a concept demands that the latter be adequately well-defined, we had to tackle an additional research topic: the absence of a univocally-accepted definition of sales cannibalization (Lomax et al. 1997). We tackle this issue in Section 2.3 as an element of our literature review. We have therefore addressed the following preliminary research question as well:

Preliminary Research Question (*PRQ*)
How can sales cannibalization be conceptually defined?

1.4. Scientific Contributions

We believe to have provided three forms of scientific contribution to the research on sales cannibalization in the IS domain:

- Conceptual – in the form of new constructs which allow researchers to define the phenomenon of cannibalization in IT markets rigorously
- Methodological – in terms of novel research approaches for the detection and measurement of sales cannibalization in IT markets in the presence of innovative product and services
- Empirical – in the form of new findings which shed light on current IT trends and on their potential future developments.

1.4.1. Conceptual Contributions

Based on a qualitative explorative study and an in-depth analysis of the literature which revealed extant definitions and their limitations, we have formulated a novel *nominal* definition of sales cannibalization (Section 2.3.1). While being generic enough to reflect all cannibalization occurrences encountered in the praxis, this definition is precise and rigorous. We also distinguish between volume and monetization effects of cannibalization and define them. This conceptual work allows our operationalizations to be precise, rigorous, and consistently comparable between each other and with those from the literature. We provide three alternative *operational* definitions of cannibalization (Section 2.3.2).

1.4.2. Methodological Contributions

We have extended the range of available methods for the detection and measurement of cannibalization, elaborating approaches suitable for tackling the problem when, given the innovation dynamics at work in IT markets, traditional methodologies from the Marketing Science and Management Science disciplines would not be appropriate.

In the quasi-experimental design of Case I, the date of the natural experiment – the date in which cannibalization allegedly manifested itself – is selected by the researcher based on his own judgment and then statistically tested for significance. Concretely, we elaborated an iterative procedure to pretest a given set of dates for significance before entering the phase of model selection and estimation. Once the dates were screened, further tests were applied (for instance, the Perron test for the detection of unit roots in the presence of structural breaks) and the effects of the structural changes estimated.

In Case II, the date of the natural experiment cannot be identified a priori. The research design is thus longitudinal while the search for the tentative breakdate is conducted and quasi-experimental thereafter Formally, the research challenge is testing for a structural change of unknown date in the sales-generating process of the victim. Our study is, to our knowledge, the first microeconomic application of the unit-root testing procedure proposed by Zivot and Andrews, which endogenously determines the unknown date of the change (Zivot & Andrews 1992). Reading the estimated date in light of the milestones in the history of the cannibal, and validating against alternative explanations, it is possible to demonstrate the cannibalistic origin of the decrease in victim's sales.

In Case III, we investigate the cannibalization effects of an IT innovation still in its infancy: online sales channels for enterprise software. While a dominant design for an online sales channel already exists in the consumer software market (the "app store" à la Apple iTunes), it is not yet clear which attributes such a store shall have in the enterprise software market. We are still in the "fluid" phase of innovation, i.e., performance criteria and customers' expectations are still in the making (Utterback 1996). Moreover, an online sales channel for enterprise software represents a complex composite innovation, partly process innovation (influencing how enterprise software products and services are delivered) and partly service innovation (influencing how customers are served along the software buying process).

A qualitative research strategy (to our knowledge the first application of qualitative research to sales cannibalization), based on semi-structured interviews for data collection and coding for data analysis, has allowed us to tackle the problem effectively. Semi-structured interviews offer the flexibility required to build a shared understanding of the innovative context between the interviewer and the interviewee, no matter what the preexistent knowledge and expectations of the latter might be. For instance, the interview guide provides a common terminology. A high degree of consistency among the interviews is also ensured. Subsequently coding allows the researcher to bring structure to the yet not fully articulated customers' attitudes.

In Case IV, we combined the quantitative and qualitative approaches from the previous cases (i.e., we have performed mixed-method research) for the analysis of the self-cannibalizing transition of a software vendor from on-premise to on-demand. The qualitative component consisted in the interpretation and analysis of publicly available written accounts with coding and systematic comparisons of codes and quotations. We thus identified the transition milestones, qualitatively extracting the input for the quantitative phase. The econometric part of the study is a structural break analysis analogous to those performed in Cases I and II. We have estimated intervention models to test for a change in the mean of the time series, and verified if any such change could be ascribed to the previously identified milestones.

In addition to that, we have proposed simulation as a means of validating the econometric outcomes further. As we have explained above, detecting cannibalization ex-post involves the problematic comparison of two alternative states of nature. Whether an *actual* sale should be qualified as "cannibalized" namely depends on the buyer's *hypothetical* behavior before a market landscape without cannibal product, ceteris paribus. On this premise, simulation is a valuable research methodology, since it allows an experimental investigation to take place that would otherwise be impossible or impractical as a field experiment. It allows the researcher to investigate a market model experimentally – retaining control of the cannibal's presence in the simulated market– and to incrementally/selectively tackle environmental and competitive factors, which may drive, hinder, or confound cannibalization effects.

An Agent-Based Modeling and Simulation approach, in particular, enables different operational definitions of the cannibalization variable by empowering the researcher to observe the purchasing agent's evolving preference structure. We illustrated how to design, implement, and employ an agent-based Computational Laboratory for the study of sales cannibalization in software markets through numerical experiments.

In the last chapter, we provide an overview and a comparison of the detection and measurement methodologies presented throughout this work. This should help practitioners understand how different approaches can be applied, either separately or together for a triangulated assessment of the phenomenon.

1.4.3. Empirical Contributions

Finally, in addition to the conceptual and methodological contributions, we provide empirical findings to decipher the current and future state of some IT markets. Since the specific cases we have examined focus on topical IT market trends, the outcomes of the applied methodologies represent a contribution to the understanding of the developments observed in the industry.

In Case I, we assessed the occurrence of sales diversion within the portfolio of Apple handheld devices capable of playing digital music, i.e., iPods, iPhones, and iPads. We examined product interrelationships within the iPod product line (among different models), and between this product line and the iPhone/iPad ones (instances of the smartphone and tablet product categories respectively). We could find evidence of an overall revenue expansion in the iPod product line, due to the introduction of both entry-level and premium iPod models, and of a substantial cannibalization of unit sales due to the introduction of the iPhones and, to a lesser extent, of the iPad Mini.

Platform competition may engender a substitution process whereby customers and complementors drift from one platform to another, for example, as the aftermath of a competitive race between a general-purpose platform and a single-purpose rival. In Case II, we have statistically verified and quantified how sales of personal navigation devices (PND) have been sapped by GPS-enabled smartphones with comparable turn-by-turn navigation functionalities. Using a structural-break unit-root econometric model, we have assessed the impact of smartphones on the quarterly volume sales of the two leading PND manufacturers. Our econometric analysis reveals a significant shift in the mean level of the underlying sales-generating processes and dates the structural change at the third quarter of 2008, when the iOS and Android online "app stores" were launched.

These successful app stores, pioneered by the iTunes App Store, illustrate to which extent sales channels have "dematerialized" in consumer software markets under the influence of the e-commerce paradigm. In enterprise markets, instead, traditional "offline" channels based on intermediaries and sales professionals still represent the dominant approach. Nonetheless, the diffusion of online sales channels for consumer software applications, is acting as a catalyst for the launch of analogous online sales channels by enterprise software vendors.

However, it is disputable whether the online purchase of a software application is as compelling for an organizational buyer as it is for an individual consumer, whether drivers and barriers of online channel adoption are the same in these two different contexts, and whether online and offline channels enhance or cannibalize each other. The channel adoption decision by organizational software buyers and its strategic repercussions for enterprise software vendors are namely the focus of Case III.

Relying on a qualitative research strategy, we have explored this organizational channel adoption decision to construct a qualitative channel adoption model. Our adoption model encompasses the relevant drivers and barriers of adoption for both the online and offline channel, and the interdependencies among these factors. Moreover, it takes into account the differences between the individual phases of the organizational software buying process.

Feeding our adoption model with the various enterprise software product and services it is possible to determine for each of them the degree of "appification", i.e., suitability for an online distribution, and whether the two channels will enhance or cannibalize each other. Practitioners can derive recommendations for the design of a multichannel sales system according to the classes of enterprise software products and services they provide.

As a unifying remark for cases II and III: online sales channel play a key role for software consumers today and will probably do it in the near future for enterprise software consumers just as well. We have shown in Case II what a disruptive impact a state-of-the-art online sales channel has had in consumer software markets, representing an advantageous discontinuity for smartphone platform leaders and their complementors, at the expense of other incumbent IT ecosystems. Based on the findings of Case III, we believe it has also the potential to radically enhance how *enterprise* software is evaluated, purchased, and ultimately consumed, to the benefit of enterprise software customers and vendors alike.

Another topical software trend is the focus of Case IV (Chapter 6), namely the increasing adoption of on-demand delivery models. Verdicts on the advisability for software vendors to adopt such models are widespread in the business and technology press. Especially incumbent vendors are prompted to transition to on-demand and cannibalize their on-premise customer-base, in order to supposedly enjoy market expansion, economies of scale and revenue predictability. Relying on a mixed-method research approach, we have examined the transition of two software companies which originally entered the market as on-premise vendors and turned into pure on-demand players over time. Specifically, we identified the transition milestones, and shed light on the actual impact such milestones have had on the vendors' performances.

1.4.4. Validation and Dissemination

All along the research project, preliminary, intermediate, and final results were disseminated in the scientific community by means of conference talks and publications. Table 1.5 contains the complete list of articles published by the author. They were reviewed, presented, and discussed at the most relevant conferences in the Information Systems domain, such as the *International Conference on Information Systems* (2013), the *European Conference on Information Systems* (2013), the *International Conference on Software Business* (2012 & 2013), and the *International Conference on Wirtschaftsinformatik*[10] (2013). Selected publications have found place in the Springer series "*Lecture Notes in Business Information Processing*" and "*Lecture Notes in Computer Science*".

Table 1.5 Scientific contributions published in the course of this research project

Publication	VHB rating[a]	Chapter
Novelli, F., and Wenzel, S. 2013. "*Online and offline sales channels for enterprise software: cannibalization or complementarity? A qualitative study*." In Proceedings of the 33th International Conference on Information Systems, Milan, Italy.	A	5
Novelli, F., and Wenzel, S. 2013. "*Adoption of an Online Sales Channel and Appification in the Enterprise Application Software Market: a Qualitative Study.*" In Proceedings of the 21st European Conference on Information Systems, Utrecht, the Netherlands, pp 1–12.	B	5
Novelli, F. 2013. "*Sales Cannibalization in Information Technology Markets: Conceptual Foundations and Research Issues*." In Software Business. From Physical Products to Software Services and Solutions. Series: Lecture Notes in Business Information Processing, Vol. 150, eds. Georg Herzwurm, and Tiziana Margaria, Heidelberg: Springer, pp 31-42. Presented at the 4th International Conference on Software Business (ICSOB 2013), Potsdam, Germany.	C	2
Wenzel, S., Novelli, F., and Burkard, C. 2013. "*Evaluating the App-Store Model for Enterprise Application Software and Related Services*." In Proceedings of the 11th international Conference on Wirtschaftsinformatik (WI 2013), Leipzig, Germany, pp. 1407-1421.	C	5
Novelli, F. 2012. "*A Mixed-Methods Research Approach to Investigate the Transition from on-Premise to on-Demand Software Delivery*." In Economics of Grids, Clouds, Systems, and Services. Series: Lecture Notes in Computer Science, Vol. 7714, eds. K. Vanmechelen, J. Altmann, and O.F. Rana. Heidelberg: Springer, pp. 212–222. Presented at the 9th International Conference on Economics of Grids, Clouds, Systems, and Services (GECON 2012), Berlin, Germany.	C	6
Novelli, F. 2012. "*Platform Substitution and Cannibalization: The Case of Portable Navigation Devices*." In Software Business. Series: Lecture Notes in Business Information Processing, Vol. 114, eds. M. A. Cusumano, B. Iyer, and N. Venkatraman. Heidelberg: Springer, pp. 141–53. Presented at the 3rd International Conference on Software Business (ICSOB 2012), Cambridge, MA, USA.	C	4
Kiemes, T., Novelli, F., and Oberle, D. 2012. "*Service Pricing*." In Handbook of Service Description, eds. Alistair Barros and Daniel Oberle. Heidelberg: Springer, pp. 227–242.	–	1
Novelli, F. 2012. "*An Agent-Based Computational Laboratory for Sales Cannibalization Studies.*" In Proceeding of the 3rd International Conference on Computer Modelling and Simulation (CSSim 2012), Brno, Czech Republic, pp. 72–79.		7
Novelli, F. 2011. "*A Simulation Study of the Interdependence of Scalability and Cannibalization in the Software Industry*." In Proceedings of the 8th International Mediterranean & Latin American Modeling Multiconference (I3M 2011), Rome, Italy, pp. 599–604.	–	7
Draisbach, T., Novelli, F., and Buxmann,P. 2011. "'*Premium-Services: Pricing Strategies Simulator'-A Decision Support Tool for Pricing Strategies on the Basis of a Multi-Attribute Utility Model and Agent-Based Simulation*." In Proceedings of the 9th Conference on Information Science Technology and Management (CISTM 2011), Porto Alegre, Brasil, pp. 1–10.	–	7
Novelli, F., and Draisbach, T. 2011. "*An Agent-Based Approach to Strategic Customer Value Management*." In Proceedings of the 13th Pricing Conference, Syracuse, New York, USA, pp. 47–49.	–	7

Note: a) VHB rating 2011 (Hennig-Thurau & Sattler 2011)

[10] The German equivalent for "Information Systems Research".

1.5. Structure of the Dissertation

The overall structure of this document should appear straightforward. Topics are arranged sequentially and four main parts can be identified:

1) Survey of already existing concepts and measurement methods concerning the cannibalization phenomenon; their elaboration and augmentation to provide the conceptual and methodological basis of the research project (Chapter 2);
2) Presentation of four empirical cases of cannibalization detection and measurement in IT markets (Chapters 3 to 6);
3) Introduction to the use of agent-based simulation in numerical experiments on sales cannibalization (Chapter 7);
4) Summary and comparison of research methodologies and findings, limitations and open research issues (Chapter 8).

The conceptual and methodological foundations are described in Chapter 2. Section 2.1 presents the exploratory qualitative study. In Section 2.2 our literature reviewing methodology is presented, followed by its outcomes: the novel definition of cannibalization (Section 2.3.1), the main characteristics of the phenomenon (Section 2.3.3), the methodological compendium on the detection and measurement of sales cannibalization (Section 2.3.4), and a summary of previous empirical findings relevant for ISR (Section 2.4.2). Our philosophical orientation and the research methodology chosen to address the research questions formulated above are explained in Section 2.5.

Chapters 3, 4, 5, and 6 present a detailed account of the four case studies in our multi-case research project. Each of these chapters follows an analogous structure:

- The case study is introduced and described
- The research design and data employed are explained
- The empirical findings are illustrated and discussed

To supplement the empirical methodologies employed in the case studies, Chapter 7 explains how to use Agent-Based Modeling and Simulation (ABMS) to perform numerical experiments on sales cannibalization. The chapter provides the theoretical foundations of ABMS (Section 7.2), guidelines for modeling cannibalization (Section 7.3), a blueprint for a dedicated Computational Laboratory (Section 7.4), and an illustrative experiment based on Case IV (Section 7.5).

In Chapter 8, the case studies are summarized and compared to each other from the point of view of both the research methodologies employed and the empirical findings obtained (Section 8.1). Eventually, we put our scientific contributions in perspectives with limitations and possible future streams of research (Section 8.2).

The Appendix contains a short glossary of the econometric terminology employed in Chapters 3, 4, and 6, the detailed tabular representation of some input-data, and the results of some intermediate analytical steps.

2. Conceptual and Methodological Foundations

In this chapter, we lay the foundations for the whole research endeavor. On the one hand, we describe the conceptual foundations, that is, the basic constructs necessary to describe and understand the phenomenon of cannibalization in IT markets. On the other hand, we outline the methodological foundations, that is, how we have designed the research process implemented in this dissertation, and why so.

The main conceptual constructs introduced here are the nominal and operational definitions of sales cannibalization (Section 2.3.1). We have elaborated them from the definitions commonly employed in the academic literature – duly surveyed with a systematic and interdisciplinary literature review (Section 2.2) –, and in the business praxis, by means of a qualitative analysis of articles from the IT trade press (Section 2.1).

From an academic point of view, we have considered two disciplines: Marketing Science, to gain a generic research perspective on the phenomenon (Section 2.3), and ISR, given our focus on IT (Section 2.4). From the array of prior empirical studies in these two disciplines, we have also collected:

- the dimensions of the cannibalization process (Section 2.3.3),
- the detection and measurement models proposed (Section 2.3.4),
- the numerical findings with regard to IT markets (Section 2.4.2).

With regard to the definition of our research approach, we first clarify our philosophical orientation and the paradigm choice underlying this research endeavor (Section 2.5.1). Subsequently, we detail the overall research design (Section 2.5.2), and finally outline the research process (Section 2.5.3).

2.1. Exploratory Qualitative Study

The term "cannibalization" originally refers to the practice of cannibalism, i.e., "*the act of eating of the human flesh by a human*" or, more generically, of the flesh of an animal by another animal of the same kind[11]. It does not have an intrinsic univocal meaning in the business domain. It has rather been borrowed as an emphatic label for behaviors and phenomena which somehow resemble the biological ones.

Therefore, the first – exploratory – step in our research project on cannibalization was to survey how economic actors in IT markets employ this term. For this purpose, we have performed a qualitative study of reports and articles from the trade press which mention sales cannibalization in conjunction with an IT entity (agent, product, service, or market). The objectives of this qualitative study were to understand which business meanings lie behind the word cannibalization, that is, which specific market phenomena or behaviors are commonly signified by it in the domain of IT. Thereby, not only have we investigated the semiotic link between the cannibalization term and those phenomena and behaviors, but also glimpsed at sales cannibalization from the practitioners' point of view. As a by-product, we have collected noteworthy cases of cannibalization as well – useful for illustrative purposes throughout this dissertation.

2.1.1. Research Methodology and Data

The secondary data collection phase of this explorative study consisted in gathering articles about cannibalization occurrences in the IT industry from selected online sources. The data analysis consisted in coding them and developing both the dimensions and the interrelationships of the elicited codes.

[11] Definitions of "cannibalism" taken from the Merriam-Webster dictionary: http://www.merriam-webster.com/dictionary/cannibalism [accessed on 1 May 2013]

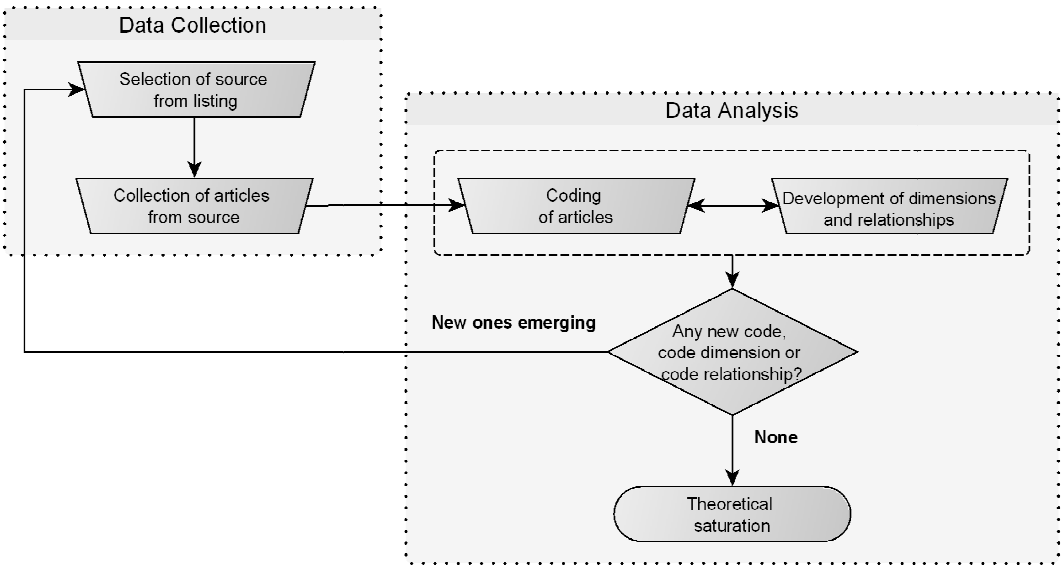


Figure 2.1 Iterative research process for the explorative study

To aim at completeness in our exploration of the way practitioners use the term cannibalization, we complied with one of the tenets of qualitative inquiry: we executed data collection in parallel with data analysis until we reached "theoretical saturation". Theoretical saturation is the phase of qualitative data analysis in which the researcher realizes that all concepts are well-developed and no additional data would let new ones appear (Morse 2004). In our specific case, we iteratively collected the articles and analyzed them until no new relevant cannibalization aspect was emerging from the analysis, i.e., until we stopped devising new code, code dimension, or link between codes in the coding process. Figure 2.1 illustrates the overall research process and highlights the relationships between the major research activities, detailed in the next paragraphs.

We collected articles from online sources which had been selected based on relevance, trustworthiness, and accessibility. In other words, we sought online sources which disseminate news about the IT industry, are considered reliable by professionals, and allow unrestricted full access to their content (i.e., without the need of subscriptions). To fulfill the first two requirements, we selected our sources from the rankings made publicly available by the web information company Alexa.[12]

Alexa listings are categorized and can be filtered by topic and publication type. We picked four subcategories: "Business > News and Media" (generic sources of business news), "Business > Investing > News and Media" (sources of news about public companies), "Business > Information Technology > News and Media" (sources of enterprise technology news), and "Computers > News and Media" (sources of consumer technology news). This choice has allowed us to encompass a plurality of perspectives: both consumer and enterprise technology, from both a technical and a business/financial point of view.

With regard to reliability, first of all, we excluded sources categorized as "Weblogs" and "Columnists", whose content may reflect subjective views rather than factual reports and analysis. In addition, we employed online popularity (web traffic measurements by Alexa) as a proxy for trustworthiness, selecting only top-ranked online sources among the remaining candidate sources.

When we halted the data collection process – once theoretical saturation was attained –, we had selected eight sources, listed alphabetically in Table 2.1. All of them are among the top ten websites in their respective category. Moreover, with the exception of CIO.com and InfoWorld, they all belong to different publishers and should therefore reflect a diverse set of editorial policies.

[12] Source: http://www.alexa.com [accessed on 23 July 2013]

Table 2.1 Selected sources for the exploratory study

Source	Publisher	Category	Rank
Barron's	News Corp	Business > Investing > News and Media	7
Bloomberg.com	Bloomberg	Business > News and Media	3
CIO.com	IDG	Computers > News and Media	8
Fortune	CNN	Business > Investing > News and Media	8
InformationWeek	UBM Tech	Business > Information Technology > News and Media	4
InfoWorld	IDG	Business > Information Technology > News and Media	6
PCMag	Ziff Davis	Computers > News and Media	1
ZDNet	CBS Interactive	Business > Information Technology > News and Media	2

We searched these sources for articles about cannibalization by exploiting the lexical search capabilities of the Google search engine. The basic query string was "*cannibal OR cannibalization OR cannibalize OR cannibalizes OR cannibalizing OR cannibalized OR cannibalism*", to take into account all the possible wordings used to refer to the phenomenon. We restricted the search to a given source website by concatenating the "site" operator[13] to the list of keywords (for example, "*site:infoworld.com*"). We used specific subdomains of the Barron's and Fortune websites (the exact URLs are reported in Table 2.2) to circumscribe the lexical search to the website pages focusing on technology. This was not possible in the case of Bloomberg and we therefore added the keywords "*software OR computer*"[14] to the query to exclude generic articles on cannibalization.

In addition to that, we employed two additional Google search parameters.[15] We deactivated the personalized search feature (parameter "*pws*") to allow replicability of the search task. For our explorative purposes, we restricted the time range to the years 2010-2012 (parameter "*as_qdr*"). The query string for each of the selected source was created automatically with a VBA script, which also sent the resulting Google URLs directly to the browser. The search results were saved locally as Microsoft Word documents, manually removing duplicates and spurious results.

As a final remark, we provide the reader with an illustration of the interaction between data sampling and data analysis in qualitative inquiry – an example of a development which signaled the approach of theoretical saturation. After having coded the articles from the first six sources, we decided to filter out the articles focusing on the iPad-driven cannibalization of notebooks, because we realized only getting repeated accounts of the same occurrence without any new insight. We therefore appended "*-iPad*" to the Google query to exclude this topic from the two subsequent data collection iterations.

The qualitative material we collected from the eight online sources amounted to 236 articles for a total of about 163,000 words (Table 2.2). For the data analysis step, we performed qualitative content analysis by means of coding. Coding is the process of assigning a word or short phrase (the code) to a portion of text (the quotation) as an instrument of categorization and interpretation (Saldaña 2009). Given the extensive qualitative material collected, we employed a Computer-Aided Qualitative Data Analysis Software (CAQDAS) – a software environment expressly designed to support qualitative research activities. Concretely, we used the ATLAS.ti commercial software application, which provides document management, coding, and quotation retrieval functionalities.

[13] Cf. https://support.google.com/websearch/answer/136861?hl=en for a reference of Google search operators.

[14] We experimented with different keyword sets to reach a good representativeness of the wide array of IT domains discussed in the press. In particular, we tried the longer variants "*software OR computer OR streaming OR ondemand*" and "*software OR computer OR streaming OR ondemand OR computing OR phone OR mobile OR internet OR electronic*". They did not improve the results and we stuck with the more parsimonious keyword pair.

[15] Google provides users with appropriate GUI controls to set these search parameters (called "Search tools" in the Google web interface), but they can also be set programmatically by directly manipulating the URL as we did. Cf https://developers.google.com/custom-search/docs/xml_results for a reference of Google search parameters.

The act of coding is itself an analytical step. It allows researchers not only to index the qualitative material, but also to interpret and reduce the concepts conveyed by it. Codes namely summarize the essence of a passage of text *from a given perspective*, and multiple codes can be assigned to a significant quotation with several meanings or relevant on different levels of abstraction. A code can also be a multi-dimensional entity to reflect the many facets of a concept (cf. Table 2.3).

Codes themselves can be the object of analysis after they have been conceived and applied during the coding phase. On the one hand, the already mentioned code dimensions can be investigated to explore which properties characterize the concept represented by the code or which possible instances exist. On the other hand, relationships between codes can be investigated and conceptual structures, such as a code hierarchy, can be constructed building upon these relations.

Table 2.2 Details of the qualitative materials collected for the exploratory study

Source	URL used in the query	Articles	Words	Target audience
Barron's	blogs.barrons.com/techtraderdaily	53	29,393	Financial professionals
Bloomberg.com	www.bloomberg.com/news	35	23,931	Financial professionals
CIO.com	www.cio.com	14	12,023	IT professionals and decision makers
Fortune	tech.fortune.cnn.com	15	15,368	Financial professionals
InformationWeek	www.informationweek.com	10	8,005	IT professionals and decision makers
InfoWorld	www.infoworld.com	14	10,582	IT professionals and decision makers
PCMag	www.pcmag.com	50	33,109	Buyers of consumer electronic products
ZDNet	www.zdnet.com	45	30,469	IT professionals and decision makers

2.1.2. Explorative Findings

In the introduction, we have already attempted to define the phenomenon of sales cannibalization with as clear a working definition as possible. As a matter of fact, our explorative investigation reveals that the term is loosely employed by IT and financial professionals and represents a less rigorously defined set of sales diversions than in the academic world. We arrived at this conclusion by coding the articles and then exploring the dimensions and conceptual links within the resulting code list. A graphical representation of the elicited codes and their relationships is in Figure 2.3; code dimensions are recapitulated in Table 2.3.

Codes, their dimensions, and their relationships will be discussed henceforth, quoting significant text excerpts to provide evidence and illustrate the constructs. The articles deal with a wide array of alleged cannibalization occurrences or *cases*. Some cases bore a prominent role in the press and were reported by several articles over the whole data collection period. For instance, cannibalization of laptops by iPads and cannibalization of on-premise computing by cloud computing were regularly addressed by analysts and discussed by journalists. Each case encompasses one or more *companies* facing some form of sales *diversion* in a specific business *context*.

The most often encountered context is that of a new-product introduction – the archetypical cannibalization scenario where a new product diverts sales from other existing items. Commenting the market launch of the Nexus 10 tablet by Samsung, for example, a journalist remarks: "*It is a next-generation device when compared to the Tab 2 and Note and pretty much puts the slightly older tablets to shame […] Samsung risks* cannibalizing *sales of its existing 10-inch tablets.*"

Acquisitions are another common context of cannibalization, since the latter is a possible consequence of the overlap between the portfolios of the acquiring and acquired companies. Offerings which used to

belong to rivals will at once belong to the same organization but will keep competing with each other as long as they are concurrently sold in the market. With regard to the acquisition of the SaaS vendor Ariba by SAP, for instance, a market researcher observes that "*the combination of Ariba and SAP does create overlaps […] the overlaps will give network members options to use on-premise or cloud-based tools, but […] consolidation will be required.*"

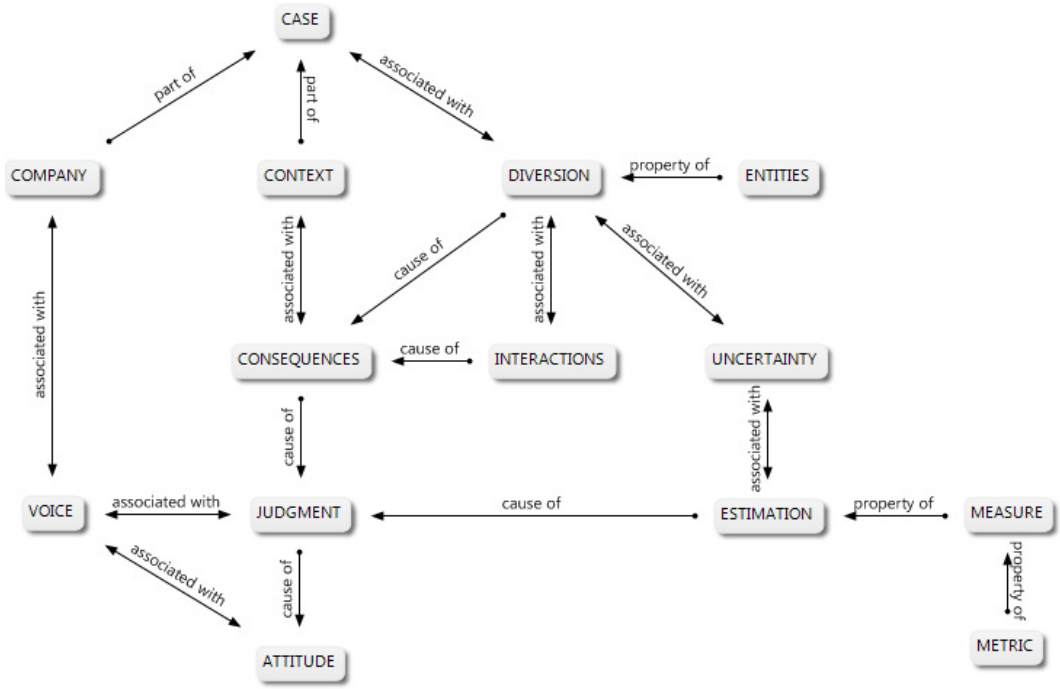


Figure 2.2 Graphical representation of the relations between the identified codes

A less common but nonetheless intriguing scenario is the strategic decision of licensing assets to third parties which could thereby directly compete with the licensor in some market segments. A case in point is given by the smartphone manufacturer RIM's possible decision to license its proprietary mobile operating system. While licensing would produce additional revenues in terms of royalties or license fees, licensees could release devices in direct competition with RIM's own ones and thus divert customers. An analyst estimates the repercussions of a license deal with Samsung: "*Our sensitivity analysis assumes 20%* cannibalization *and 25% of RIM's typical Services ARPU* [average revenue per user]. *At the high-end, $10/handset fee and Samsung selling 20M handsets would add $0.36 to RIM's ESP* [earnings per share] *($0.10 of which would come from selling fewer loss-making RIM handsets)*". As the last figure mentioned by the analyst suggests – $0.10 incremental EPS due to the cannibalization of loss-making sales –, sales cannibalization would actually improve RIM's financial performance

The focal point of each cannibalization case is the particular sales diversion observed or expected in that specific context. A wide range of sales diversions is qualified as cannibalization in the business press. In Table 2.4 we have reported the several instances mentioned in the articles, specifying the entities between which the diversion is supposedly occurring or expected to occur. As it can be seen, the unit of analysis, which determines at which level of the product hierarchy and within which organizational perimeter sales are aggregated, is not necessarily the same for both cannibal and victim. Aggregated substitution trends between product categories are also referred to as cannibalization (rows I-II in Table 2.4). An analyst namely affirms that "*tablets in general will* cannibalize *PCs*". The sales diversion taking place between offerings belonging to market rivals – what would be couched more rigorously as competitive draw – is often emphatically labeled as cannibalization (rows IV-V in Table 2.4). For example, another analyst affirms that "*a smaller iPad might* cannibalize *30% of Android sales*".

As the quotations employed throughout this section let imagine, the sales diversion is surrounded by *uncertainty*: its existence, direction, and magnitude cannot be easily assessed. The phenomenon is

sometimes only hypothesized given such qualitative factors as similarity among the products or customer segments served: "*Leaked photos and videos already demonstrate the physical similarities between the two Nokia devices, so Nokia may be keeping the N9 from these shores in fear of* cannibalizing *sales and confusing consumers*". Sometimes, instead, quantitative data let the presence or the absence of cannibalization be assumed: "*Consumer PC sales grew 24 percent sequentially, which emphasizes the fact that media tablets are not yet* cannibalizing *the PC market in India like in the West*".

In the most rigorous analysis we have found, cannibalization is not only guessed but also made object of *estimation*. A *measure* of cannibalization is calculated and explicitly stated in the article: "*we are lowering our Mac forecast by 1.6 million units over the next six Qs [quarters]. We think strong iPad demand is negatively affecting Mac sales, despite the recent MacBook refresh. For the next six Qs, we reduced our Mac sales by 40% of the increase in iPad sales*".

Table 2.3 Code dimensions

Code	Dimensions
Attitude	Willingness to cannibalize; denial; necessary evil; fear of cannibalization
Case	Tablet cannibalization; cloud cannibalization; media>video; media>music; media>press; smartphones; open-source; social-media; telecom
Company	Apple; Cisco; Facebook; Google; Intel, etc.
Consequence	• Direction: possibly profitable; possibly unprofitable • Scope: own performances; upstream in the value chain; downstream in the value chain; across markets
Context	New-product introduction; acquisition; strategic licensing decision
Diversion	• Type: inter-generational; inter-category; intra-category; inter-organizational; intra-organizational; intertemporal • Organizational perimeter: single organization; set of organizations; market; undefined
Entity	• Ownership: own; competitor; partner; complementor • Unit of analysis: product item; product line; product class; distribution channel • Id: cannibal; victim
Estimation	Ex-ante; ex-post
Interaction	Attraction effect; competitive draw; market expansion
Judgment	Positive; negative
Measure	• Type: absolute; relative • Unit: monetary sales; unit sales • Base: cannibal sales; victim sales
Uncertainty	Hypothesized without data; hypothesized from qualitative data; hypothesized from quantitative data; rigorously estimated
Voice	Analyst; journalist; company possibly gaining; company possibly losing

Table 2.4 Sales diversions qualified as cannibalization in the trade press

#	Cannibal entity		Victim entity	
	Unit of analysis	Example	Unit of analysis	Example
I	Product class	Tablet	Product class	Notebook
II	Product line	Apple iPad	Product class	Notebook
III	Product line	Apple iPad	Own product line	Apple MacBook
IV	Product variant	Apple iPad mini	Competitors' product lines	Android tablets
V	Product variant	Apple iPad mini	Competitor's product variant	Amazon fire
VI	Product variant	Apple iPad mini	Own product variant	Apple iPad 2

However, there is no univocal way of expressing the magnitude of cannibalization. Different analyses come up with measurements which not only differ in terms of their numerical results, but also with regard to the employed *metric*. By way of illustration, a relative figure may be employed where the base are the cannibal entity's sales in the last six months: "*14% of new iPad owners (six months or less) decided to purchase an iPad in place of a PC*". However, the victim's sales annual growth can be the

chosen base just as well: "*The devices will* cannibalize *purchases of consumer PCs, reducing computer sales growth by 2 percent annually between 2010 and 2015*".

The sales diversion is regarded as an important factor because it is reckoned that it will produce some form of financial or competitive *consequences* for the involved companies. Consequences will not only be produced by the cannibalistic sales diversion alone but by the *interactions* with other market phenomena as well. For example, the often simultaneously occurring market expansion must be considered. An executive from a mobile operator sees this interdependence in the case of "Voice over IP" services: "*VoIP traffic is only expected to grow. It might* cannibalize *some revenue, but we think it's a much greater opportunity*". An opposite "attraction" effect may also accompany cannibalization: "*Apple says the benefit of the halo effect, whereby the iPad brings previously non-Apple consumers to the Apple platform and product line, outweighs any* cannibalism". Moreover, given the plurality of sources of demand for a product (see Section 2.3.1 for details), sales diversions from competitors may take place in parallel as well: "*there's much more* cannibalization *of Windows PCs than of the Mac by the iPad*".

From a normative point of view, the cannibalistic sales diversion (in terms of either its merely hypothesized presence or a precise estimation) will be attached to a *judgment* – positive or negative depending on the overall expected competitive and financial consequences for the organization or group of organizations under assessment. The judgment will be expressed by a specific *voice*, i.e., a company representative, an analyst, a journalist, etc. Purely "informative" voices such as analysts and journalists are supposed to have a neutral perspective. On the contrary, companies have something at stake and their declarations will be carefully formulated accordingly. It is therefore useful to distinguish voices representing a company possibly gaining from the phenomenon from those representing a company possibly endamaged by it. These voices namely carry a subjective *attitude* towards the phenomenon.

The most commonly encountered attitude is that of denial: sales cannibalization does not occur, it is minimal or lower than expected, or does not play any detrimental role after all. Intel CEO, for instance, denied any PC cannibalization by tablets: "*[tablets are] an additive category of computing, just as netbooks were. Like netbooks, which had the higher potential to* cannibalize *PCs, tablets are used differently than PC*s". Or, as a Microsoft executive put it with regard to the alleged cannibalization threat of cloud computing: "*the growth Microsoft is seeing in Azure isn't at the expense of Windows Server. It's been a case of incremental growth, rather than* cannibalization – *net additive for them [Microsoft's customers] and us*".

Interestingly enough, companies whose success is undermined or menaced by cannibalization do not monopolize this attitude. Even companies with clear advantages to gain sometimes publicly deny or minimize the importance of the phenomenon. This is the case when, although beneficial for that particular company, cannibalization may prove detrimental for partners upstream or downstream along the supply chain. IT vendors launching innovations with a disruptive effect for complementors often publicly exhibit the same attitude. A case in point is an IT innovation with repercussions for the media industry, such as Google TV: "*Too many people in the content business see Google TV as a cable killer. But that's not how Google imagines it. We think that it's a new market that hasn't been open before*".

Obviously, companies possibly endamaged by cannibalization could very naturally show a negative attitude expressing their fear of cannibalization. As a complement to the previous quotation about Google TV, for instance, that is the case for traditional cable operators: "*[ABC, CBS, Fox, NBC, and Viacom] fear that making their shows available through the Chrome browser on Google TV will lead viewers to stop paying for cable service, from which the networks derive revenue*".

Another possible attitude towards the manifestation of the phenomenon is that of qualifying it as a necessary evil, viz., a sacrifice of current sales, profitability, and/or assets for future growth. For instance, with regard to the possible repercussions of the SAP acquisition of the SaaS vendor

SuccessFactors, SAP co-CEO Bill McDermott rhetorically puts it as follows: "*Will [SuccessFactors]* cannibalize *some of our on-premise revenue? Probably, but it's the right thing to do*".

2.2. Literature Reviewing Methodology

In performing our literature review we followed the framework for literature reviewing formalized in Brocke et al. (2009) and depicted in Figure 2.3. According to this framework, it is first necessary to define the review scope (I), and identify key concepts and provide working definitions (II). The relevant academic articles to be reviewed are subsequently selected (III). Finally, the collected literature is analyzed and synthesized (IV) to substantiate a research agenda (V). In this section, we will provide a detailed account of each step and its outcomes.

Defining the review scope (phase I in Figure 2.3) is especially important for our survey, given its multidisciplinary nature and the consequent need to limit the possibly very high number of included articles. As recommended by Brocke and his co-authors (2009), we define the scope of the review in terms of the taxonomy for literature reviews conceived by Cooper (1988), i.e., along the six dimensions listed in Table 2.5.

Firstly, the review scope shall be defined in terms of focus, i.e., what is most important to the reviewers. We focus on sales cannibalization measurement and detection methods and their applications, and, whenever they were applied to IT products and services, on the research outcomes as well. With regard to the review goals, we want to summarize and integrate methods proposed by the ISR, Marketing Science, and Management Science disciplines, critically assessing the applicability of those coming from outside ISR and not yet employed for IT products or services. Our review is concept-centric, that is, concepts determine its organizing framework (Webster & Watson 2002). We have a neutral perspective for we do not espouse a particular position with regard to the phenomenon. We wrote the review trying to make it understandable for all scholars. Finally, we have considered all the relevant sources from the existing literature on sales cannibalization measurement (exhaustive), but will present here only a sample thereof (selective).

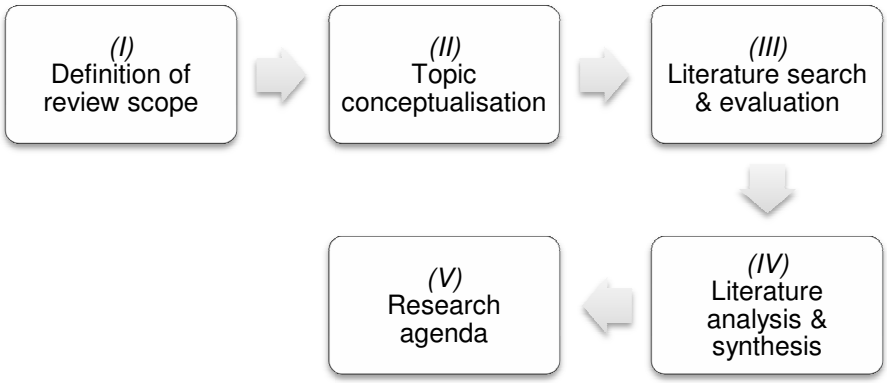


Figure 2.3 Framework for literature reviewing (Brocke et al. 2009)

The preliminary conceptualization of the topic (phase II in Figure 2.3) was developed by examining some standard references in the marketing field and querying Google Scholar to get a rough idea of the range of available sources and disciplines involved. We employed the query "*allintitle: cannibalization OR cannibalism OR cannibal OR cannibalizes OR cannibalized OR cannibalizing AND product OR market*", i.e. we conducted a lexical search of publication titles to select those dealing with the cannibalization phenomenon in a business context. The results clearly advised us to take into account, besides ISR, the Marketing Science and Management Science disciplines. This phase provided the foundation for Section 2.3.1.

The search and evaluation step (phase III in Figure 2.3) consists in selecting the relevant sources and evaluating them. We structured this phase according to the recommendations in Brocke et al. (2009).

We first selected top-ranked journals and conferences in the ISR, Marketing Science, Management Science, and Business Administration disciplines – i.e., only those rated as either "A" or "A+" in the VHB rankings[16] (Hennig-Thurau & Sattler 2011). The thus selected sources are listed in Table 2.6. Then, we identified the scholarly databases necessary to access articles published in those journals and conferences. EBSCO[17] and the AIS eLibrary[18] were sufficient in our case.

Table 2.5 Our review scope according to the review taxonomy in Cooper (1988)

Characteristic	Categories	Characteristic	Categories
Focus	☑ Research methods ☑ Research outcomes ☐ Theories ☑ Applications	Goal	☑ Integration ☑ Criticism ☐ Central issues
Organization	☐ Historical ☑ Conceptual ☐ Methodological	Perspective	☑ Neutral representation ☐ Espousal of position
Audience	☑ Specialized scholars ☑ General scholars ☑ Practitioners/ politicians ☐ General public	Coverage	☐ Exhaustive ☑ Exhaustive and selective ☐ Representative ☐ Central/pivotal

The string we employed in all database searches was simply "*cannib**" to subsume all possible nouns and verb forms related to the topic (*videlicet*, cannibalism, cannibalization, cannibal, cannibalize and its conjugated variations). This lexical search considered the papers' title and abstract only. The abstract and introduction of each identified article were read to omit spurious sources (i.e., according to our review scope, to exclude papers not actually dealing with cannibalization or dealing with other aspects of the phenomenon than its detection and measurement). Subsequently, we searched both the bibliography of each selected article to spot further relevant references (backward search) and sources citing the selected articles (forward search).

Finally, the last two phases in the framework, analysis/synthesis of the collected literature and formulation of a research agenda (phases IV and V in Figure 2.3) – whose outcomes are detailed in Sections 2.3 and 2.4 below – were conducted. We relied on the same computer-aided qualitative analysis software application employed in the explorative study (cf. Section 2.1.1) to classify and annotate the sources, and compiled concept matrices in a spreadsheet.

Table 2.6 Selected publication sources for the database query

Journal	Rating	Field of study	Database
Journal of Marketing	A+	Marketing Science	EBSCOhost (Business Source Corporate Plus)
Journal of Consumer Research	A+	Marketing Science	EBSCOhost (Business Source Corporate Plus)
Information Systems Research	A+	Information Systems Research	EBSCOhost (Business Source Corporate Plus)
Journal of Marketing Research	A+	Marketing Science	EBSCOhost (Business Source Corporate Plus)
Marketing Science	A+	Marketing Science	EBSCOhost (Business Source Corporate Plus)
Management Science	A+	Operations Research	EBSCOhost (Business Source Corporate Plus)
Operations Research	A+	Operations Research	EBSCOhost (Business Source

[16] The ranking considered relevant within the author's academic institution.

[17] http://www.ebscohost.com/

[18] http://aisel.aisnet.org/

			Corporate Plus)
Academy of Management Journal	A+	Business Administration	EBSCOhost (Business Source Corporate Plus)
Academy of Management Review	A+	Business Administration	EBSCOhost (Business Source Corporate Plus)
Mathematical Programming	A	Operations Research	EBSCOhost (Computers & Applied Sciences Complete)
MIS Quarterly	A	Information Systems Research	EBSCOhost (Business Source Corporate Plus)
Journal of the Academy of Marketing Science	A	Marketing Science	EBSCOhost (Business Source Corporate Plus)
Proceedings of the International Conference on Information Systems (ICIS)	A	Information Systems Research	AIS Electronic Library
SIAM Journal on Computing (Society for Industrial and Applied Mathematics)	A	Operations Research	EBSCOhost (Computers & Applied Sciences Complete)
Strategic Management Journal	A	Business Administration	EBSCOhost (Business Source Corporate Plus)
Journal of Management Information Systems	A	Information Systems Research	EBSCOhost (Business Source Corporate Plus)
Discrete Applied Mathematics	A	Operations Research	EBSCOhost (Computers & Applied Sciences Complete)
International Journal of Research in Marketing	A	Marketing Science	EBSCOhost (Business Source Corporate Plus)
Journal of Economics and Management Strategy	A	Business Administration	EBSCOhost (Business Source Corporate Plus)
IIE Transactions	A	Operations Research	EBSCOhost (Business Source Corporate Plus)
Journal of Product Innovation Management	A	Business Administration	EBSCOhost (Business Source Corporate Plus)
Journal of Retailing	A	Marketing Science	EBSCOhost (Business Source Corporate Plus)
OR Spectrum (formerly: OR Spektrum)	A	Operations Research	EBSCOhost (Business Source Corporate Plus)
European Journal of Operational Research EJOR	A	Operations Research	EBSCOhost (Business Source Corporate Plus)

2.3. Sales Cannibalization in General

2.3.1. Nominal Definition of Sales Cannibalization

In this section, we critically review the definitions of sales cannibalization proposed in the marketing literature and elicit the constituent parts of the construct. Subsequently, we rigorously identify the buying patterns involved and provide a novel nominal definition. Finally, we put cannibalization in perspective with substitution.

Nominal Definitions from the Literature

An accurate, comprehensive definition of sales cannibalization is a strict requirement for an accurate and comprehensive literature review. Moreover, the absence of a generally accepted definition is a shortcoming acknowledged by marketing researchers themselves (Lomax et al. 1997, p.27). Therefore, we provide a systematic comparison of nominal definitions from the literature. Table 2.7 lists the most frequently cited cannibalization definitions from the marketing literature.

When comparing these definitions with each other, three common constituent parts (illustrated in Figure 2.4) become evident. First of all, the economic entities whose generated sales either benefit or suffer from the occurring of cannibalization. From now on, we will call these entities respectively “cannibal(s)” and “victim(s)” (the elements marked with ‘1’ in Figure 2.4). Secondly, the common organizational realm their revenues accrue to (the element marked with ‘2’ in Figure 2.4). Thirdly, the

specific interdependence between their respective sales-generating processes (the element marked with '3' in Figure 2.4). However, another thing appears evident by systematically comparing the definitions with each other along these dimensions (Table 2.8): not every scholar agrees on the specific instances of each component.

Table 2.7 Most frequently cited definitions of sales cannibalization

Source	Definition	Total citations	Cit. related to cannibalization
Heskett (1976)	"*The process by which a new product gains a portion of its sales by diverting them from an existing product.*"	875	24
Kerin et al. (1978)	"*'Redistributed' revenue, in that existing buyers are substituting one item for another in the company's product portfolio.*"	71	71
Moorthy (1984)	"*Competition within a firm's own product line.*"	428	203
Lilien et al. (1992)	"*The effect of the new brand on the market shares of own brands.*"	1068	56
Mason & Milne (1994)	"*The extent to which one product's customers are at the expense of other products offered by the same firm.*"	104	104

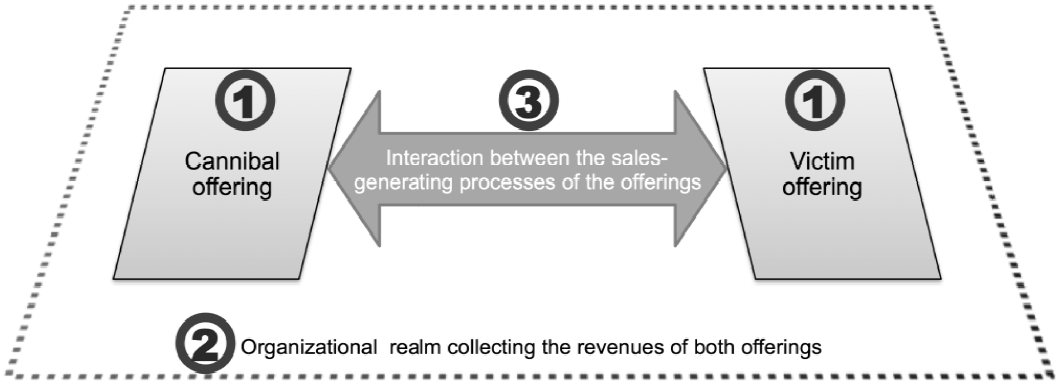


Figure 2.4 Components of a nominal definition of sales cannibalization

One first caveat affects the first component in the definition – the cannibal and victim entities. Researchers do not agree on the a priori identification of a distinguishing trait between them. Heskett (1976) associates cannibal and victim with a *new* and an *old* product respectively, and there is indeed a rich body of research along these lines (Reddy et al. 1994; Lomax et al. 1997; van Heerde et al. 2004; van Heerde et al. 2010). Other scholars either distinguish cannibal and victim along a different dimension (e.g., *new* and *used*; Guide & Li 2010; Smith & Telang 2008) or detect the phenomenon's patterns and direction endogenously within their analysis, that is, without any a priori identification of cannibal and victim (Mason & Milne 1994; Carpenter & Hanssens 1994).

With regard to the organizational realm, scholars mostly agree. All the authors mentioned in Table 2.7 but Heskett[19] defined cannibalization explicitly as an *intra-firm* phenomenon. The firm of reference can be the manufacturer/provider of the offerings or any intermediary between the manufacturer/provider and the end-customer (e.g., a retailer, as in Biyalogorsky & Naik, 2003). However, there exist empirical studies which considered cannibalization from a larger perspective and in which no specific firm defines the boundaries of the phenomenon. For instance, the research stream on the cannibalistic effects on state revenues of licensing rival gambling businesses in the same administrative area (Walker & Jackson 2008; Elliott & Navin 2002).

[19] Although Heskett did not constrain cannibalization this way in his definition, he only mentioned examples where that is the case (1976, pp. 115-118 and 150-152), so it might have been merely an oversight not to state it explicitly.

Finally, examining the way the relationship between sales of the two entities is defined, we encounter very generic descriptions such as "competition" or "redistribution", which would not offer much guidance in the formulation and selection of a proper operational definition for the concept. Moreover, scholars seem to disagree on the relevant metric, although the majority focuses on unit sales (market shares being the alternative). None seems to be interested on the cannibal's effect on the victim's sales *value*.

Table 2.8 Comparison of the sales cannibalization definitions from the literature

Definition	Victim / cannibal entities	Common organizational realm	Relationship between sales-generating processes	Metric
Heskett (1976)	Existing / new products	No a priori specification	Sales diversion from the victim to the cannibal	Unit sales
Kerin et al. (1978)	No a priori specification	Seller's product portfolio	Substitution of the victim for the cannibal	Unit sales
Moorthy (1984)	No a priori specification	Seller's product line	Competition among victim and cannibal	No a priori specification
Lilien et al. (1992)	Existing / new brands	Seller	Interdependence of market shares movements	Market shares
Mason & Milne (1994)	No a priori specification	Seller	Customers won by cannibal at the expense of the victim	Unit sales

A Novel Nominal Definition

In order to formulate a *novel* nominal definition of sales cannibalization, we formally address each of the three components identified in the previous section (cannibal and victim entities, the organizational realm, the interaction between the sales processes). We wish to bring some structure and coherence in the set of concepts involved in defining the cannibalization phenomenon, but without losing in generalizability.

First, let us define the cannibal and victim entities as distinct *offerings* present in the market simultaneously. We univocally identify an offering in the market by specifying its attributes for all the marketing mix components, which are, relying on the so-called "Four Ps" marketing mix framework (Kotler 2003, pp.15–17): product, price, promotion (i.e., advertising and customer sales management), and place (i.e., distribution). In the context of the rather dematerialized IT industry, we can merge the third and fourth "Ps" to obtain a simplified scheme, which will be sufficient to identify univocally all the offerings we consider throughout this work. We thus define an offering as a product, service, or any bundle of products and services, offered at a certain price (which may also be zero), through a certain sales channel. A specific offering is then described by the following tuple:

- The set of artifacts and/or activities offered (product, service, or bundle thereof)
- The price attached to it
- The sales and distribution channel employed to reach its end-customers.

Specifying all three attributes is a *sufficient though not necessary* condition to identify a cannibalization scenario univocally. As we will discuss below with regard to operationalization, we may investigate cannibalization at an aggregated level of analysis and therefore aggregate across one or more dimensions. The first attribute alone may suffice if we consider one specific product item as cannibal against another specific product item as victim, independently of prices and distribution channels (i.e., we aggregate across all prices in the market and over all employed channels and leave just the product entity disaggregated). The channel attribute alone may also suffice, when studying how online sales cannibalize offline sales (i.e., we aggregate channel sales across all sold products and their prices). Please also note that one attribute suffices to distinguish between cannibal and victim. For instance, the

victim could be a specific product item sold at a specific price through a brick-and-mortar retailer, and the cannibal the same product item sold at the same price via e-commerce.

The second cardinal element in the definition of cannibalization is the organizational realm within which the phenomenon can be properly called *cannibalization* as opposed to *competitive draw*. The organizational boundaries for the phenomenon of cannibalization are identified by the unitary perimeter of the one organization (or set of organizations) benefiting from the cumulative sales of both cannibal and victim. In the case of competitive draw, instead, there are as many organizational realms as there are competitors. The sales of a competitor's item only benefits that competitor and a sale is "drawn" when it is diverted from one organizational realm to another.

The third is the most critical definition element: the relationship between the sales-generating processes of the cannibal and victim entities, i.e., what to "gain", "divert", "redistribute", or "substitute" sales ought to mean precisely. Cannibalistic patterns are detected by comparing ex-post (ex-ante) the actual purchase decision with the hypothetical one taken in absence (presence) of the cannibal item (cf. Section 1.2.3). In other words, those buyers, among the cannibal's customers, who would have bought the victim, had the cannibal not been present, are qualified as cannibalized. Equivalently, in the ex-ante scenario, those buyers, among the victim's customers, who would have bought the cannibal, had it been present, are qualified as potentially cannibalized.

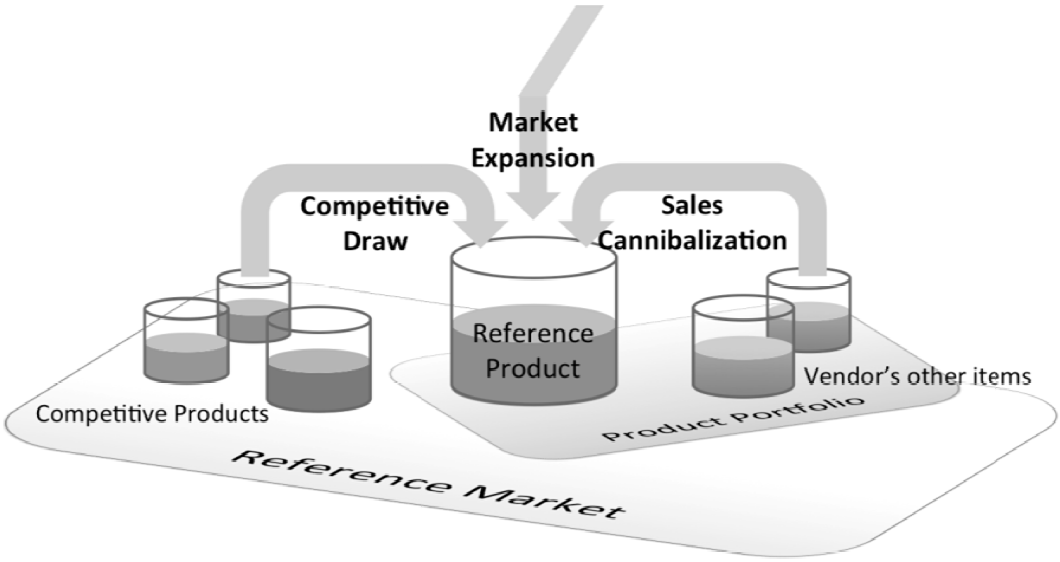


Figure 2.5 Sources of demand for a reference product

To clarify this further, let us consider the possible "sources" of demand for a generic product or service, which we will call the "reference product" and is sold in its "reference market".[20] Reference-product buyers making up its demand can be former customers of an item in a competitor's portfolio, former customers of other products from the same manufacturer of the reference product, or customers who had not yet purchased in the reference market.

Figure 2.5 illustrates the sources of demand for the reference product in the metaphorical form of flows between jars. The jars are the products in the market and the content of a jar represents the level of demand for the item. Demand for the reference product is determined by the incoming flows of buyers from competitors' items (those coming from the left side in the illustration), from items in the same portfolio (those coming from the right side in the illustration), and from outside the considered market

[20] Our discussion of the sources of demand for a product was inspired by an old article from the marketing literature, in which three "components of new product sales revenue" are identified: new consumers who were not previously buyers of the product type, consumers of competitive brands, and consumers of an existing company brand switching to the new product (Kerin et al. 1978).

(from the top in the illustration). These flows can be respectively labeled sales cannibalization, competitive draw, and market expansion.

More formally, buyers of the reference product can be classified according to the following behavioral profiles:

- Buyers who would have not bought any other product in the reference market if they had not bought the reference product
- Buyers who would have bought a competitor's product if they had not bought the reference product
- Buyers who would have bought something else from the same product portfolio if they had not bought the reference product.

The first group of customers comprises those who, in absence of the reference product, would not have been interested in any other offering in the considered reference market. In other words, depending on their past purchase behavior, they could be said to have either left the market or merely stayed out of it, possibly purchasing in another product category or not purchasing at all. The second group includes reference-product customers who would have bought a product or service from a competing vendor, had the reference product not been present in the market. Finally, customers in the third group would have still purchased from the vendor even in absence of the reference product. They would just have picked some other item from the vendor's own portfolio. These classes of potential reference-product customers correspond to the three demand sources we shall call respectively market expansion or retention[21], competitive draw, and sales cannibalization. Table 2.9 recapitulates the distinctive characteristics of each source, together with a clarifying example where the tablet market is the reference market and the Apple iPad the reference product.

Table 2.9 Sources of demand for the reference product

Source	Customer's behavioral profile in absence of the reference product	Customer's hypothetical purchase decision in absence of the reference product	Example[a]
Market expansion	Customer would have stayed out of the market	Purchase in another product category or no purchase	iPad buyer who would not have bought any other mobile computer and did not previously own one
Market retention	Customer would have left the market		iPad buyer who would not have bought any other mobile computer but instead a desktop
Competitive draw	Customer would have bought from a competitor	A competitor's product or service	iPad buyer who would have bought a tablet, notebook, or netbook from a competitor (e.g., HP, Lenovo, etc.)
Sales cannibalization	Customer would have bought another item in the vendor's portfolio	A substitute of the reference product within the vendor's portfolio	iPad buyer who would have bought an Apple notebook

Note: a) Vendor: Apple; reference product: iPad; market perimeter: mobile computing platforms

In conclusion, we propose to define cannibalization as follows:

[21] Market *expansion* and market *retention* are indistinguishable based on the way we have formally defined the sources of demand for the reference product. In both cases we deal with customers who, at purchase time, would have not purchased at all or would have purchased outside of the considered market (e.g., in another product category), had the reference product not been present in their choice set. Knowledge of their past behaviors would be necessary to discriminate between the two options. Reference-product buyers who had previously purchased in the considered market are "retained". Reference-product buyers who had not previously purchased in the considered market should be counted as market expansion.

the intra-organizational phenomenon of sales diversion by means of which sales of a product or service (the cannibal) are generated by diverting potential sales that a substitute product or service (the victim) would have obtained in absence of the former, ceteris paribus, within a common organizational realm collecting the revenues of both.

Monetization and Volume Effects

Up to now, we have investigated the cannibalization phenomenon in the context of a purchase decision described as a univocal choice between mutually exclusive alternatives, all other aspects kept equal. Customers are assumed to decide between the clear-cut options of not buying, buying the victim, the cannibal, or a competitor's offering, and the firm is assumed to be only interested in the outcome of *that* purchase decision. We have considered cannibalization only in terms of sales volume.

In real scenarios, customers may face a more complex and dynamic set of decisions to take, each with its own economic repercussions for the vendor. Consider, for example, the case, often encountered in IT, of products which do not only generate revenues for the vendor at the time of the initial purchase but also subsequently, by means of additional complementary services, tie-ins, usage fees, etc. The firm monetizes a product sale through all those potential revenue streams and is thus not only interested in the initial purchase decision but in the subsequent behavior of the customer as well.

Moreover, the vendor has levers to influence the effect of a potentially cannibalizing offering. Let us consider the limit case in which a firm introduces a cannibal product and simultaneously reduces the prices of the victim. The firm might be able to manage prices so that no victim's potential customer is ever incentivized to buy the cannibal. The cannibal product appeal to the victim's customers but, by lowering the victim's price appropriately, the firm makes it never so appealing as to alter the customers' purchase behavior. Employing the criteria from the previous section, no customer would be qualified as cannibalized in this situation. Yet, the monetary revenues obtained from the victim product would be definitely lower than in a scenario without the cannibal. The introduction of the cannibal has not diverted the victim sales but has affected their monetization by reducing the customer's willingness to pay for them.

As a more generic perspective on the cannibalization phenomenon, we may therefore see customers as economic agents who do not merely decide whether to buy one product or the other, but rather how much income they are willing to allocate on each, if any. The presence of the cannibal may reduce the willingness to allocate income on the victim. In an extreme case it may disincentivize buying the victim altogether (i.e., the customer is not willing to allocate the necessary fraction of income on the victim). The firm's marketing function may react to this pressure and reduce price levels for the victim and/or its peripheral products and services. In sum, the cannibal hampers the victim's sales monetization process.

In IT markets, moreover, monetization is itself a complex process affected by many factors. A single IT offering may generate several revenue streams at once. Enterprise software applications, for instance, generate revenues both upfront at the time of their acquisition and implementation, and over time through maintenance and support fees. Many of today's consumer electronic devices are also sources of revenues both at the time of purchase and over their lifetime (e.g., purchases of "apps" and digital content for smartphones and tablets). Each of these revenue streams may react differently to the presence of the cannibal offering.

In addition to that, the price employed in each transaction may be determined ad-hoc. It is a common practice in the enterprise software market, for instance, to have teams of professional salespersons negotiating terms and conditions (such as discounts) on each customer deal separately. The presence of

the cannibal could influence the behavior of the agents participating in the price determination process. For instance, it could pressure salespersons to offer more generous discounts for the victim offering.

In conclusion, the cannibalization phenomenon may manifest itself in two non-mutually-exclusive ways. On the one hand, less units of the victim might be sold by the vendor due to the cannibal's power of dissuading potential customers from acquiring the victim. On the other hand, lower revenues per victim unit sold might be obtained by the vendor due to the cannibal's power of reducing the customers' willingness to pay for the victim and/or its complements. We call the former the *volume effect* of cannibalization and the latter the *monetization effect* of cannibalization.

Substitutability and Sales Cannibalization

The question could be posed whether cannibalization merely represents an emphatic synonym for substitution. Therefore, we will briefly dwell on the relationship between the two concepts. Just like cannibalization, substitution is a multidisciplinary topic. It has drawn attention from several fields of research: competitive strategy, microeconomics, marketing, and diffusion of innovation.

In his investigation of the competitive forces determining the structure of an industry, Porter defines substitution and substitutes from a functional point of view. Substitutes are "*products that can perform the same function as the product of the industry*" (1980, p.23) and substitution is "*the process by which one product or service supplants another in performing a particular function or functions for a buyer*" (1985, p.273). The industry itself is defined by an arbitrarily chosen level of substitutability (1980, p.32), by means of which the two competitive forces of "*direct rivalry*" and "*threat of substitution*" – respectively due to existing competitors within the industry and latent ones outside of the industry boundaries – can be distinguished. Drivers of substitution are the relative value/price of the substitute, switching costs, buyer perception of value, and buyer propensity to switch (1985, pp.291–296).

According to modern microeconomic consumer theory, the (Hicksian) *substitution effect* is one of the two forces determining changes in demand behavior after a relative price shift. This effect is always nonpositive, that is, a price decline produces a positive substitution effect and we expect the consumer to substitute the relatively cheaper goods for the relatively more expensive ones. However, since a price change alters the consumer's overall purchasing power as well, allowing him to change the quantity demanded for all goods (income effect), the total effect of a price change will depend on the goods' response to income increases (Jehle & Reny 2001, pp.48–54).

In microeconomic terms, two goods are then called substitutes if a price change of one of them has an effect of equal sign on the demand for the other (Mas-Colell et al. 1995, p.70). If this is the case, the cross-price elasticity (or cross-elasticity) of demand for the latter with respect to the price of the former must be positive (Bain 1952, p.52). Given that cannibal and victim must be substitutes, cross-price elasticities are also at the centre of some empirical approaches for the measurement of cannibalization (see Section 2.3.4). The antitrust literature provides a *trait d'union* between this microeconomic perspective and the previous one from the literature on competitive strategy, since some antitrust cases also employ substitutability to define a perimeter within the economic space. Concretely, the cross-elasticity of demand is used as an indicator of product substitutability to identify the boundaries of the relevant market for the antitrust case (Werden 1992).

Substitutability, investigated in the context of consumer choice theory in marketing, represents a "*negative similarity effect*" (Huber & Puto 1983), whereby a new item will take relatively more share away from items similar to it than to dissimilar ones, that is, disproportionately compared to predictions based on the principle of Independence of Irrelevant Alternatives (IIA, or Luce's Axiom; Luce, 1959). Experimental and analytical approaches have been developed to derive brands' differential substitutability from physical or perceived attributes and to predict market share movements accordingly. Some cannibalization measurement approaches are indeed rooted in marketing choice

theory, either benchmarking actual market shares changes against IIA predictions (Lomax et al. 1997) or incorporating choice models (Gentzkow 2006).

Substitution between different generations of a technology is a phenomenon of interest in diffusion research (see Peres et al. 2010 for an overview). When a technology's market penetration encompasses multiple generations, there may namely be dependencies among their diffusion processes. In this context, *technological* substitution is defined as the mechanism by which adopters and potential adopters of preceding generations of a base technology opt for a successive generation (Norton & Bass 1987). Technological substitution may be a driver of intergenerational cannibalization whenever one firm simultaneously offers products relying on distinct technology generations. In such a scenario, multigenerational diffusion models have been employed to measure cannibalization (Mahajan & Muller 1996; Shen & Altinkemer 2008).

The occurrence of sales cannibalization implies indeed a positive degree of substitutability in terms of either functional equivalence, similarity, or technological kinship between cannibal and victim, otherwise the customer would just not consider the two as hypothetical alternatives. At the same time, substitution is a concept employed without concern for the organizational perimeter within which or through which it manifests itself. Instead, we have defined cannibalization an *intra-organizational* phenomenon and we can look at it as the realization of an intra-organizational process of substitution. From a methodological point of view, research on cannibalization measurement has been greatly enhanced by the several research streams on substitution which we have briefly recalled here.

2.3.2. Operational Definition of Sales Cannibalization

Given our research focus on detection and measurement, the key issue is how the concept of cannibalization should be operationalized, i.e., how it should be connected to observations, and which indicators should embody this connection. One fundamental aspect in operationalizing a phenomenon is the choice of the variable to be measured. Since we defined cannibalization as a particular phenomenon of sales diversion, a cannibalization estimate must be expressed in terms of sales.[22] Subsequently, we envisage several ways to operationalize the cannibalization definition, based on the analysis of either disaggregated customer responses or an aggregated sales response function.

Attributes of Sales Measurements

Several possible ways of measuring sales exist. They can be classified depending on the directness of the measurement (direct measurement of realized sales or indirect measurement of potential sales), the form of transaction recorded to allow the sales measurement to be taken (sell-in or sell-through), and the unit of measurement (money or volume). Moreover, individual sales measurements can be aggregated along several dimensions.

In terms of the directness of the measurement, sales measures can represent potential or observed sales. Potential sales are derived from some other intermediate measurements, for example, from customers' preferences. Observed (historical or realized) sales are direct measurements of purchase behavior. In our quantitative analysis, we will rely on secondary data collection from financial statements, thus employing direct sales measures (i.e., shipments and net sales figures from income statements). In our qualitative analysis, instead, we will develop a model of the customer's adoption decision given his profile and the context of the transaction, thus employing an attitude-based indirect sales measurement.

[22] The choice of sales over profit as the cannibalization measure merits some further explanation. The overall generated profit may indeed be the ultimate criterion to decide on the opportunity to launch a potentially cannibalizing offering into the market but our focus here is descriptive rather than normative. From this perspective, the use of profit would lead to an irremediable loss of information, since it confounds monetary and volume effects of cannibalization. On the contrary, assuming the cost function to be known, we could derive the effects on profit from volume and revenue figures.

Direct sales measurements can be taken at different stages along the channel. A sale from the manufacturer to a retailer or distributor is called "sell-in" or shipment. A sale from the retailer/distributor which has reached the end-customer is called "sell-through". Sell-in figures are less conservative estimates of the manufacturer's sales than sell-through, since they also encompass units which have not yet been purchased by end-customer (and may never be), those which make up the inventory volume within the distribution system. Sell-in figures are what manufacturers usually publish in their financial statements and they may introduce some degree of measurement error in a cannibalization study, since we assess customer behavior from sales measures actually taken upstream.

From the point of view of the unit of measurement, sales can be expressed in terms of monetary value (called monetary sales, revenues, or turnover) or in terms of volume (unit sales or sales volume). Total (monetary) revenues for a product or product category are actually a composite variable since they equal average revenues times total volume. This figure will confound volume and monetization effects. Therefore, we employ revenues expressed as an average per unit sold (average revenue per unit sold, or ARPU) whenever possible, in order to distinguish the monetization effect from the volume effect which we may elicit from unit sales data.

One further aspect to consider is the aggregation space, since it is possible to aggregate individual sales measurements along several dimensions to obtain aggregated measures. The aggregation space is the result of choosing the aggregation level along each of the following dimensions: entity (buyer or product), time, and space. At the entity level, we decide to which extent we aggregate on the demand side and on the supply side of the recorded transactions. If we aggregate sales at the entity level *across buyers*, we consider total sales for a product within a give customer group and not individual buyers' sales. We may for example consider aggregate sales of customers located in a specific geographical area or belonging to a specific market segment. If we aggregate *across products*, we obtain total sales for a product line, product category, or any other level in the product hierarchy. We may for example consider aggregate sales of all the items in the portfolio of a PC manufacturer belonging to the "tablet" product category or, higher in the product hierarchy, sales of all its portable devices (thus including also notebooks, netbooks, etc.). On the supply side, it is obviously possible to aggregate even further *across sellers* to obtain, for instance, total industry sales.

In our quantitative analysis, given the constraints of the secondary data sources (the publicly available periodical financial statements), we will consider, unless otherwise stated, worldwide quarterly shipments and monetary sales, aggregated at the product line or platform level. Our quantitative data are thus aggregated across all buyers, all places, at a quarterly time interval, and represent the cumulative sales of all products within a product line (for instance, all iPods) or all products based on a specific technological platform (for instance, all portable navigation devices by Garmin). With regard to our qualitative analysis, the data we have gathered are (qualitative) measures of potential unit sales disaggregated at the unit level in terms of buyers, and aggregated at the product line level and at the channel level. The temporal dimension is not relevant for the qualitative analysis, since we have employed a cross-sectional research design.

Table 2.10 Distinctive attributes of a sales measurement

Attribute of the sales measurement	Options
Directness of the measurement	• Direct measurement of realized sales • Indirect measurement of potential sales
Form of transaction	• Sell-in (sale to retailer/distributor) • Sell-through (sale to end-customer)
Unit of measurement	• Monetary sales • Unit sales
Aggregation space	• Entity (buyer / product) • Time • Space

Envisaged Operationalizations

We envisage and present in this section several possible ways to operationalize the nominal definition of cannibalization. The empirical analysis in the case studies in Chapters 3-6 and the Computational Lab presented in Chapter 7 are particular instances/implementations of these operational definitions. Table 2.11 and Table 2.12 summarize the operational definitions and their characteristics.

The simplest operationalization conceivable is to survey the customers directly on their attitudes towards the victim and the cannibal (cf. column *a* in Table 2.12). This operational definition consists in conducting a *thought experiment* with a customer. The researcher poses what-if questions to gauge how the cannibal may alter the customer's response. The thought experiment aims at eliciting the customer's purchase intention in the presence and in the absence of the cannibal. This operationalization was implemented in the course of Case III (Chapter 5) with a qualitative research strategy and a cross-sectional research design. A sample of customers were guided through a semi-structured interview designed to function as a thought experiment. We introduced and discussed alternative scenarios, and asked the participants to state explicitly what their hypothetical purchase decision would have been in each of them.

Instead of merely recording a stated purchase intention, which is the outcome of the customer's own decision-making, the underlying decision-making can itself be made the object of analysis, investigated, and modeled. Modeling the customer's decision-making allows the researcher to subsequently derive a customer's purchase intention or preferences and verify under different circumstances to what extent cannibalization may be occurring. This type of operational definition thus entails two steps: (1) modeling a customer's decision-making, and (2) analyzing and employing the model to detect and measure cannibalization.

Building an *adoption model* for the cannibal and the victim is one possible operationalization of this sort (cf. column *b* in Table 2.12). An adoption model includes the factors which determine the chances of adoption of each entity. A factor's influence on adoption can be positive (a driver of adoption, e.g., quality) or negative (a barrier of adoption, e.g., price). Building the model is by itself a helpful exploratory task to detect possible cannibalistic relationships among the entities. For example, if the adoption decisions for the cannibal and for the victim appear influenced by some common factors, the entities are related and cannibalization cannot be excluded.

Table 2.11 Description of the operational definitions of cannibalization implemented in this research project

Operational definition	Detection	Measurement
Thought experiment	A cannibalistic purchase intention is stated by a customer	Total number of customers with a cannibalistic purchase intention
Adoption model	A cannibalistic adoption decision is predicted by the model for a buying situations	Total number of buying situations with that cannibalistic outcome
Preference formation model	The victim is second to the cannibal in a customer's preference ranking	Total number of customers with that cannibalistic preference structure
Exogenous-break test	A given cannibal-related event causes a structural change in the victim's SGP	Difference between observed sales levels and those predicted by removing the effects of the identified structural change
Endogenous-break test	A structural change can be detected in the victim's sales-generating process and ascribed to a cannibal-related event	Difference between observed sales levels and those predicted by removing the effects of the identified structural change

Most importantly, once an appropriate model is built, the researcher can feed it with a given buying situation or scenario to assess the outcome of a customer's adoption decision in that specific context. Buying situations with and without the cannibal can then be compared. If adding the cannibal changes

the outcome of a buying situation where otherwise the adoption of the victim would be expected, this provides evidence of a cannibalistic relationship between the entities. The adoption model could be derived from an empirical analysis of a sample of customers or from existing theories.

We implemented this operationalization in Case III (Chapter 5) and in the simulation-based Computational Lab (Chapter 7). In Case III, we built an adoption model for the cannibal on the basis of a qualitative content analysis of semi-structured interviews with current adopters of the victim, and then employed it to establish in which circumstances a sale would be cannibalized. In the Computational Lab, we show how to design an adoption model based on microeconomic consumer theory and then employ it in numerical experiments. In these numerical experiments, two alternative states of nature are simulated. In one, the cannibal is in the market with the victim and possibly diverts some of its sales. In the alternative scenario, the cannibal is not present in the market, all other things held equal. Customer responses are simulated and recorded in both scenarios. The victim's total cannibalized sales are the difference between the sales levels in the scenario without cannibal and in that with it. A positive difference would represent cannibalization, i.e., the victim would lose sales due to the cannibal's appearance and/or presence in the market.

A further operationalization approach can be envisaged by simplifying the one just presented. It still relies on a customer response model but without experimenting with different buying situations or scenarios. This operational definition consists in modeling the customer's *preference formation* process (cf. column *c* in Table 2.12). This model is similar to the adoption model employed in the previous operationalization but, instead of providing the adoption or purchase decision, it provides the customer's preferences over all offerings in the reference market. To detect cannibalization, we build such a model of preference formation and inspect its outcomes for buyers of the cannibal. A customer won by the cannibal is qualified as "cannibalized" whenever the second best option in its ordered preferences is the victim. Therefore, this operationalization entails obtaining the preference rank orders over all offerings in the market for a sample of customers of the cannibal and counting those whose product ranking has the cannibal as the top item and the victim as the second best choice.

This approach, like the previous one, could be addressed either by taking direct measures of preference empirically (e.g., in a conjoint analysis study) or with numerical experiments. In this research project, we show how to implement the latter option by taking advantage of a specific simulation methodology – Agent Based Simulation and Modeling. This methodology allows the researcher to model the buying agent's decision-making and record the derived preference rankings. We implemented this operational definition in the Computational Lab (Chapter 7).

This second way of employing a model of customer response can be seen as a simplified and computationally less intensive version of the first one. It operationalizes sales cannibalization in a single scenario with the cannibal present instead of comparing two scenarios with each other. We should ask ourselves if this simplification might come at the cost of precision or validity and compare the two operational definitions to establish under what circumstances they may differ. As a matter of fact, they produce the same cannibalization estimates under the condition that the cannibal does not alter consumers' preferences over the other products in the market, videlicet, if the relative positions of the products in the customer's preference ranking remain the same when we add or remove the cannibal. Instead, if the cannibal does alter consumers' preferences in a way which affects the relative rankings as well, different cannibalization levels will be obtained with the two approaches, and the second one will not provide accurate estimates.

The last two operational approaches we envisaged take the aggregated sales response function as the object of observation (cf. columns *d* and *e* in Table 2.12). The underlying assumption of both is that the occurrence of cannibalization will produce a modification (a "break") in the victim's sales-generating process (SGP). The SGP of a product is the stochastic process describing the behavior of its aggregated sales over time. It can be viewed as the combined result of all market interactions at the level of individual economic agents (e.g., the transactions between the seller's organization and the buyers),

whose outcomes can be observed in terms of sales volume and value, as illustrated in Figure 2.6. The observed sales levels are one realization of the "true" SGP. The properties (i.e., parameters) of the true SGP can never be known with certainty – being stochastic in nature – but only estimated. If an offering has cannibalistic potential, its launch, or any other relevant event in its life cycle, could affect the victim's SGP. In other words, the victim's SGP prior to the date of that event in the cannibal life cycle exhibit different characteristics than after it. We can then operationalize cannibalization as the difference between the observed behavior of the victim's SGP and the hypothetical behavior estimated by removing the effects of the cannibal on the SGP.

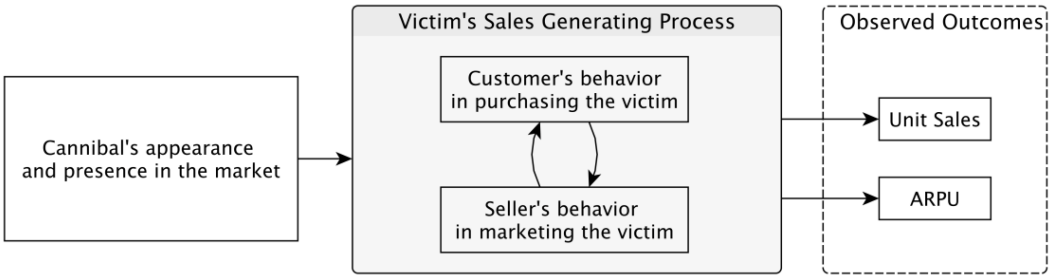


Figure 2.6 Cannibalization operationalized as a determinant of parameter instability in the victim's sales-generating process

A change in the parameters of the SGP is called a structural break (or structural change). Depending on whether the breaks possibly affecting the SGP are given (i.e., *exogenous* breaks) or determined/discovered within the operationalization (i.e., *endogenous* breaks), the operational definition will comprise one or two steps respectively. When the candidate breaks are known a priori, the operational definition simply consists in testing their significance and quantifying their effects. A quasi-experimental research design taking tentative structural breaks as the natural experiments is one possible implementation. In Case I (Chapter 3), new-product launches within the victim's product line and in adjacent product categories were considered as the given natural experiments and tested for their significance in producing structural breaks in the victim's SGP.

When the candidate breaks are determined endogenously, this will represent the first step in a two-step operationalization. This first step is a longitudinal research design, since we must observe a development over time and select the tentative breakdate(s) in that interval. The second step is then the quasi-experimental analysis conducted in the same way as for exogenous breaks. This two-step operationalization was implemented in both Cases II and IV (Chapter 4 and 6 respectively) but relying on different research strategies for the first step. In Case II, the endogenous determination of tentative breakdates was performed by means of an econometric testing procedure capable of identifying structural changes in a time series. Subsequently, we verified whether any of them could be ascribed to the cannibal. In Case IV, the candidate breakdates were identified through qualitative content analysis of a set of documents spanning the interval of potential occurrence of cannibalization.

We conclude our discussion on operationalization by considering the above presented operational definitions in the light of the challenges posed by technological innovation. As stated in Section 1.2.4, innovation hampers the univocal identification and quantification of customers' preferences, since it may act as a discontinuity in their development. This way, the set of attributes and performances considered a priori by the vendor may not be the relevant one in the market anymore. Therefore, the implementation of operational definitions based on the empirical analysis of customer response (i.e., thought experiments and empirically derived adoption or preference formation models) will produce accurate estimates only if it takes the possibility of such a discontinuity into account. The way we tackled this issue was by exploiting a qualitative strategy, which lets concepts and categories emerge from the data rather than imposing some predefined ones on them.

Technological innovation makes it also more difficult to identify demand interdependences between products in the market and to understand how these develop over time. In operational definitions

which rely on testing the SGP for parameter instability (i.e., exogenous and endogenous break tests), innovation may hamper the identification of structural changes and of their effects. On the one hand, it may hinder the a priori selection of events to be considered as the natural experiments of the quasi-experimental design. In non-IT, less innovative markets, such events usually correspond to the market introduction of the cannibal offering, but, in innovative markets, the cannibalistic potential of an offering may change over time. On the other hand, technological innovation may introduce an evolutionary component in an otherwise stationary SGP. Evolutionary processes require different analysis techniques than stationary ones (Hanssens et al. 2001, pp.279–283), and evolution and structural changes must be jointly investigated (Enders 2010, pp.227–234). To respond to these challenges, we employed econometric tests appropriate to the evolutionary context and we provided procedures for indentifying and screening the natural experiments, both quantitatively (Case I and II) and qualitatively (Case IV).

Table 2.12 Characteristics of the operational definitions of cannibalization implemented in this research project

	(a) **Thought experiment**	(b) **Model of adoption**	(c) **Model of preference formation**	(d) **Exogenous-break test**	(e) **Endogenous-break test**
Required operational steps	1	2	2	1	2
Comparison of states of the world	Yes	Yes	No	Yes	Yes
Hypothetical state of the world	What-if scenario	Cannibalistic buying situation		Removal of break effects	Removal of break effects
Ex-ante / Ex-post	Both	Both	Both	Ex-post	Ex-post
Analyzed customer response	Disaggregated	Disaggregated	Disaggregated	Aggregated	Aggregated
Customer response measurement	Direct	Indirect	Indirect	Direct	Direct
Sales measure	Purchase intention	Purchase intention	Purchase intention	Realized purchase	Realized purchase
Research design	Cross-sectional	Cross-sectional or numerical experiment	Numerical experiment	Quasi-experimental	Longitudinal for step 1 and quasi-experimental for step 2
Chapter	5	5; 7	7	3	4, 6

2.3.3. Characteristics of the Phenomenon

From a descriptive point of view, the nature of the cannibalization phenomenon is fully determined if we are able to specify it in terms of patterns, magnitude and variation over time. This translates into a series of characteristics of the sales-cannibalization generating process which we have collected from the literature. They are represented in Figure 2.7 and detailed in Table 2.13.

The analysis of cannibalization patterns should take into consideration the possibility of asymmetries (Carpenter & Hanssens 1994) and the involvement of items both within and between product categories (van Heerde et al. 2010). When the study does not target a predefined pair of entities (e.g., the new and old product pair), the stochastic model should be able to account for multivariate cannibalization within a given set of products, that is, support the discovery of which item is diverting customers from which other item. With regard to the temporal dimension, cannibalization may change over time due to customers' heterogeneity in adoption timing and other disturbances (van Heerde et al. 2010). It may also produce cross-period effects (van Heerde & Gupta 2005) and alter the long-term performance of the victim (Deleersnyder et al. 2002).

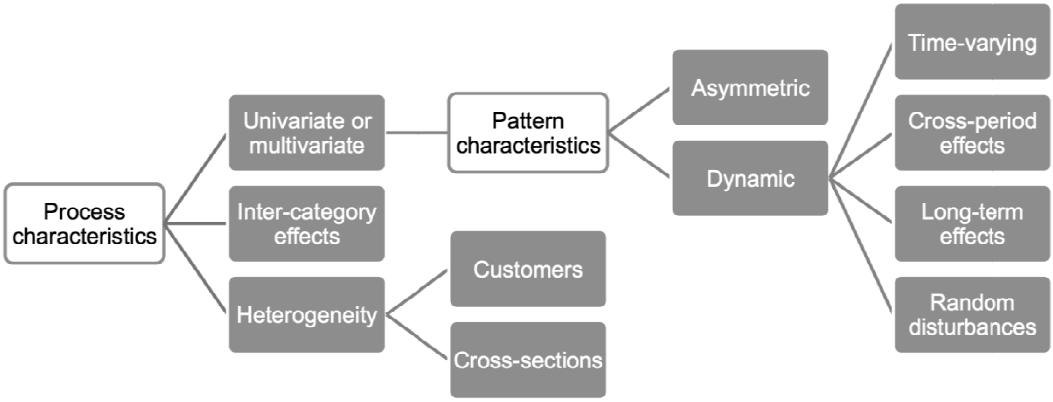


Figure 2.7 Characteristics of a sales cannibalization stochastic process

Table 2.13 Characteristics of the sales-cannibalization generating process collected from the literature (in chronological order)

#	Process characteristic	Description	First source of an apt model specification
I	Asymmetry of cannibalization patterns	Sales of one product mix item may affect sales of a second item differently than the other way around.	(Mahajan et al. 1993)
II	Variation of cannibalization patterns over time	Diversion of sales between two items in the product mix may change over time (in magnitude and/or direction).	(Mahajan et al. 1993)
III	Multivariate cannibalization	A cannibal may divert sales from multiple victims. Conversely, a victim may lose sales to multiple cannibals.	(Carpenter & Hanssens 1994; Mason & Milne 1994; Reddy et al. 1994)
IV	Stochastic effects	The cannibalization patterns may be subject to temporary nondeterministic disturbances.	(Reddy et al. 1994)
V	Long term effects	The addition of the cannibal may change the underlying (base) sales-generating processes.	(Deleersnyder et al. 2002)
VI	Cross-period effects	Cannibalistic shifts in sales may encompass stockpiling or anticipation and therefore produce lead or lagged effects.	(Biyalogorsky & Naik 2003)[a]
VII	Cross-sectional heterogeneity	Sales response may differ depending on the considered aggregate data cross-section (e.g., store).	(van Heerde et al. 2004)
VIII	Customers heterogeneity	Potential customers may react differently to the presence of the cannibal, in terms of the type of response or its timing.	(Kaiser 2006)
IX	Inter-category effects	Cannibalistic sales diversion may take place also among items which belong to different product categories.	(van Heerde et al. 2010)

Note: a) lagged effects only.

2.3.4. Detection and Measurement Models

The cannibalistic diversion of sales between two offerings (whereby, according to our definition, we make abstraction of any intrinsic characteristic, such as new and old, high-end and low-end, etc.) can be formulated as a generic cannibalization rate:

In the estimation of the numerator lies the research challenge. How should the victim sales reduction *due to the cannibal* be quantified? How should the customers intercepted by the cannibal among the victim's potential sales be identified?

What we call "detection and measurement models" are methodologies conceived to detect and quantify the phenomenon represented by that numerator, and whose estimation was the goal of the empirical

studies we reviewed. We decided to classify the array of measurement approaches in the literature along different dimensions: the sales data employed by the methodology; the research design (how are data collected and analyzed); the estimation goal (estimation of past or future impact or long-run effects). All the approaches introduced here are recapitulated in Table 2.14.

From the point of view of the employed sales data, we can distinguish three possibilities: historical measures, ad-hoc measures, and artificially generated measures. Historical measures are data on historical sales originally taken for goals other than the cannibalization study. Ad-hoc measures are new measures taken purposely for the cannibalization study in the market or in a laboratory setting. Artificial measures are artificial sales data generated by means of simulation. They can be spanning different periods (time series) or refer to one period only, be the disaggregated measures from different entities (cross-sections) or an aggregation thereof into a single measure, and be expressed in terms of units sold ("unit sales" or "sales volume") or in terms of revenues (or "monetary sales"). The most common combination is time series of aggregated unit sales.

A research design is a framework which guides the execution of the research methods selected for data collection and data analysis. It is a meta-model prescribing at which point(s) in time and from which cases the variable(s) of interest ought to be measured. A cross-sectional design consists in the collection of data on a series of variables from a sample of cases at a single point in time. In our specific context, sales data for the cannibalization analysis will be taken at a single point in time from several individuals (e.g., households). A longitudinal design consists in measuring the same variable from the same sample in at least two occasions. For instance, the victim's sales volume is observed twice, before and after the introduction of the cannibal, and the two measurements are compared to estimate the cannibalistic effects. Alternatively, it may be recorded over a longer time span to produce time series to feed an econometric model.

In a (classical) experimental design, experimental subjects are randomly allocated to different groups. The groups are usually two: an experimental group (or treatment group) which will receive the experimental treatment, and a control group which will not receive the experimental treatment (i.e., it will receive none or a control treatment). The independent variable is measured before administering the experimental treatment (when the manipulation of the dependent variable is supposed to take place) and again afterward. Experiments can take place in a laboratory or contrived-setting (laboratory experiments), or in a real-life setting (field experiments). In our context, the "treatment" is the presence of the cannibal product and the "field" is a real market or a laboratory where the shopping environment is simulated.

In a quasi-experiment, the manipulation of the independent variable takes place naturally without the researcher's intervention (it is namely called natural experiment). There is no random assignment or control group. The natural experiment of a quasi-experimental cannibalization study will often be the cannibal market launch (as in our illustrative case I), but, as case II will demonstrate, in IT markets the cannibalization potential sometimes does not fully manifest itself until a much later date in which the cannibal acquires its cannibalistic characteristics as a consequence of the innovation process.

Table 2.14 Cannibalization detection and measurement approaches

Approach	Research design	Sales data	Sales response	Cannibal launch
Descriptive	Cross-sectional	Historical measures (cross-sections)	Not formalized	Not considered
	Longitudinal/quasi experimental	Historical measures (time series)	Not formalized	Observed
Econometric	Longitudinal/quasi experimental	Historical measures (time series)	Formalized	Observed
Simulation	Experimental	Artificial measures	Formalized	Controlled
Field study	Experimental	Ad-hoc measures	Not formalized	Controlled

Based on the criteria mentioned up to now, we classified the cannibalization measurement approaches from the literature into four groups (Table 2.14): descriptive, econometric, simulation, and field study.

Both descriptive and econometric approaches apply mathematical models to historical sales data (of the cannibal, victim, or both), but distinguish themselves in the way in which these data are analyzed. The former are nonparametric models, since they do not formalize a response function with unknown parameters. Instead, they provide quantitative indicators of cannibalization through relatively simple algebraic passages. Econometric models mathematically formalize the stochastic sales response of one or more product items including the cannibal, the victim, or both, and calibrate the response function(s) with the historical sales data. Cannibalization is then either represented by an estimated coefficient in the response function (as in structural-break models) or derived from some other model parameters (e.g., from estimated cross-price elasticities).

Table 2.15 Possible goals of a cannibalization measurement study

		Cannibalization effect	
		Impact	**On-going**
Cannibalization measurement problem	**Ex-ante**	Forecast impact cannibalization effects (short-term future)	Forecast long run cannibalization effects (long-term future)
	Ex-post	Estimate impact cannibalization effects (past)	Estimate long run cannibalization effects (present)

Both simulation and field study generate new sales estimates. Simulation approaches generate artificial sales data endogenously to feed subsequent analytical steps. These artificial data may come from numerical simulations in a computer environment or be generated by first calibrating a mathematical model and then feeding it with different sets of inputs. Field studies encompass ad-hoc direct measurements taken in a real market or in a virtual shopping environment, where the presence of the cannibal product can be controlled.

Furthermore, approaches vary in the estimation goal they pursue. We have already defined the two problems of ex-post and ex-ante cannibalization detection and measurement (Section 1.2.3). They fundamentally translate into the two analytical problem of forecasting *future* cannibalization rates (those which will follow the cannibal's market launch) or estimating *past* and *present* cannibalization rates (those which have followed the cannibal's market launch). However, we must further distinguish the impact effects from the long-run ones (Table 2.15). The former occur simultaneously or in proximity to the market launch and represent the temporary repercussions on the victim's sales. The latter are the on-going (steady-state or long-run) cannibalization rates, that is, those observed when the market has returned to stability. Some descriptive methodologies are built on the assumptions of market stability/stationarity and thus cannot estimate the impact effect. Some econometric models have parameters to represent both. Different combinations of sales data and research design may differently suit these goals.

Table 2.16 Possible uses of cannibalization detection and measurement approaches (as reported in the literature)

		Estimate		Forecast	
		Short run	Long run	Short run	Long run
Approach	Descriptive	✗	✓	✗	✗
	Econometric	✓	✓	✓	✓
	Simulation	✓	✓	✓	✓
	Field	✗	✗	✓	✓

Descriptive Models

Descriptive models are less demanding than econometric ones in terms of analytical complexity, since they are nonparametric in nature and thus do not require calibration. The cost of such simplicity is that they *alert* the researcher of a *potential* occurrence of cannibalization rather than providing actual estimates of the sales diversion.

Among the descriptive methodologies, we find an ecology-inspired cluster analysis of purchasers, used to detect potential cannibalization among a manufacturer's brands and brands' variants (Mason & Milne 1994). The authors argue that an analogy exists between the way in which biological species compete for scarce resources in an ecological environment and the way in which brands compete for customers in the marketplace. They exploit this analogy to propose a framework for on-going cannibalization "measurement" in mature markets at multiple levels of analysis.

In their approach, relevant customers' characteristics (e.g., demographics, psychographics, value and lifestyle data, benefits sought, and usage data) define a multi-dimensional space used to classify consumers. In this space, each brand variant has its own *niche* – a perimeter (more properly, a hyper-sphere) containing the variant's majority of customers, that is, all the customers within a given distance from its average purchaser (analytically, from the centroid of the standardized variables).

Specifically, customers are classified based on their position relative to the niche border. *Core customers* are the variant's customers who lie within the variant's niche. They are the prototypical consumers of the variant in terms of the dimensions which define the analysis space. All other buyers of that variant (i.e., those who are outside the boundaries of its niche) are called *fringe customers*. These are the more atypical ones. Obviously, the niche borders may include customers (either core or fringe) of other variants and brands as well.

Once the niches for each variant are specified, their relative localization is investigated to estimate competitive draw and cannibalization. In particular, the overlap between the respective niches of two variants from the same manufacturer serves as a proxy for cannibalization potential. In other words, every consumer who falls within the niche of two brands or two variants produced by the same manufacturer is a potentially cannibalized consumer. Given two brands A and B, an indicator of potential cannibalization of B's potential customers by A will be the fraction of A's core customers which are within B's niche, and vice versa. Cannibalization rates can be calculated pairwise (between two individual variants), at brand level (aggregating over all the variants of a given brand), or at manufacturer's level (aggregating over all the manufacturer's brands).

The authors remark that the validity of their approach strictly depends upon the degree of accuracy in the selection of relevant dimensions. Omitting relevant dimensions can cause overstating the niche overlap, and thus the cannibalization rates. Drawing substantive conclusions about a market may therefore require an extensive set of dimensions (*viz.*, more than the eight dimensions they consider in their empirical example). They also warn that niche dimensions may vary from one product category to another and namely apply the methodology to a case of purely intra-categorical sales diversion. Eventually, the authors specify that their approach is suitable for the analysis of *mature* product lines.

Lomax and her co-authors have proposed a set of descriptive techniques to detect cannibalization of the parent brand engendered by the launch of a line extension (Lomax et al. 1997; Lomax et al. 1996; Lomax & McWilliam 2001). The techniques are not in alternative to one another but must be compared and interpreted together to shed light on the underlying market dynamics.

The first method is called "gains loss analysis" and consists simply in taking the ratio of the victim's market share loss to the cannibal's market share gain:

$$Cannibalization\ (\%) = \frac{Parental\ Share\ Loss}{Line\ Extension\ Share\ Gain}$$

In the case of a line extension winning a 10% market share while its parent brand reduces from 24% to 22%, for instance, this cannibalization indicator would take on a value of 20% [(24 – 22)/10 = 2/10 = .2]. The higher this ratio compared to competitors' brands, the more plausible a cannibalistic explanation of the line extension's gains in the market. The authors warn that this indicator is merely a benchmark and ignores underlying trends in parental share and movements at the individual household level.

"Share movements analysis" focuses on the changes in a brand's shares of purchase (i.e., the percentage of purchase occasions accounted for by the brand in a period). This method benchmarks the actual change between pre- and post-launch shares against the theoretical change predicted by a share order effect model. The former simply assumes – according to the Independence of Irrelevant Alternatives (IIA) assumption (Luce 1959) – that all brands will lose share to the new entrant in direct proportion to their size before the launch. Using the figures given in the example above, the IIA prediction for the parent would be 21.6% [24*(100-10)/100], i.e., a share loss of 2.4%, more than the observed 2% and thus suggesting no cannibalization. An unpredicted – disproportionately large – share loss by the parent would be instead an indicator of cannibalization.

"Buyer analysis" is an intertemporal measure of cross-purchase. It takes into account the pre-launch purchase behavior of the customers who bought the extension, compared to the average customer. If, before the launch, the extension buyers were disproportionate purchasers of the parent compared to the generic category buyers, they may have substituted the new line for the parent after the launch.

"Duplication analysis" is another measure of cross-purchase, which, however, examines the level of cross purchasing between line and parent in the post-launch period. Similarly to the share movements analysis, empirically measured cross purchasing is compared with the theoretical level predicted in accordance with the IIA (i.e., according to Ehrenberg's Duplication of Purchase Law, formalized in the Dirichlet model). Once again, deviations from the expected values (higher than predicted) would signal potential cannibalization.

The difficulty is that none of these techniques per se can provide sufficient evidence of cannibalization or its absence: "*Neither prove cannibalization, but they would be expected to give an indicator of when cannibalization is more likely*" (Lomax & McWilliam 2001, p.395). The various measures must be compared to obtain some understanding of the underlying market dynamics. For instance, if the buyers of the new entrant are found to be disproportionate purchasers of the parent brand before the launch of the extension (buyer analysis) or after the launch (duplication analysis) cannibalization may have occurred. This hypothesis is then tested against share movements. If the parent has also suffered an unpredicted share loss, this corroborates the cannibalistic explanation. All the descriptive models we have reviewed (cf. Table 2.18) were conceived for non-innovative fast-moving-consumer-goods (cigarettes and detergents), consider only intra-category sales diversions, and require conditions of market stability. Therefore, their applicability in IT markets may be questioned. IT offerings are mostly characterized by their innovative content. Innovation often blurs or alters the boundaries between IT product categories. In fact, IT markets seldom experience the stability observed in mature consumer markets.

Econometric Models

Econometric models provide a mathematical formalization of the sales-generating process for the victim, the cannibal, or both of the entities. These models differ in the way they tackle the cannibalization measuring problem.

A first group of models specify a sales response function for the victim entity alone and devote explanatory variables to formalize the impact of the cannibal, detecting any reduction in the victim sales and attempting to explain it in terms of the cannibal's introduction, presence, and/or attributes. This approach is employed by scholars assessing the cannibalization effect of a companion website for a

printed publication. In a study, for instance, a structural-break unit-root test is employed to verify whether the web companion negatively affected the circulation and advertising revenues of national newspapers (Deleersnyder et al. 2002). The only required information about the cannibal is the website's launch date. In an alternative model design (Simon & Kadiyali 2007), a cannibal's attribute is integrated into the model, namely the degree of overlap with the printed content. When analyzing the cannibalization of retail-stores revenues by the online channel, not only is the existence of the cannibal considered but the cannibal-generated monetary sales as well (Biyalogorsky & Naik 2003). All of the cannibalization studies relying on Amazon rankings as proxies for sales volume (Ghose et al. 2006; Smith & Telang 2008; Danaher et al. 2010; Smith & Telang 2010; Hashim & Tang 2010) also formalize a response function only for the victim.

Some scholars take the opposite approach and decompose the cannibal's demand to ascertain whether one of its sources is the diversion of sales from other items in the portfolio. A dummy variable regression is employed and a process equation accounts for the time-varying nature of the cannibalization effect (Reddy et al. 1994). A vector error-correction model allows linear unit-sales decomposition as a method to study a radical innovation diverting customers from other product categories (van Heerde et al. 2010). Multigenerational diffusion models that only support forward substitution also fall into this category (Mahajan & Muller 1996; Shen & Altinkemer 2008).

Another body of research approaches the entities symmetrically from the modeling point of view. That is the case for multigenerational diffusion models which contemplate both forward and backward substitution (Mahajan et al. 1993), and for response models conceived as systems of log-linear demand equations (Carpenter & Hanssens 1994; Meredith & Maki 2001; Yuan et al. 2009). The latter set of models does not allow the quantification of cannibalization in absolute terms but rather through cross-elasticities, which may be turned into sales diversion ratios (Yuan et al. 2009).

Simulation Models

Simulation-based approaches do not rely on historic sales data but generate artificial sales data endogenously to feed the subsequent analytical steps. With attitude-based models, preference measures can be transformed into sales predictions with an appropriate choice model. If this transformation is repeated for alternative scenarios with and without the cannibal, the artificial sales data can be inspected to detect and quantify cannibalization.

Conjoint analysis, for instance, is a viable methodology to produce preference order ranks which are subsequently transformed into market share predictions to compare the performances of product lines which include or exclude the cannibal (Page & Rosenbaum 1987). Other researchers have quantified the cannibalization effect by first calibrating a discrete choice model and then simulating a hypothetical scenario where the cannibal item is removed from the choice set (Gentzkow 2006; Albuquerque & Bronnenberg 2009). The computed delta in victim sales then constitutes cannibalization.

Field Study

A fourth approach to sales cannibalization detection and measurement encompasses observing the customers' behavior directly as they purchase in a real market or in a laboratory where the researcher retains control over the presence or absence of the cannibal product or service (i.e., in an experimental setting).

The marketing literature distinguishes between *pretest* and *test* marketing models and measurement systems (Urban & Hauser 1980, chap.14–15). Test market analysis is conducted in a real though circumscribed market, where the seller can reproduce in a smaller scale its national marketing strategy and possibly experiment with it. It is a highly costly and long lasting endeavor, with which the seller runs the risk of disseminating confidential plans and information to the competition. Pretest market analysis, instead, is conducted in simulated retail environments and should amount to a fraction of the costs and time of an analogous test market, while allowing more discretion.

Both test and pretest market models have been employed to analyze fast moving consumer goods but their suitability for services, durables, and industrial goods has not been ascertained yet and has actually been questioned. Considering that in IT markets services have a widespread role, the transacted goods are predominantly durable, and enterprises are an important customer segment, the relevance of both these marketing methodologies is debatable.

To our knowledge, there is only one cannibalization field experiment documented in the IS literature. This field study relies on online auctions to estimate the cannibalization potential of remanufactured products towards brand new ones (Guide & Li 2010). Based on the analysis of bidding behaviors and bid results, the hypothesis of cannibalization is evaluated (and rejected in that particular case).

Table 2.17 Descriptive models for the detection and measurement of sales cannibalization

Model	Measurement problem	Cannibal	Victim	Product category	Indicator of cannibalization	Level of analysis	Reference
Ecology-inspired cluster analysis	On-going	Brand variant	Other variant or brand	Cigarettes	Overlap of customer clusters	Disaggregated (individual customer)	(Mason & Milne 1994)
Gains loss analysis	Ex-post	Line extension; flanker brand	Parent brand	Detergents	Parental share loss follows the extension launch	Aggregated (brand share)	(Lomax et al. 1997; Lomax & McWilliam 2001)
Share movements analysis	Ex-post	Line extension; flanker brand	Parent brand	Detergents	Parental share loss is higher than predicted by the share order effect model	Aggregated (brand share)	(Lomax et al. 1996; Lomax et al. 1997)
Buyer analysis	Ex-post	Line extension; flanker brand	Parent brand	Detergents	Cannibal buyers are disproportionate purchasers of the parent before the extension launch	Disaggregated (individual household)	(Lomax et al. 1996; Lomax et al. 1997; Lomax & McWilliam 2001)
Duplication analysis	Ex-post	Line extension; flanker brand	Parent brand	Detergents	Customers' cross-purchasing with parent is higher than predicted by the Dirichlet model	Disaggregated (individual household)	(Lomax et al. 1997; Lomax & McWilliam 2001)

2.4. Sales Cannibalization in Information Systems Research

2.4.1. Sales Cannibalization and IT

Based on both the explorative study and the literature review, we outline the main cannibalistic trends in the IT industry. We have already shown how sales cannibalization represents a ubiquitous phenomenon in markets related to information goods and information systems (Section 1.2.1). Indeed, an extensive tally of *alleged* casualties may be compiled: traditional media (records, books, newspapers, television broadcasts, etc.) cannibalized by their digital counterparts, packaged software cannibalized by SaaS, enterprise servers cannibalized by IaaS, and traditional advertising cannibalized by online ads – just to name a few recent occurrences in the press (cf. examples in Section 2.1.2).

With regard to information goods, the Internet has played a central role in determining cannibalistic situations for content providers. Successive generations of online platforms have namely allowed content providers and content consumers to transact in an ever-increasing range of formats and channels (without generating too much enthusiasm on the supply side, to couch it euphemistically). Table 2.18 details the array of possible buying situations resulting from such a platform evolution, based on the nature of the purchased entity (physical good, logical good, service) and on the type of underlying platform (retail or e-commerce).

The Internet has begot a first cannibalistic situation by providing an alternative channel to sell information goods in physical form that were already being distributed through retail stores (Biyalogorsky & Naik 2003). Following the widespread adoption of portable media players and under the pressure of piracy, a new generation of online stores has then arisen, where the same information goods can be purchased as individually downloadable encoded files (Kannan et al. 2009; Danaher et al. 2010). The most recent development is the shift towards a service paradigm, where users can access digital content on-demand through dedicated service providers, such as Amazon, NetFlix, or Spotify (Hashim & Tang 2010).

Table 2.18 Information goods' buying situations

	Brick & Mortar platform	**Internet-based platform**
Information good with physical manifestation	On paper; on disc	On paper; on disc
Information good with purely logical manifestation	Prepaid gift card	Download of an encoded file
Service	Exhibition; performance; broadcast	Hosted data services; on-demand services

All software and hardware vendors are vulnerable to cannibalization as well. If we classify the technological components of information systems into the four product families of hardware, software, databases, and telecommunications (Stair et al. 2008), we can readily see cannibalistic situations in all of them. For instance, chip manufacturers currently see cannibalization both among microprocessors for enterprise servers and those designed for data centers, and among low-consumption microprocessors for mobile devices and the more powerful ones for personal computers; database vendors witness the same phenomenon arising between in-memory and traditional database offerings; network operators among traditional phone services and VoIP. With regard to software, higher than average cannibalization rates and the ability to successfully introduce a new product during the growth phase of the previous one have been found to be distinguishing features of successful software vendors (Hoch et al. 2000).

Some IT segments are experiencing dematerialization and servitization trends analogous to those illustrated for information goods. Special-purpose devices are being substituted for functionally-equivalent software applications on general-purpose computers, often offered by the same vendor. Manufacturers of personal navigation devices, for instance, have started developing navigation software

for GPS-enabled smartphones. At the same time, hardware and software resources are increasingly delivered "as a service", and marketed under the roughly equivalent names of on-demand, cloud computing, SaaS/PaaS/IaaS, etc. This servitization trend poses additional challenges due to the different revenue models that victim and cannibal may employ (e.g., perpetual licensing vs. subscription). In such a scenario, cannibalization quantified in terms of monetary sales may be more meaningful than in terms of unit sales as common in the marketing literature. Table 2.19 recapitulates these trends and some illustrative cannibalistic situations they beget for IT vendors.

Table 2.19 Trends engendering sales cannibalization in IT-related markets

	Information goods	**IT products and services**
Dematerialization	Physical manifestation vs. purely logical manifestation	Special purpose devices vs. software applications on general purpose devices
Servitization	Discrete purchases vs. on-demand services	Enterprise servers vs. Infrastructure-as-a-Service On-premise applications vs. Software-as-a-Service

2.4.2. Empirical Findings from the IS Research Literature

In this section, we review the findings of prior measurement studies which have empirically investigated cannibalization occurrences in IT-related markets. Several studies have estimated cannibalization rates in IT-related markets, whereby the great majority has focused on information goods and only few articles have dealt with other types of IT products and services.

Existing measurement studies on cannibalization of information goods are enumerated in Table 2.20. Most scholars have addressed the cannibalizing impact of digital, electronically distributed media on sales of their physical counterparts (printed publication or CD/DVD). There are few exceptions: the cannibalization problem for a retailer selling physical copies both online and through its stores (Biyalogorsky & Naik 2003); the cannibalization effects of online secondary markets on sales of brand-new copies (Smith & Telang 2008; Ghose et al. 2006).

Table 2.20 Measurement studies on cannibalization in IT markets

Study		**Product category**	**Product forms (Cannibal / Victim)**	**Horizon**
(Deleersnyder et al. 2002)	Information goods	Newspapers	Online edition / printed edition	1990-2001
(Biyalogorsky & Naik 2003)		Music records	Online sales / retail sales	1998-1999
(Filistrucchi 2005)		Newspapers	Online edition / printed edition	1976-2001
(Ghose et al. 2006)		Books	Used copy / new copy	2002-2004
(Gentzkow 2006)		Newspapers	Online edition / printed edition	2000-2003
(Kaiser 2006)		Magazines	Online edition / printed edition	1996-2004
(Simon & Kadiyali 2007)		Magazines	Online edition / printed edition	1996-2001
(Smith & Telang 2008)		Music records; movies	Used copy / new copy	2004
(Smith & Telang 2009)		Movies	Free television broadcast / DVD	2005-2006
(Kannan et al. 2009)		Academic publications	Digital purchase / Printed book	2002-2004
(Danaher et al. 2010)		TV programs	Digital purchase / DVD	2007-2008
(Hashim & Tang 2010)		Movies	Digital rental or purchase / DVD	2008
(Mahajan & Muller 1996)		Mainframe computers	Next generation / previous generation	1955-1978
(Shen & Altinkemer 2008)		Game consoles	Next generation / previous generation	1996-2005
(Guide & Li 2010)		Network devices	Remanufactured / new	2008?

The findings of these studies are detailed by market segment in Table 2.21. The results with regard to the press market are partly inconclusive, as detected cannibalization rates (in terms of reduced circulation of the printed edition) ranged from insignificant (Deleersnyder et al. 2002) to noteworthy (Filistrucchi 2005). The effects of customers' heterogeneity have been revealed as well, showing that,

for instance, cannibalization rates can differ from one age group to the other (Kaiser 2006). This result was confirmed in the market for academic publications, where some customers see the printed version and the PDF one as substitutes, others as complements (Kannan et al. 2009). Content markets segmentation has also been investigated: legitimate digital and physical copies of NBC television series were not seen as substitutes by most customers (Danaher et al. 2010).

Outside of the markets for digital content, few scholars have attempted to measure sales cannibalization. A multigenerational diffusion model has been employed to estimate cannibalization rates (as the percentage of technology adopters buying the latest available generation) for successive generations of IBM mainframe computers (Mahajan & Muller 1996). The estimated rate ranges from 90% for the second generation to 34.5% for the fourth one. In another multigenerational diffusion study, this time in the market for game consoles, estimation say that less than 10% of the customers of the Sony Playstation-2 were cannibalized from potential Playstation-1 adopters (Shen & Altinkemer 2008). A field experiment based on online auctions has dealt with the cannibalization potential of remanufactured products, whereby a network security device by CISCO in brand-new and remanufactured form was auctioned (Guide & Li 2010). Based on the analysis of bidding behaviors and bid results, the hypothesis of cannibalization was rejected for that particular instance.

Table 2.21 Comparative review of findings on information goods cannibalization

Study	Cannibalization[a]	Empirical Approach
	Press (newspapers and magazines)	
(Deleersnyder et al. 2002)	No significant cannibalization	Structural-break
(Filistrucchi 2005)	−3.1% (short-term) −26.4% (long-term)	Discrete choice modeling (aggregate logit)
(Gentzkow 2006)	−1.47%	Discrete choice modeling
(Kaiser 2006)	−4.2%	Discrete choice modeling (nested logit)
(Simon & Kadiyali 2007)	−3-4%	Fixed-effects
	Academic press	
(Kannan et al. 2009)	−2.44% (short-term) +10% (long-term)	Structural-break
	Entertainment (music and video)	
(Biyalogorsky & Naik 2003)	2.80% [b]	Simultaneous dynamic equations
(Danaher et al. 2010)	No significant cannibalization	Difference-in-difference
(Hashim & Tang 2010)	−41.6%	Fixed-effects
	Secondary markets	
(Ghose et al. 2006)	16% [c] (books)	Discrete choice modeling (aggr. logit)
(Smith & Telang 2008)	24% [c] (CDs), 86% [c] (DVDs)	Discrete choice modeling (aggr. logit)

Notes: a) In percentage change of victim's unit sales due to cannibalization, unless otherwise noted b) In percentage of cannibal's monetary sales diverted from the victim c) In percentage of cannibal's unit sales diverted from the victim.

2.5. Research Methodology

2.5.1. Philosophical Orientation and Paradigm Choice

We briefly dwell on the philosophical reflections underlying our research endeavor on cannibalization and the paradigm choice on which we have based the research project. Two aspects must be addressed. Firstly, how we consider the phenomenon of cannibalization ontologically: what nature shall be attributed to it in relation to other social actors and entities. Secondly, how we consider its investigation epistemologically: what kind of knowledge obtained about it shall be regarded as acceptable, and whether the methods of the natural sciences shall be considered suitable for the attainment of such knowledge.

Ontological Position

From an ontological point of view, the phenomenon of cannibalization could call for either an objectivist stance or a constructionist one. Based on the former, cannibalization would be described as an objective phenomenon existing independently of the involved social actors, i.e., we could define it as the objective and directly observable way in which two sales-generating processes are intertwined with each other. Seen as such an objective phenomenon, cannibalization exists/occurs independently of the consumers and vendors acting in the observed market.

Based on a constructionist stance, instead, the phenomenon of cannibalization would be qualified as a social construction, *videlicet*, the product of the interactions and perceptions of the social actors (buyers and sellers) in the observed market. From a constructionist point of view, cannibalization does not exist independently of the interactions and perceptions of the involved social actors – the IT buyers and sellers transacting with each other.

A critical realist perspective lies, roughly speaking, somewhere in the middle. Real generating mechanisms exist but are not directly accessible to the researcher. Nevertheless, they can be investigated through the lenses of their observable consequences. In the case of sales cannibalization, the sales-generating processes, which cannot be directly observed, would be investigate through measurements of either purchase intentions or actual purchases. These observable consequences can be viewed hierarchically: on an individual basis (the individual customer's purchase decision) or cumulatively (the overall demand for a product or service). Sales cannibalization is one particular preference configuration between two products (as presented in the second operational definition, cf. Section 2.3.1).

Epistemological Position

Epistemologically, the objectivist stance calls for a positivist approach and the constructionist for an interpretivist one. From a positivist point of view, the collection and analysis of quantitative data (e.g., unit sales data or preference measures) will allow producing valid knowledge of the phenomenon of sales cannibalization. This obviously on the premise that the classic requirements of good scientific inquiry are met. From an interpretivist point of view, only an immersion in the social world where cannibalization is constructed, and the contacts with the social agents constructing it, will allow a true understanding of the phenomenon. Therefore, it demands the employment of appropriate qualitative methodologies of data collection and analysis.

As the reader can see, just as each ontological position demands a specific epistemological position, the epistemological position begets a tendency in the research strategy choice (that is why these reflections deserve careful thought). An objectivist-based positivist position will favor a quantitative research strategy while a constructionist-interpretivist position will favor a qualitative one. Common tendencies in pairing philosophical stances with research strategies are summarized in the following Table 2.22.

Table 2.22 Coupling tendencies among philosophical stances and research strategies

Ontological position	Epistemological position	Research strategy
Objectivist	Positivist	Quantitative
Constructionist	Interpretivist	Qualitative

Paradigm Choice

In the case of business research, the third element of paradigm choice is the function or purpose of the envisioned research. The two contemplated purposes are *descriptive*, where the goals are description and explanation of a business phenomenon, and *normative*, where the goals are the formulation of judgment on the phenomenon and the identification and implementation of appropriate changes. An effective way of combining the research purpose with the previous reflections on ontology and epistemology in the social sciences is the four-paradigm model proposed by Burrell and Morgan (1979), schematically reproduced in Table 2.23.

In their model, the normative perspective is labeled “radical” and the descriptive one “regulatory”. The framework presents four possible paradigmatic positions for the study of organizations. The most common – dominant – approach is the functionalist: the description and explanation of organizations, conceived as real processes and structures, from an external viewpoint. The radical structuralist position alters the objective into the attainment of change. The interpretative position instead views explanation as a reachable goal only when taking the perspective of the individuals involved, since organizations are socially constructed products, maintaining the descriptive goal. Lastly, the radical humanist stance, building on the same ontologically constructionist and epistemologically interpretivist position, embodies the normative purpose of judgment and change.

Table 2.23 The four-paradigm framework proposed by Burrell & Morgan (1979)

	Regulatory		
Objectivist	Functionalist	Interpretative	Subjectivist
	Radical structuralist	Radical humanist	
	Radical		

Whether these four paradigms are incommensurable – that is to say, whether a research study ought to rest exclusively on one of the four paradigms alone – is a source of debate among scholars. We believe multi-paradigm research to be an acceptable approach, and we consider our research endeavor a good example thereof. In investigating the phenomenon of sales cannibalization, we have namely taken both a functionalist and a radical humanist perspective. In Cases I, II, and IV we have observed the phenomenon from an external viewpoint (exemplified by the predominantly quantitative secondary data collection from publicly available financial statements) and relied on econometric models to describe the phenomenon. In Case III, instead, we have taken an interpretivist position (exemplified by the qualitative primary data collection among active enterprise software buyers) and aimed at producing knowledge with a normative purpose. That case was namely performed in collaboration with an international enterprise software vendor, whose objective in the research was the improvement of its online software distribution policies and the underlying commercial platform.

2.5.2. Research Design

In light of the challenges posed by the research questions we were to tackle, we have deployed a *mixed-method* research design, i.e., we have combined quantitative and qualitative research within our project. This choice was driven by both theoretical and practical factors. On the one hand, a mixed-method research strategy is fully coherent with our multi-paradigm philosophical stance. Under a multi-paradigm stance as the one we have taken, none of the dogmatic tendencies introduced above needs be necessarily followed – the researcher is free and willing to integrate insights from both quantitative and qualitative investigations whenever needed. On the other hand, we have found indeed cases in which only the combination of the two research strategies could make detection and measurement of sales cannibalization possible.

In fact, the uncertainty surrounding product performance criteria and customers’ preferences in the “fluid” phase of an innovation cycle – which represents all but a perennial feature of the IT industry, constantly emerging in one segment or the other – has demanded ad-hoc choices in terms of research strategy and research design. Each choice must suit the particular instance of sales cannibalization under study. The interdependence between the phenomena of sales cannibalization and technological innovation may preclude the use of traditional methodologies altogether, or require appropriate augmentation. This can be the case with the mostly positivist quantitative approaches from the disciplines of Marketing Science and Management Science.

As an overall research design for the project, we have implemented a *multi-case study research design*. That is, we have investigated multiple cases of sales cannibalization. Three were picked by the researchers based on representativeness and availability of publicly accessible data (Cases I, II, and IV). One (Case III) was commissioned by the enterprise software vendor with which the researchers were affiliated. All cases represent exemplary cannibalization occurrences where innovation dynamics poses methodological issues.

For each case, depending on the peculiar instance of cannibalization and the embodied innovation dynamics, we picked one or more operationalizations from those envisaged in Section 2.3.2. Subsequently, two crucial decisions ought to be taken for the implementation of each operational definition: the research strategy (qualitative, quantitative, or mixed-method) and the research design (longitudinal, cross-sectional, or experimental/quasi-experimental). According to this methodological architecture, specific methods of data collection and analysis were selected and executed for each case. Methodological issues with regard to each case are detailed in the corresponding chapter dedicated to the case. We provide an overview here and summarize the key aspects in Table 2.24.

Table 2.24 Research strategies and research designs selected to implement the operational definitions

Operationalization	Research Strategy	Research Design	Chapter
Exogenous-break test	Quantitative	Quasi-experimental	3
Endogenous-break test	Quantitative	Longitudinal + Quasi-experimental	4
Endogenous-break test	Mixed-method	Longitudinal + Quasi-experimental	6
Adoption model (empirically derived)	Qualitative	Cross-sectional	5
Thought experiment	Qualitative	Cross-sectional / Experimental	5
Preference formation model	Quantitative	Numerical experiment	7
Adoption model (derived from theory)	Quantitative	Numerical experiment	7

Each case, with its unique endowment of historical data, has compelled us to exploit different research paths. When investigating a cannibalization occurrence ex-post, it was possible to rely on some already collected historical data and to feed a quantitative model with them in a positivist fashion. That is what we have done in Cases I, II, and IV, calibrating econometric models with financial time series[23]. Nonetheless, we had to take the dynamics of innovation into account. We thus augmented the econometric methodologies from the literature (as in Case I and II) or combined quantitative and qualitative research (as in Case IV).

When investigating the cannibalization potential ex-ante, there were no or limited availability of historical data at our disposal, and cannibalization estimates had to come from a sample of observations collected for this purpose from potential adopters. As we have mentioned in the introduction, taking quantitative preference measurements, as recommended for frequently purchased consumer goods in stable markets, is not a suitable solution when performance criteria and attitudes in the marketplace are not yet well formed. We believed that an interpretivist perspective was better suited for investigating customers' preferences and their interdependences with product/service attributes when both are not well-articulated yet. Therefore, we have designed our research in Case III as a cross-sectional qualitative study.

In the intermediate situation, where we had access to historical data but these did not comprise unit sales, we needed additional information to correctly interpret the data at hand, to formulate a correct

[23] The reader can find in the Appendix (p. 178) a glossary of time series analysis with the most relevant terms, as an aid to thoroughly understanding the econometric applications in Cases I, II, and IV.

model, and to fully understand its outcomes. Mixing and matching qualitative and quantitative research has cumulatively increased the understanding of the cannibalistic situation in Case IV.

2.5.3. Research Process

The mixed-method multi-case research design we have chosen in light of our multi-paradigm approach lies at the core of this dissertation and builds on the methodological and conceptual foundations we laid, in order to produce scientifically relevant contributions. The multiple-paradigm position and the overall research design of the dissertation we have described in the previous section are the methodological foundations on which the overall research process was performed.

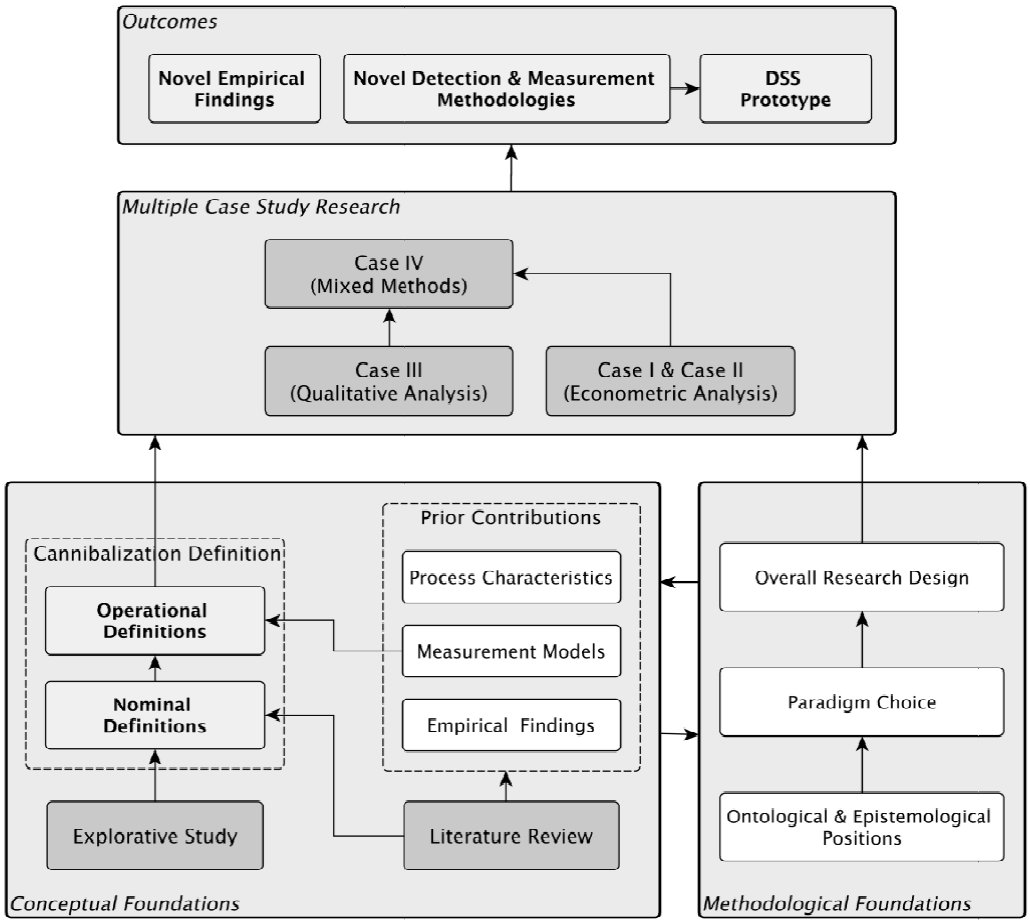


Figure 2.8 Overall research process

The conceptual foundations are represented by the outcomes of two distinct activities: an exploratory qualitative examination of the IT trade press and the literature review. The literature review allowed compiling an interdisciplinary list of cannibalization measurement models and a compendium of the empirical findings on the occurrence of cannibalization in IT markets. A novel nominal definition and a set of alternative operationalizations were the outcomes of both the explorative qualitative study and the literature review activities. Based on the thus elaborated nominal and operational definitions and on the chosen research designs, the case studies were conducted.

Case I and II are purely quantitative case studies in which time series econometric tests are employed to detect and measure cannibalization in the context of rapid developing IT products and platforms. Case I addresses sales cannibalization of the Apple iPod product line in the period 2000-2014. Case II focuses on the cannibalization of Personal Navigation Devices due to the diffusion of powerful generic portable computing platforms. Case III is a predominantly qualitative case aiming at the potential of channel cannibalization in introducing the “app-store” model into the enterprise software market. Some

quantification of qualitative materials does find place there indeed but rather as a complement to the qualitative analysis. Case IV is a thorough example of mixed-method research and builds on the methodologies employed in cases I–III. It relies on both qualitative content analysis (qualitative component) and econometric tests (quantitative component).

Finally, we compared and put in perspective with each other the empirical findings and methodological lessons-learned of the individual cases. Moreover, some of our methodological contributions were implemented in the prototype for a Decision Support System.

2.5.4. Computer-Aided Research Tasks

Several software applications were employed for key tasks at different stages of this research endeavor. Econometric analyses were performed within the statistical software environment R (version 3.0.1). The quantitative time series from our secondary data collection (cases I, II, and IV) were beforehand collected from financial reports (in Excel and PDF format) and manually consolidated into an Excel spreadsheet. We employed a variety of R packages, most prominently the package "urca" for unit-root testing and the package "dse" for models estimation. However, we wrote several ad-hoc R routines for both the explorative and confirmatory stages, especially to ease the creation and calibration of intervention models in the latter phase.

Agent-based simulation experiments were implemented and conducted in the Java simulation environment Repast Simphony. R played a role there as well. It was used to create the seeds to initialize the random number streams of the Monte Carlo experiments run in Repast, and to analyze the simulation traces recorded from those experiments.

With regard to our qualitative analyses, the "raw" qualitative materials consisted of Microsoft Word documents, created by transcribing our digitally recorded semi-structured interviews (in Case III) or by converting Internet web pages (in the exploratory study and in Case IV), and PDF documents collected from corporate websites (in Cases I, II, and IV). Documents were subsequently loaded into and managed with a Computer-Aided Qualitative Data Analysis Software (CAQDAS) environment: the commercial product Atlas.ti. With Atlas.ti, we coded the documents and performed various forms of proximity analysis on codes and quotations. Lexical search and quotation retrieval functionalities were extensively employed as well. Lists of codes, code co-occurrences, and quotations were exported from Atlas.ti to Microsoft Excel, where further steps of analysis took place, namely the compilation of qualitative tables and frequency calculations.

Table 2.25 List of the main software applications employed in this research project

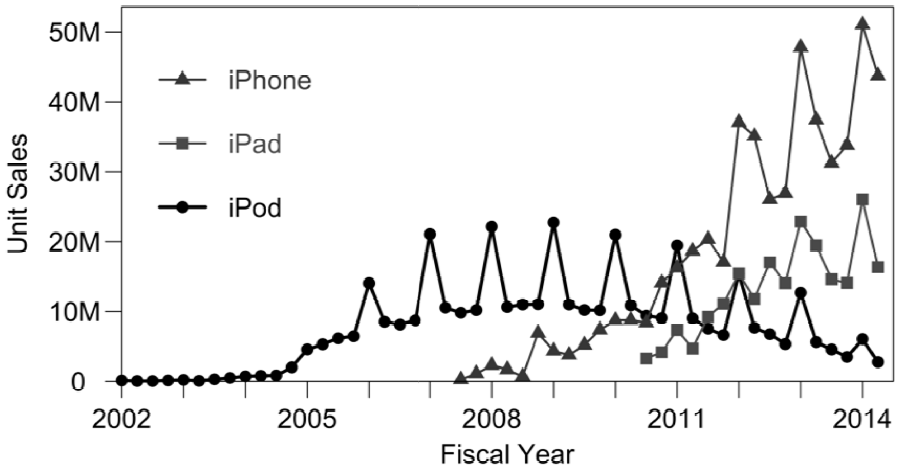
Software application (version)	Task	License	Official website
Atlas.ti (7)	Qualitative data management and analysis (document management, coding, proximity analysis, lexical search, quotations retrieval)	Commercial	www.atlasti.com
R (3.0.1)	Econometric analysis; initialization and analysis of agent-based simulation experiments	GNU GPL-2	www.r-project.org
R package "Dynamic System Estimation (dse)" (2)	Econometric analysis (model estimation)	GNU GPL-2	cran.r-project.org/web/packages/dse
R Package "Unit root and cointegration tests for time series data (urca)" (1.2)	Econometric analysis (unit-root testing)	GNU GPL-3	cran.r-project.org/web/packages/urca
Repast Simphony (2.1)	Agent-based simulation	New BSD	repast.sourceforge.net
Microsoft Excel (2011)	Quantitative and qualitative data management and analysis	Commercial	office.microsoft.com
Microsoft Word (2011)	Qualitative data	Commercial	office.microsoft.com

3. Case I – Product Cannibalization: Handheld Devices with Music-Playing Capabilities

3.1. Introduction

In this first case study, we deal with cannibalization within a portfolio of IT products in partly overlapping markets. We consider the handheld portable computing platforms of the renowned IT manufacturer Apple. These can be classified in the product categories of portable digital music players, smartphones, and tablets. Apple is active in these three categories with the product lines branded as iPod, iPhone, and iPad respectively. A relationship between the processes of sales generation of these product lines can be assumed, given the partial overlap in functionalities which could make them mutually substitutable. Apple might therefore witness a cannibalistic diversion of sales between its own portfolio items. We aim at verifying the occurrence of cannibalization of iPod sales, both intra-categorical and inter-categorical. Intra-categorical diversion would take place within the portable music player category, due to the launch of product line extensions (e.g., new iPod models). Inter-categorical diversions would take place from the portable music player category to the smartphone and tablet categories, due to the launch of iPhone and iPad devices.

IPod unit sales exhibit two very apparent traits: the yearly winter peaks characteristic of consumer products and the "bell" shape of a standard product life cycle (Figure 3.1). We can roughly identify the introductory and growth phases, where unit sales increased, first slowly and then substantially, followed by a plateau (maturity), and finally the current stage of declining sales. This behavior could partly be the consequence of a cannibalistic diversion of sales from the iPod product line to the iPhone and iPad ones. The iPod sales volume namely increased until around the quarter in which the iPhone was launched, then started to slow down, and further declined as the iPad hit the shelves. However, alternative explanations for the slowdown in iPod sales could be the saturation of the portable music player market or the rising competition within it.



Source: Apple financial statements

Figure 3.1 Total quarterly unit sales for the Apple iPod, iPhone, and iPad product lines

From the point of view of *monetary* sales, the iPod average revenue per unit (ARPU) exhibits a clear downward trend (Figure 3.4, Panels *c* and *d*). This could be due to the introduction of entry-level models – the iPod Shuffle and the iPod Mini (later replaced by the Nano) – and thus be a consequence of intra-categorical cannibalization. However, iPhones and iPads could also play a role there and affect Apple's capacity to monetize iPod sales (e.g., by pressuring its price and hampering the sale of iPod peripherals and support services).

The process of technological innovation at work in this case is embodied by an array of product innovation instances. It determined and affected both the cannibal and victim entities, and was both

radical (in terms of brand new cannibal entities introduced into the market – the iPhones and iPads) and incremental (in terms of versioning, line stretching, and renewal of the product lines). The competitive strategies implemented by Apple since the release of the iPod accounted for more than sixty product innovation "moves" (market launches, generational updates, discontinuations, etc.; cf. Appendix) in the three above-mentioned markets alone.

However, given the level of temporal and entity aggregation of the data at our disposal (i.e., total quarterly sales at the product line level), we had to constrain the analysis to a subset of all product events. We discarded the less disruptive processes of versioning and generational renewal and instead focused on few major product introductions: the entry-level iPod models, the iPhone, the iPod Touch, the iPad, and the iPad Mini. Table 3.1 recapitulates the analysis scope we thus defined, in perspective with all the innovation-driven product strategies implemented by Apple in these handheld-device markets.

Table 3.1 Innovation-driven product strategies implemented by Apple in handheld-device markets

Technological innovation	Product Strategy	Product line		
		iPod	iPhone	iPad
Incremental	Versioning	×	×	×
	Upward line stretching	iPod Touch	NA	×
	Downward line stretching	iPod Shuffle, Mini, Nano	×	iPad Mini
Both	Generational renewal	×	×	×
Radical	Diversification in new product category	1st generation iPod	1st generation iPhone	1st generation iPad

Notes
× = implemented by Apple but not considered in our analysis; NA = not implemented by Apple.
The complete set of events from which this subset was distilled is reported in the Appendix.

This chapter is organized as follows. We first describe the case by sketching the historical development of the market for portable digital music player (Section 3.2). We then review the literature which specifically addresses the case topic and supplements the generic material surveyed in Chapter 2 (Section 3.3). We present our research methodology (Section 3.4) and the data we collected (Section 3.5). We subsequently proceed with the data analysis and illustrate the main empirical results (Section 3.6). Eventually, we discuss meaning and limitations of our findings (Section 3.7).

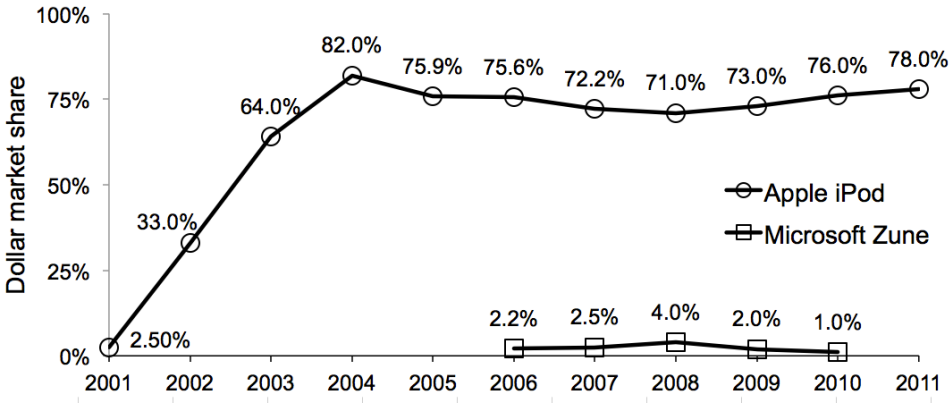
3.2. Case Description

The market for portable digital music players was in its infancy when Apple released its first iPod in 2001 (all events mentioned henceforth are recapitulated in Table 3.2). Though acting as a late mover, Apple overtook the market by the end of 2002 and has retained a dominant position ever since. Exemplarily, the time plot in Figure 3.2 shows the path of the iPod share of the US market compared to that of a "top" competitor.[24] In fact, the rival Microsoft Zune player never gained a market share higher than 1/18 of that of the iPod and was as low as 1/76 before being discontinued.

Apple has built its competitive advantage on several pillars: vertical integration (design and control of hardware, software, and online store), customer experience, and low-cost production (EmeraldGroup 2002). Moreover, by providing the first legal solution for digital music consumption with its iTunes Music Store, Apple has revolutionized the music industry and driven market expansion for the whole MP3 player category.

[24] Source: NPD Group Ltd (https://www.npdgroup.co.uk)

In an analogous way, Apple entered the already existent smartphone market in 2007, where Nokia had been the prime mover with the Nokia 9000 Communicator (released in 1996 already). Nonetheless, Apple conquered it by exploiting the same levers that made the iPod successful (West & Mace 2009): control of the platform, redefinition of form-factor and means of human-computer interaction for a more pleasant mobile Internet experience, and cost control. Apple leveraged its online commercial platform once again, this time to supply its devices with software applications through the iTunes App Store.



Source: NPD Group Ltd

Figure 3.2 Dollar market shares of Apple and Microsoft in the US digital music player market

Most recently, Apple has launched its iPad product line of tablet computers. The tablet is a computer platform mainly aimed at content consumptions and may thus respond to the needs of a potential iPod buyer, as well as to those of a laptop user. Cannibalization rumors have been spreading since the release of the first generation of the iPod (Yarow 2010). The introduction of a smaller iPad model (the iPad Mini) has potentially increased this threat, but the topic of cannibalization among Apple devices is controversial (Elmer-DeWitt 2012).

In penetrating the market for portable music players, Apple has introduced several iPod models over the years. Some of the later ones constrained the already offered set of functionalities to an entry-level product format (iPod Shuffle), while others expanded it by integrating features from the iPhone product line (iPod Touch). In diversifying its business, Apple has entered first the smartphone product category with the iPhone and then the tablet category with the iPad. In each category, product lines were extended and updated over time.

Table 3.2 Noteworthy events in the product categories considered in this case

Date	Event	Product class
March 1996	Nokia introduces the first smartphone (Nokia 9000 Communicator)	Smartphone
February 1998	SaeHan Information Systems introduces the first portable MP3 player (MPMan F10)	Digital music player
August 1999	Samsung Electronics introduces the first music-playing smartphone (SPH M-2100)	Smartphone
November 2001	Apple introduces the iPod	Digital music player
Q4 2002	Apple becomes market leader in the US digital music player market (in monetary sales)	Digital music player
April 2003	Apple opens the iTunes Music Store	Digital music player
October 2003	Apple launches iTunes for Windows	Digital music player
January 2004	Apple introduces the iPod Mini	Digital music player
January 2005	Apple introduces the iPod Shuffle	Digital music player
September 2005	Apple introduces the iPod Nano and discontinues the iPod Mini	Digital music player
May 2006	First rumors of an Apple cellphone capable of downloading and playing music from the iTunes Music Store	Smartphone
January 2007	Apple announces the iPhone	Smartphone

June 2007	Apple introduces the iPhone	Smartphone
September 2007	Apple introduces the iPod Touch	Digital music player
July 2008	Apple opens the iTunes App Store	Smartphone
January 2010	Apple announces the iPad	Tablet
April 2010	Apple introduces the iPad	Tablet
February 2012	First rumors of a smaller iPad model	Tablet
November 2012	Apple introduces the iPad Mini	Tablet

These processes of market penetration and diversification have resulted in a portfolio of items with partly overlapping functionalities, as highlighted in Figure 3.3. Different items within the digital music player category are by definition functionally related. They are all designed to provide portable music playing capabilities, though with distinctive packages, performances, and price points. For instance, the iPod Shuffle has the most basic music playing capability, accessible through a Spartan interface. The more expensive iPod Nano and Classic offer a user-friendly GUI with navigation menus. The iPod Touch has a multitouch screen and wholly support the iOS software platform.

Some overlap exists between different product categories as well. All iOS devices feature the same "jukebox" software application of the iPod and comparable technical specifications as music playing devices. The form factor, additional capabilities, and pricing represent the differentiating elements. The iPhone can be considered an iPod with smartphone capabilities. The iPod Touch has the same features and capabilities of the iPhone (form-factor, touchscreen, operating system, Wi-Fi, compatibility with apps, etc.), with the exception of the mobile telecommunication functionalities. The iPad is a larger content-consuming device than the iPod, both in terms of form factor and range of consumable content. The smaller iPad Mini approaches the size and features of the bigger iPods and could be appealing to potential iPod customers.

With regard to pricing, the iPhone is more expensive than the iPod, but some network operators heavily subsidize its purchase. The already mentioned iPad Mini is actually cheaper than the top iPad variants. From a practical point of view, all product lines have entry-level and premium price points.

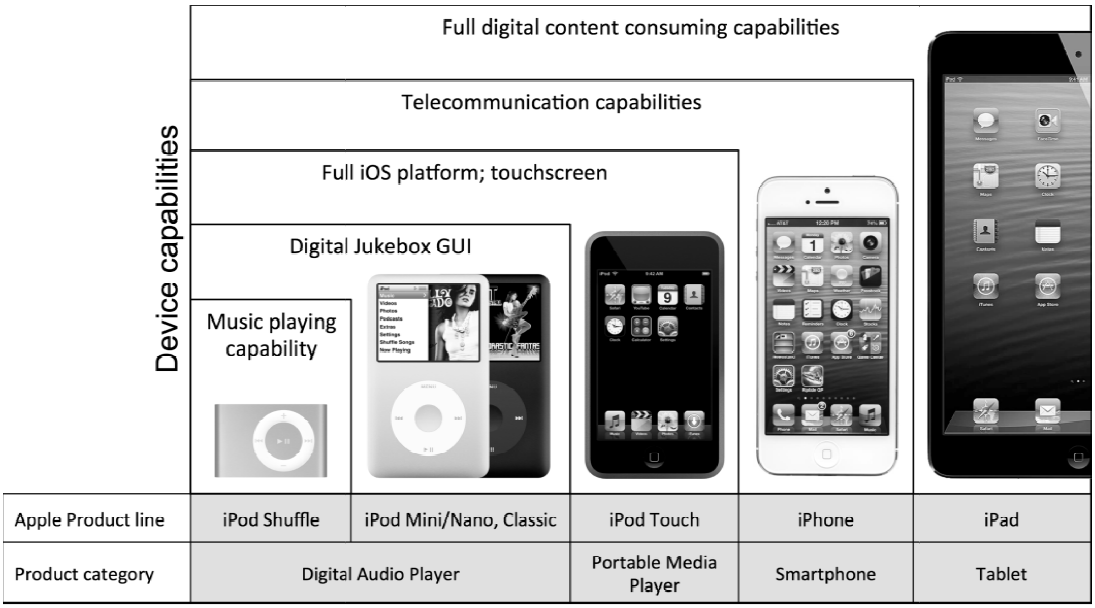


Figure 3.3 The product entities considered in this case and their relative capabilities

In conclusion, given the overlapping functionalities and the articulated pricing structure, all these devices may be substitutable to some degree and engender cannibalization. We may thus formulate a

series of hypotheses on the effects which the product strategy pursued by Apple may have determined within its portfolio of handheld devices (listed in Table 3.3). The entry-level iPod models introduced to stretch the product lines downwards may have driven volume sales while depressing their average value. iPhone and iPad may have diverted sales away from the iPod product line. The premium iPod models introduced to extend the product lines upwards may be expected to have expanded the upper quality-sensitive consumer segments or at least secured them against competitive computing platforms.

Table 3.3 Apple product strategies and hypothesized effects on iPod sales

Product line	Product model(s)	Underlying product strategy	Hypothesized effect(s) on sales of the "Classic" iPod product line
iPod	Mini, Nano, Shuffle	Downward line stretching	Expansion in volume; Cannibalization in unitary value
iPhone	1st Generation	Diversification in a new product category	Cannibalization
iPod	Touch	Upward line stretching	Expansion / Retention
iPad	1st Generation	Diversification in a new product category	Cannibalization
	Mini	Downward line stretching	Cannibalization

3.3. Related Work

The Apple iPod has been the motivating example or the central topic of a multitude of research articles over the years. Its relevance is due not only to its undisputable market success, but also to its role as a fundamental component of the archetypical iTunes ecosystem, and to the crucial part played in determining the overall development of both the computer industry and the music industry. Therefore, several streams of research are pertinent to an explanation of the iPod phenomenon.

Considered per se, as an innovative product, the factors determining its appeal to consumers have been investigated in the fields of design and marketing, the dynamics of its market success in those of diffusion of innovation and technology adoption. As a component of the iTunes ecosystem, it is an often-encountered topic in the literature on software platforms and multi-sided markets. As a milestone in the history of the renowned IT vendor Apple, it is a common case study of corporate strategy and business model innovation. Finally, as a driver in the development of the music industry, IS researchers have analyzed its effects on online distribution of digital content and piracy.

Though not the prime mover in the market for portable digital music players, Apple has rapidly gained and ever since retained its dominance with the iPod product family, while at the same time driving market expansion (Abel 2008; Peterson 2007). The reasons for this success lie in the merits of the product (Reppel et al. 2006), of the ecosystem built around it (Evans et al. 2005), and of the peculiar organizational capabilities of which Apple disposes (Cooper 2011).

The key distinctive product attributes of the iPod are (Reppel et al. 2006):

- The user-interface, in terms of hardware (the "click wheel") and software (menu navigation)
- The ease of connection to additional accessories (through the standard "dock connector")
- The design

The latter is not limited merely to the consumers' desire for ease-of-use and beauty but answers a reflective need as well, making iPod users feel good, proud, and individual. The iPod design can be qualified as "innovative" in the sense that it led to the incorporation of features which were perceived as unique and increased the perceived value of the product in the market (Rindova & Petkova 2007). However, the iPod was neither a pioneering device nor a radically innovative one. Apple faced more than 50 vendors when it entered the market, and the iPod phenomenon is thus judged an exemplary case against the first mover advantage theory (Abel 2008). The iPod was not even a radical innovation

but became the dominant design by incrementally improving earlier designs, based on the consumer preferences developed by the early entrants (Peterson 2007).

Apple has cleverly managed the development of the iPod product family over time. On the one hand, it has introduced entry-level models offering actually *less* than their predecessors (for example, the iPod Shuffle, which lacks a display) but carefully calibrating the value of each offering to market demands (Reppel et al. 2006, p.240). On the other hand, in terms of timing and sequential introduction, the alternate launches of low-end and high-end iPod models could have followed competitive needs, as assumed in the premise to an analytical study (Haruvy et al. 2013; Reppel et al. 2006, p.240). Overall, the iPod long-term success in the market can reasonably be ascribed to Apple's ongoing effort in maintaining leadership in product performance and value to consumers from one iPod generation to the other (Peng & Sanderson 2014, p.87).

Being able to see the bigger picture beyond the merits or demerits of a device or product line was one decisive factor in the competitive game played by Apple. With the introduction of the iTunes Music Store, Apple could namely solve one key problem in the market for digital music: the shortage of legally downloadable music (Abel 2008). iTunes was the first example of a mature digital content platform, i.e., a software platform which controls access to digital content and provides the technology for the users to consume the content (Evans et al. 2005, p.216). Apple has followed a vertically integrated platform strategy by producing both its own hardware (iPod) and software (iTunes), and operating its own content-provision service (iTunes online store).

Only the music is bought from third parties – the record labels, which receive a percentage of revenues for each downloaded song. Music acts as a complementary consumable (Gilbert & Jonnalagedda 2011) to drive iPod sales (Evans et al. 2005, pp.216–218). The iPod phenomenon can be seen as an innovative business model combining hardware, software, and service to sell a high-margin product (the iPod itself) by giving away a low-margin complement (the music), in a reversal of the traditional blades-and-razor model (Johnson et al. 2008).

Being considered "*one of the greatest product development companies in history*" (Cusumano 2008, p.22), Apple and the iPod are often used as illustrative examples in corporate strategy. Apple leveraged a set of unique capabilities, assets, and strengths to provide its integrated iTunes/iPod system (Cooper 2011):

- ability to vertically integrate,
- expertise in hardware, software, and design,
- ability to simplify complex systems,
- broad and effective distribution channel system,
- loyal customer base.

As a last remark in this survey on the iPod as a multidisciplinary topic of research, we mention that the introduction and diffusion of portable digital music players was a key factor in the dramatic evolution of the music industry, together with the development of the Internet and of peer-to-peer (P2P) networks (Bhattacharjee et al. 2009). It has even changed long standing socio-cultural habits. For instance, it has begot a shift to mixed bundling where *songs* are bought rather than albums (Elberse 2010).

3.4. Research Methodology

The way we operationalize the cannibalization detection and measurement in this case is through the concept of parameter instability of a stochastic process of sales generation (cf. Section 2.3.2). We model this process with time series econometrics. The reader unfamiliar with the terminology of time series analysis can find a glossary of the most relevant terms in the Appendix (p. 177), as an aid to understanding our application of this quantitative approach.

We assume that a stochastic sales-generating process exists for each product line and that the parameters of such a process can be estimated with an econometric methodology. That is, we assume that the behavior of a product line's sales over time can be modeled econometrically, and that, once such a model is properly specified and estimated, it will provide an accurate representation of the real behavior of a product line's sales. Sales cannibalization can then be interpreted as the "negative" changes in the victim's sales-generating process produced by the presence of the cannibal entities, by virtue of which sales are reduced in terms of level and/or growth rate. Formally, we view cannibalization as a negative shock to a stochastic sales-generating process, a shock which can be taken out of the noise function of the model and treated as deterministic.

Two conditions must be met in order to detect sales cannibalization in this fashion. First, the existence of a shock must be verified in terms of a statistically significant change in some of the parameters of the victim's sales-generating process. For instance, the analysis could reveal a sudden reduction in the mean of the series. Second, the shock must be somehow ascribable to the cannibal entity. The second aspect refers to the need of proving causation between the existence of a shock and an event related to the cannibal. This can be done to some degree by considering the chronology of events and evaluating possible alternative explanations. If we ascertain the presence of a structural change in the quarter in which the cannibal entity was launched, the existence and effects of other simultaneous events which could have led to the same reduction in sales cannot be excluded.

Once a structural change is plausibly attributed to a potentially cannibalistic event, we can compute total cannibalization as the difference between the observed sales (i.e., the behavior of the victim's sales-generating process as it was actually observed) and the sales predicted by removing the effects of that structural change from the estimated model. Given the key role that time series econometric models play in this process, we describe their general form in the next few paragraphs.

When considering a stochastic process such as sales generation, it is useful to think of it as the sum of several components with different properties. From this perspective, a stochastic dynamic model of a process has the following generic form (Enders 2010, p.181):

$$Response = stationary\ components + nonstationary\ components + noise$$

The stationary components are the autoregressive and moving-average terms, which represent the effects on the current response of respectively lagged output values and past disturbances, and beget the serial or seasonal correlation in the series. The nonstationary components are deterministic or stochastic trends, structural changes, deterministic or stochastic exogenous variables. The noise is the unexplained or truly random dynamic in the process. Table 3.4 recapitulates the main modeling decisions to take when designing a time series econometric model.

The statistical difficulty is that real processes are the outcome of a complex set of simultaneous and interacting elements. Structural changes such as those we are looking for are seldom the only nonstationary component. The sales process of any product or service will possibly be affected by seasonality, macroeconomic shocks, etc. Therefore, on the one hand, the cannibalization effect may be confounded by the other nonstationary components and not appear evident. On the other hand, alternative plausible explanations (and, hence, model specifications) may exist for the same observed process.

The challenge is not only the multiplicity of potential explanations but also their interdependence. Statistical test designed to ascertain the hypothesized presence of one component might be biased by the actual presence of the other. The most commonly used test to ascertain if a process possesses a unit root, for instance, is the Dickey-Fuller test, and structural breaks will bias this test towards nonrejection of the unit root hypothesis (Enders 2010, p.227). Therefore, appropriate extensions of the test must be employed.

In the context of an econometric model, sales cannibalization can be represented in various ways. With a *univariate* model, the response is the sales volume of either the cannibal or the victim, the other is an explanatory variable, and sales cannibalization is a nonstationary component in the regression. In a *multivariate* model, sales of both cannibal and victim are dependent variables, and sales cannibalization is represented by the terms linking the two processes, that is, describing the simultaneous and lagged effects between the two dependent variables.

In the univariate case when the victim's sales process alone is formalized, a convenient form of stochastic dynamic model to tackle cannibalization measurements is a structural break model. This model explains an observed structural change in the process (i.e., a change in one or more process parameters, such as mean, slope, autoregressive parameters, etc.) as the consequence of an exogenous intervention (or break) impacting it at a discrete point in time (the intervention date or breakdate). The cannibalistic effect is represented by the deterministic term in the victim's sales response which describes the (negative) shift in victim's sales upon the cannibal's market launch.

Table 3.4 Main modeling decisions in time series analysis

	Model components	Modeling choices
Stationary	Intercept	With or without an intercept term
	Serial correlation	Model family and orders: AR(p); MA(q); ARMA(p,q)
	Seasonality	Seasonal ARMA terms; seasonal differencing; seasonal dummies
Nonstationary	Deterministic trend	Linear or polynomial
	Stochastic trend	Order of differencing: ARIMA(p,d,q)
	Structural break(s)	Break date(s) Effect pattern: step, slope, pulse, or a combination; sudden or gradual impact

With regard to the generic structure of an econometric model given above, the structural break is a nonstationary component (since it alters the long-run mean of the process). In its most basic form, a structural change model qualitatively looks as follows:

$$Response = stationary\ components + structural\ change\ component + noise$$

The structural change component models the impact of the intervention on the output by means of a deterministic function of time and the relative coefficient to be estimated. One of the most commonly employed functional forms is the step function, whereby the pattern of the intervention effects is that of a "jump". The step function takes on the value of 0 before the break at time and 1 thereafter:

$$DS_t^{(\tau)} = \begin{cases} 0, t < \tau \\ 1, t \geq \tau \end{cases}$$

If we let c_0 be the coefficient of the structural change term, representing its impact effect, and allow this effect to be delayed by d lags (the power coefficient of the lag operator L), a generic structural break model is represented by the following regression (extending Enders 2010, p.275):

$$y_t = a_0 + A(L)y_t + c_0 L^d DS_t^{(\tau)} + B(L)\varepsilon_t,$$

where *A(L)* and *B(L)* are the autoregressive and moving average polynomial operators which formalize the stationary components of the process.

3.5. Data

For this case study, we gathered the publicly available sales figures published quarterly by Apple in its 10Q and 10K SEC filings.[25] The second column in Table 3.5 describes these financial data. To understand Apple product strategies and generate our list of tentative breakdates, we gathered the official press releases in the iPod/iPhone/iPad product lines. From these press releases, we extracted and categorized a list of new-product events. The third column in Table 3.5 summarizes these data while the full list of events is reported in the Appendix.

Table 3.5 Description of the data collected for Case I

Data	iPod sales time series	New-product events
Data collection	Secondary data collection	Secondary data collection
Data type	Quantitative	Qualitative & quantitative
Sources	10K & 10Q SEC filings	Apple press releases
Data points	50 x 2 (unit sales & ARPU)	65
Time span	Q1 2002 – Q2 2014	FY 2001 – FY 2014

Nominal revenues from the financial reports were deflated to account for the overall development of prices over time in the industry. Since Apple is a US-located manufacturer, we decided to employ as deflator a Producer Price Index (PPI) provided by the US Bureau of Labor Statistics.[26] A PPI measures the average change over time in the selling prices received by domestic producers for their output. Among the available indexes, two appear relevant for the adjustment of revenues generated by a portable digital music player:

- "Computer and Peripheral Equipment Manufacturing" (NAICS code 3341)
- "Audio and Video Equipment Manufacturing" (NAICS code 3343)

We could not find theoretical, logical, or practical reasons to prefer one price index to the other. Moreover, since the deflator choice is a recognized issue in time series analysis, with repercussions on empirical results (Peterson & Tomek 2000), we believed that comparing findings obtained with different deflators could be a helpful validation device. Accordingly, we produced two deflated series, which we called "Real ARPU (1)" and "Real ARPU (2)", and employed both throughout our analysis.

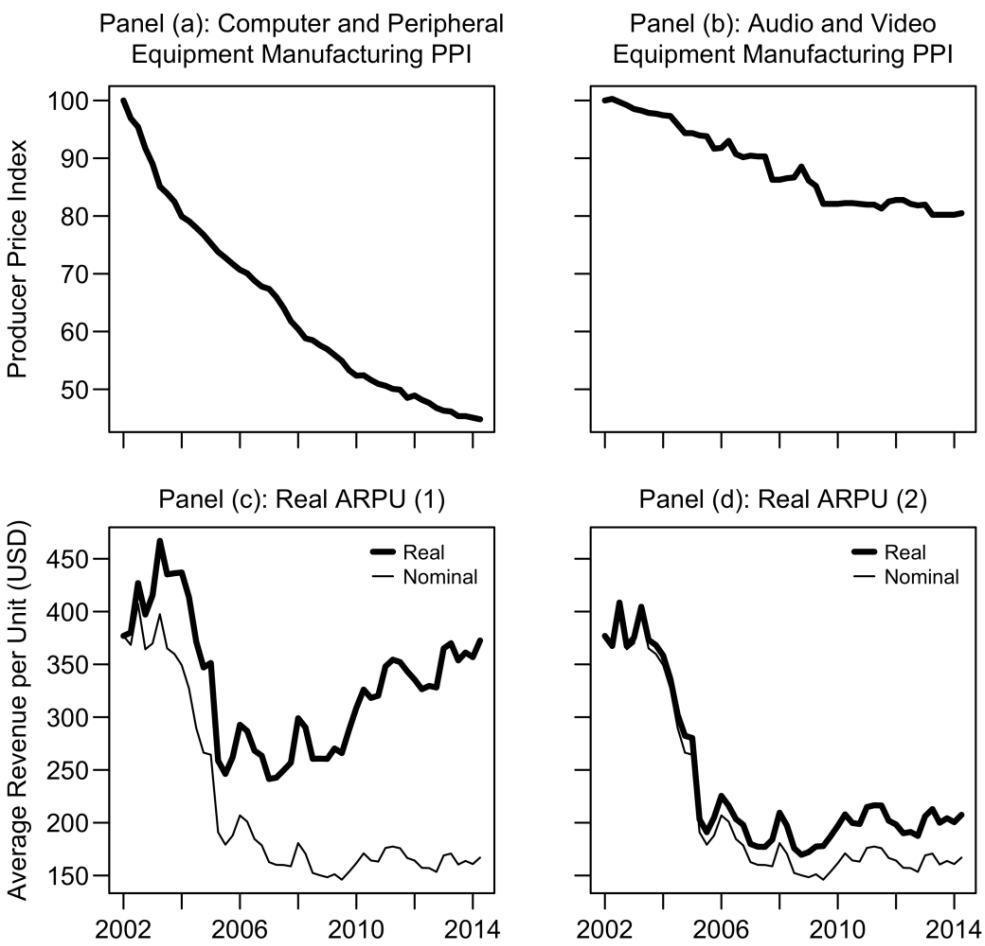
As the multipanel in Figure 3.4 shows, the two price index curves are both monotonically decreasing, albeit at a different rate (Panels *a* and *b*), so that the two deflated series differ in their trend component (Panels *c* and *d*). Manufacturers in both the computer and audio/video industries have experienced decreasing prices, but at a much higher rate in the former. Prices of computer and related peripherals have more than halved in the time span considered in our analysis (Panel *a*). The effects of the transformation are therefore stronger when using this price index: a positive increase in the slope of the trend is clearly visible in comparison with the original values in current dollars (Panel *c*). The second deflator has a more subtle effect and seems to merely counter the slightly decreasing tendency of the nominal series from around 2005 (Panel *d*).

The sources from which we extracted the set of new-product events considered in our analysis were the official press releases published by Apple through its corporate website.[27] The full catalogue of events (reported in the Appendix) comprises 65 product-related events in the product categories relevant to this case study. Based on the criteria explained above, we reduced our list of tentatively cannibalization-relevant events to the subset presented in Table 3.6 (cf. also Table 3.1 and Table 3.3).

[25] Source: http://investor.apple.com/sec.cfm

[26] http://www.bls.gov/ppi/

[27] https://www.apple.com/pr/library/



Note: The base period for both price indices is Q1 2002 (i.e., $PPI_{2002.Q1} = 100$)

Figure 3.4 Producer price indexes selected as deflators (Panels *a* and *b*), and resulting ARPU series in constant dollars (Panels *c* and *d*)

Table 3.6 Selected new-product events to be tested as tentative breakdates

Product line	Product model	Event	Announcement date	Release date
iPod	Mini	Introduction	6 January 2004	20 February 2004
iPod	Shuffle	Introduction	11 January 2005	11 January 2005
iPod	Mini	Discontinuation	7 September 2005	
iPod	Nano	Introduction	7 September 2005	7 September 2005
iPhone	1st Generation	Introduction	9 January 2007	29 June 2007
iPod	Touch	Introduction	5 September 2007	28 September 2007
iPad	1st Generation	Introduction	27 January 2010	3 April 2010
iPad	Mini	Introduction	23 October 2012	2 November 2012

Note: The complete set of events from which this subset was distilled is reported in the Appendix.

3.6. Empirical Findings

3.6.1. Exploratory Analysis

The *exploratory* data analysis is a preliminary investigative phase which precedes the selection and estimation of econometric models (*confirmatory* analysis) and provides guidance to it. In this phase, the researcher eyeballs the characteristics of the series. The visual tools we have employed to inspect the iPod unit sales and ARPU series were the following:

- time plots,
- seasonal plots,

- box-and-whisker plots,
- autocorrelograms.

We used these graphical instruments to investigate not only the original data series but also smoothers and transformations (first and seasonal differences). This allowed us to gain some additional perspectives on key attributes of the data generating process, such as nonstationarity and seasonality. In this section, we first provide some illustrative examples of how we perused each of these graphical instruments, then we summarize the outcomes of the whole exploratory phase.

The starting point of the exploration was the simple inspection of the original data. To highlight the general behavior of the trend component (i.e., the long-term tendency), we plotted a smoother together with the original series. A smoother is a nonparametric model of an unknown function, where the desired level of smoothness of the resulting curve is the only thing that needs to be set. In our analysis, we applied a smoother based on a locally weighted polynomial regression (Cleveland 1981).

Figure 3.5 shows the original "ARPU real (1)" data series with its smoother and the noise left by it (i.e., the difference between the original series and the smoother). The *f* parameter of the smoother is the proportion of neighboring data points considered to obtain each value of the smooth line. The larger its value, the smoother the obtained curve will be. What we may observe, using a smoother with *f* parameter of 0.15, is a clear drop in level occurring between 2004 and 2006, a positive slope of the trend in the periods preceding and following the drop, and a possible decrease in variance over time (the noise is larger in the first few years).

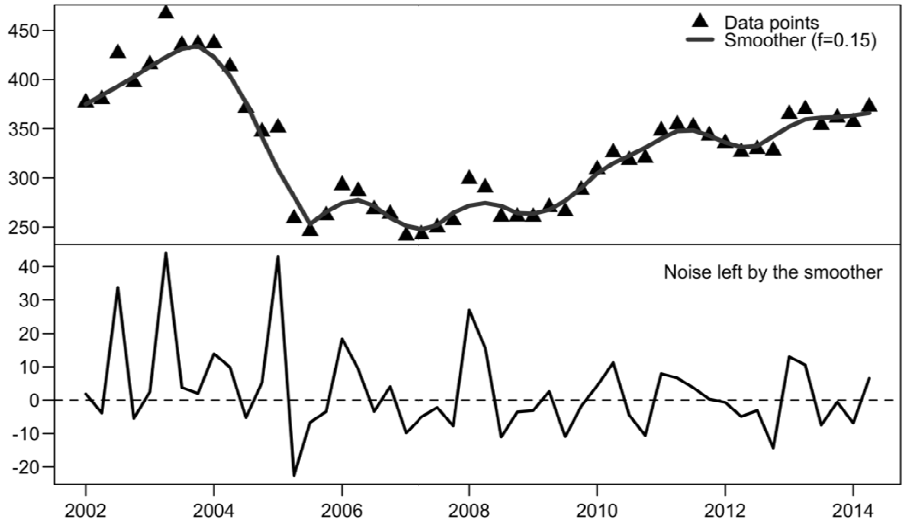


Figure 3.5 The original ARPU real (1) series with a locally weighted polynomial smoother applied to it (panel above), and the noise left by it (panel below)

The seasonal characteristics of a series can be investigated by plotting the data points in each season separately (seasonal plots), and by employing box-and-whisker plots[28] for the data points grouped by season. In our context, the seasons are the different quarters in a fiscal year.

In the case of the unit sales series, the first quarter peaks are visible in the time plot in Figure 3.1 already. The seasonal plots (Figure 3.6) and box-and-whisker plot (Figure 3.7, Panel *a*) confirm the

[28] A *box-and-whisker plot* graphically represents a five-number summary of the data. The median (50th percentile) is represented by the thick black solid line in the rectangle whose upper and lower sides are the upper and lower quartiles (25th percentile and 75th percentile). The horizontal lines outside of the rectangle are the so-called fences, located at 1.5 times the interquartile range (i.e., the range between lower and upper quartile). Outliers are defined as values lying outside the fences and, if present, are depicted as circles.

larger magnitude of the first quarter. The three remaining quarters are rather similar to each other. This form of seasonal pattern is commonly found and easily explained by the fact that the first quarter in the Apple fiscal calendar comprises the shopping period *par excellence*: Christmas. Christmas does not apparently affect ARPU: the quarters' median levels are roughly the same and the value distributions similar (Figure 3.7, Panel *b*).

A key aspect in time series analysis is serial correlation, i.e., the carryover effect – of the response variable or of a random shock – from one period to a later one. There are several justifications for the autoregressive behavior of variables in models of market response, and autoregressive pattern can be determined by the decaying impact of many marketing actions (Hanssens et al. 2001, p.262). The main instruments to investigate serial correlation are the sample autocorrelation and partial autocorrelation of kth order, which measure the degree of correlation between two observations k periods (lags) apart. These are the pillars of the model identification methodology proposed by Box and Jenkins (Box et al. 1976). Each autoregressive moving average model has a unique set of theoretical autocorrelation and partial autocorrelation functions (ACF and PACF). We can therefore try to infer plausible model specifications from an inspection of the sample autocorrelation and partial autocorrelation functions. We aim at recognizing the patterns of theoretical ACF and PACF of archetypical ARMA models.

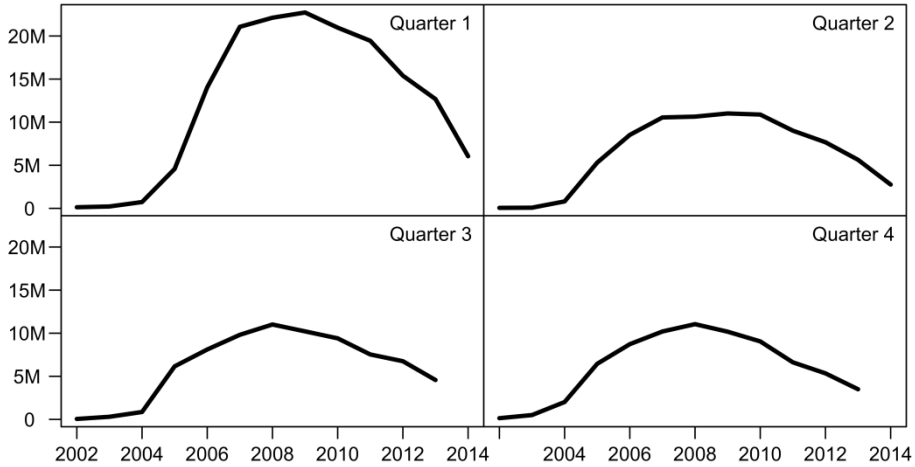


Figure 3.6 Seasonal plots for the unit sales series

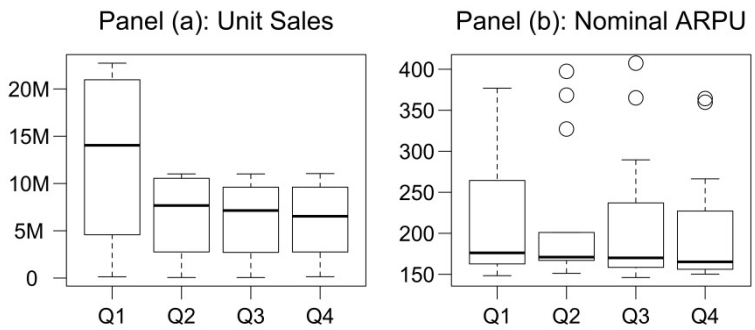


Figure 3.7 Box-and-whisker plots for the unit sales (Panel *a*) and nominal ARPU series (Panel *b*)

Moreover, the sample ACF and PACF can be used to gauge other aspects of the data generating process as well. The ACF will exhibit a slow decay whenever the process includes one of the following: a stochastic trend (unit root), a near-unit root autoregressive term, a deterministic trend, or a structural break. Specifically, if the ACF of a series slowly decays because of a stochastic trend, the ACF of its first difference should be insignificant or attenuate exponentially (since differencing turns a unit root process into a stationary one). Differencing will not act in this straightforward way if the slow decay in the ACF is actually due to another factor. Finally, in the presence of seasonal correlation, the ACF will have peaks every s lags (s being the number of seasons in a year).

We inspected the correlograms (i.e., the plots of the sample ACF and PACF) for all the time series under investigation and their first differences. Figure 3.8 shows the sample autocorrelations and partial autocorrelations for the Unit Sales and Nominal ARPU series, and their first differences. The Unit Sales series (Panel *a*) does not reflect any easily recognizable pattern, but seasonal autocorrelation is evident in the peaks at lag 4 and 8. In other words, unit sales in a quarter appear correlated with unit sales levels in the same quarter a year and two years before. Differencing does not remove autocorrelation but instead enlarges its peaks and makes it oscillate, so that unit root nonstationarity does not seem plausible (Panel *b*). The rather slowly decaying shape of the sample ACF for the Nominal ARPU series (Panel *c*) and the fact that differencing produces a stationary series (Panel *d*) could indicate the presence of a unit root in the data generating process of that series.

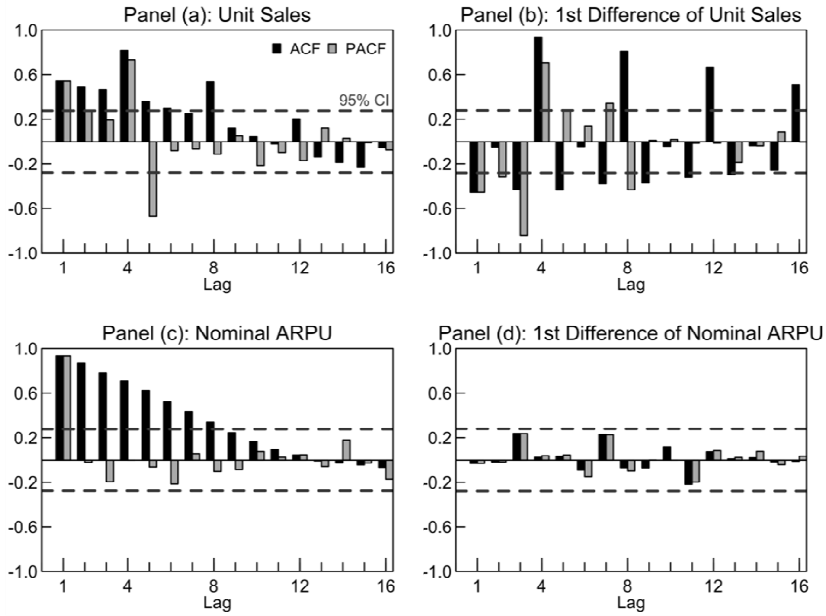


Figure 3.8 Sample autocorrelations (black bars) and partial autocorrelations (grey bars) for the Unit Sales and Nominal ARPU series, and their first differences

In the following table we summarize the clues obtained by investigating each series with the whole array of exploratory tools presented up to now. These clues served as the starting point for the selection of plausible model specifications in the subsequent confirmatory analysis. They were tested formally during that phase, as described in the next section. Nominal and real revenues have a similar behavior and distinguish themselves only for the slope of the long-run trend (which depends on the chosen deflator, as we explain above in Section 3.5).

	Unit Sales	**Nominal ARPU**	**Real ARPU (1)**	**Real ARPU (2)**
Trend	Bell-shape	Slightly negative slope	Positively sloped	No
Autocorrelation	Significant until lag 6 and at lag 8	Slow decay		
Seasonality	Peaks at Q1 Seasonal correlation at 1 and 2 years	No		
Breaks	Inflection points between 2004-2005 and 2008-2009	Dramatic drop between 2004-2006		
Unit root hypothesis	Not plausible	Plausible		
Heteroskedasticity	Q1 peaks start from 2006, become larger until 2009, and then decay	Two or possibly three regimes with 2005 and 2009 as points of change		

3.6.2. Confirmatory Analysis

In the confirmatory stage, we verified the presence and extent of cannibalization statistically. Using time series analysis, we assessed whether the new-product events listed in Table 3.6 produced

structural changes in the iPod sales-generating process, and estimated the type, sign, and magnitude of each.

We took the outcomes of the exploratory phase as the input for the testing and model identification procedures. We first performed two pretesting steps by verifying statistically the presence of breaks and unit roots in the data generating process. Some complications arose due to the interdependence between the presence of structural breaks and the power of unit-root tests. To resolve this issue, we relied on a specific procedure, which tests the unit root hypothesis conditional on the presence of a known break. Finally, we estimated the econometric models which enable calculating the magnitude of cannibalization, in terms of both sales units and their average revenues.

Structural break pretest

Our goal is verifying if the new-product events listed in Table 3.6 represent statistically significant structural changes in the iPod sales-generating process. Our procedure relies on the Chow test, which tests the null hypothesis of no structural change against the alternative of *one* change at a *known* date (Chow 1960). However, we had to deal with *multiple* potential breaks at known dates. One straightforward solution is to simply apply the Chow test on each tentative break separately and independently. A single-break test is still consistent in the case of multiple breaks, but its power in finite sample may be poor and some multi-break configurations difficult to be detected (Perron 2006). Moreover, since we have a small sample with tentative breaks which lay between 2 and 10 quarters apart, we cannot expect the Chow test applied independently on each breakdate to validate it. As a matter of fact, if we assume to test against a false breakdate with some neighboring true breakdates, we may expect the test to pick up the effects of the latter. It would correctly reject the null of parameter stability for the process but would provide only doubtful evidence on the validity of the specific alternative.

Indeed, the Chow test employed in this way only rejects the alternative in few cases, mainly with regard to the introduction of the iPad Mini, as it can be seen in Table 3.9 where the outcomes of the test are summarized. These results cannot be used to discriminate between the breakdates. In fact, all product events appear to produce a significant structural change at a 95% confidence level or higher when the level and slope effects are considered together.

Therefore, we have devised an iterative procedure to test the set of candidate breakdates more thoroughly. The procedure is illustrated in Figure 3.9. We first test each tentative structural change separately. Among those which the test qualifies as significant at conventional levels, we select the "dominant" change, that is to say, the change which allows the greatest reduction in the sum of squared residuals. We subsequently adjust the series by removing the effects of this dominant break and delete it from the set of tentative breakdates. The next iteration begins by testing each remaining date in this smaller set of candidates separately. The procedure ends as soon as either one of the two following conditions is met: no significant break can be found anymore among the remaining candidates, or the set of remaining candidates is empty. We repeated this procedure for each series using the events in Table 3.6 as the initial set of candidates.

As the results summarized in Table 3.10 show, the iterative application of the Chow test allowed us to have a more accurate perspective on the significance of the breaks. In particular, the introductions of the iPod Mini and iPod Shuffle seem to be the overall dominant events, since they correspond to the overall dominant or sub-dominant breaks in most series/effect combinations. However, we must conclude that no tentative break can be discarded altogether as insignificant. The launch of the iPod Touch appears to be an important inflection point in the unit sales series (in terms of slope change) with the iPhone being another potential milestone (in terms of slope and level). The iPad and iPad Mini also seem to have affected unit sales and revenues, albeit playing a less important role, since they were never picked as dominant by our iterative procedure.

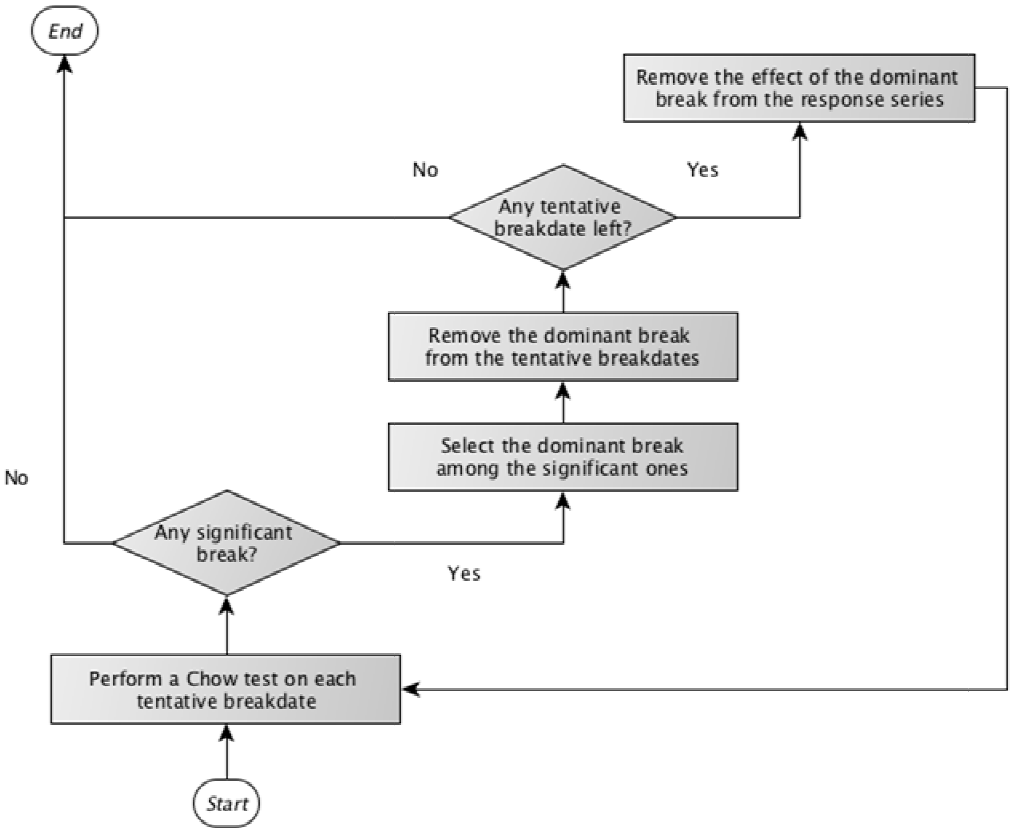


Figure 3.9 Pretesting procedure for the identification of plausible structural breaks among the new-product events considered as tentative breaks

Table 3.7 Significance levels[a] of the Chow test[b] applied independently to each tentative breakdate (i.e., product event)

	Time series			
Product event[c]	**Unit Sales**	**Nominal ARPU**	**Real ARPU (1)**	**Real ARPU (2)**
Break effect = level change				
Mini	***	***	***	***
Shuffle	***	***	***	***
Nano	***	***	***	***
Touch	***	***	ins.	***
iPhone	***	***	ins.	***
iPad	.	**	ins.	*
iPad Mini	ins.	ins.	ins.	ins.
Break effect = slope change				
Mini	***	***	***	***
Shuffle	***	***	***	***
Nano	***	***	***	***
Touch	***	***	***	***
iPhone	***	***	***	***
iPad	***	*	*	*
iPad Mini	***	ins.	ins.	ins.
Break effect = level and slope				
Mini	***	***	***	***
Shuffle	***	***	***	***
Nano	***	***	***	***
Touch	***	***	***	***
iPhone	***	***	***	***
iPad	***	***	***	***
iPad Mini	**	*	*	*

Notes:
a) Significance levels: "***" = 0.1%; "**" = 1%; "*" = 5%, "." = 10%, "ins." = not significant at any conventional level.
b) Hypothesis for the test: H0 = no structural change; H1 = structural change at the product event date.
c) Product line is iPod unless otherwise stated.

Table 3.8 Results of the iterative application of the Chow test on the set of tentative breakdates at the 5% significance level

	Time series			
Product event[a]	**Unit Sales**	**Nominal ARPU**	**Real ARPU (1)**	**Real ARPU (2)**
		Break effect = level change		
Mini	**1**	**1**	**1**	**1**
Shuffle		**2**	**3**	**2**
Nano	**2**			
Touch				
iPhone				
iPad			**2**	
iPad Mini	**3**		**4**	
		Break effect = slope change		
Mini	**3**	**1**	**1**	**1**
Shuffle	**2**	**3**	**3**	
Nano	**5**			
Touch	**1**			
iPhone				
iPad	**4**	**2**	**2**	
iPad Mini				
		Break effect = level and slope		
Mini		**2**	**2**	**2**
Shuffle	**1**	**1**	**1**	**1**
Nano				
Touch				
iPhone	**2**			
iPad				
iPad Mini				

Notes:
Coding of test outcomes: 1 = dominant break, 2 = second dominant break (i.e., dominant break conditional on the first dominant break), etc.; blank cell for insignificant breaks.
a) Product line is iPod unless otherwise stated.

Unit root pretesting

One fundamental decision in modeling a time series is whether to apply some differencing prior to the steps of model identification and estimation. Time series analytical methodologies namely impose the constraint of stationarity on the series under study. That is to say, we need to find out if the series is nonstationary with a stochastic trend (also called an "integrated" or "difference-stationary" series). Should that be the case, differencing of the values is required to obtain a stationary series. The analysis can then proceed with this newly obtained series, which will express the response in level changes from one period to the next and not in absolute levels anymore.

The traditional testing procedure to ascertain if a series has a stochastic trend is the Dickey-Fuller test. In this test, the null hypothesis of nonstationarity – or "unit root hypothesis" – is tested against the alternative of stationarity. However, this test is biased towards nonrejection of the unit root whenever the series contains a structural change (Enders 2010, pp.227–229), the presence of which is our underlying assumption for the whole analysis. Therefore, we perform an alternative unit-root testing procedure designed to take into account the presence of a structural break at a known date – the Perron Test (Perron 1989). Perron has provided a formal procedure and has produced the critical values needed to assess the null hypothesis of a difference–stationary process with a break against the alternative of a trend–stationary process with a break. The procedure allows under both hypotheses for a structural break consisting of a change in the level of the series, in the slope of the trend function, or both. In essence, the model is estimated under the alternative hypothesis of stationarity and then the t-statistic for a unitary first autoregressive coefficient is compared against Perron's critical values.

Table 3.9 Results of the Perron Test conditional on an exogenous break at Q2 2004 (i.e., $\lambda = 0.2$)

	Breaking level		Breaking level and trend	
Time Series	***t* statistic**	***Q(8)***	***t* statistic**	***Q(8)***
Nominal ARPU	-4.168	0.068	-4.585	0.151
Real ARPU (1)	-3.844	0.276	-3.967	0.291
Real ARPU (2)	-3.850	0.122	-4.142	0.237

Notes:
t statistics for the null hypothesis that the process has a unit root.
Q(8) is the p-value for the Ljung–Box Q-statistics of the residual autocorrelations for lags 1 through 8 (H0: no autocorrelation).

Table 3.10 Critical Values of the Perron Test with $\lambda = 0.2$

	Level of significance		
	1%	**5%**	**10%**
Breaking Level	-4.39	-3.77	-3.47
Breaking Level and Trend	-4.65	-3.99	-3.66

We consider the quarter in which the iPod Shuffle was launched into the market (2nd Quarter of Apple Fiscal Year 2004) as the breakdate for the test. Exploratory analysis, historical pricing considerations, and the structural break pretest make it the most plausible choice. As the visual inspection of time plots and smoothers has shown, all ARPU series exhibit a conspicuous drop in level occurring between 2004 and 2005, possibly with a simultaneous change in the slope of the trend. Moreover, the iPod Shuffle represents the lowest price point in the iPod product line, and it is thus reasonable to expect that its introduction has greatly affected average revenues. In accordance with the apparent behavior of the series at that inflection point, we have estimated two of the model specifications suggested by Perron: change in level, and change in level *and* trend. Moreover, since the test is only valid when the residuals from the estimated models are not serially correlated, and our exploratory analysis revealed the presence of serial correlation in the series, we estimated the augmented form of the regression with four lags. The test statistics we obtained using OLS are reported in Table 3.9. We verified the residuals' serial correlation using the Ljung–Box *Q*-statistics (Ljung & Box 1978), whose results are also reported in Table 3.9. At the 95% confidence level, we can exclude autocorrelation up to the eighth lag.

Finally, to have a response on the unit-root hypothesis, the *t*-statistic we obtained (Table 3.9) must be compared against the critical values for the test given by Perron (Table 3.10). Whenever the *t*-statistics are greater (in absolute value) than the critical values at a given significance level, the null hypothesis of a unit-root in the process can be rejected at that level. This happens in all but one case at the conventional 5% level already, that is, the unit-root hypothesis can be rejected at the 95% confidence level for all series under the assumption of a structural break affecting the level of the series, and for two out of three if we allow the trend to break as well. In the case of the Real ARPU (2) series, it can only be rejected at the 90% confidence level. Since we are fundamentally testing the same process repeatedly (i.e., the original realizations in current dollars and then two transformations thereof – the two deflated series), we believe that the Perron Test provides adequate evidence against the presence of a stochastic trend. In light of this result, we can avoid to perform any differencing of the time series to make them stationary.

Model Identification and Estimation

The results from the exploratory analysis and from the two pretests on structural breaks and unit roots fed the subsequent step of model identification. In this phase, we tested the structural break hypotheses by fitting econometric models on the data series.

We looked for model specifications which could balance goodness of fit and parsimony of parametrization. A good model is "close" to the (unknown) true data generating process. On the one hand, it should fit the data well, i.e., provide predictions close to the observed data points. On the other hand, since these observations are *one particular realization* of the data generating process, goodness of fit should not be the only goal at the expense of general validity. Adding parameters to the regression will always increase goodness of fit but could lead to overparametrization. The model would then represent the unique characteristics of the sample rather than those of the underlying data generating process. Overparametrization has statistical repercussions as well, since it will lead to higher estimation errors.

Therefore, as a guiding principle, we tried to identify model specifications which were well fitting *and* parsimonious. Formally, we implemented this principle in three ways: using Maximum Likelihood estimators (MLE) instead of Ordinary Least Squares (OLS), employing the Akaike Information Criterion (AIC) as a criterion to screen alternative model specifications, and setting an upper bound to the size of the model in terms of estimated parameters.

Maximum Likelihood is the estimation technique by virtue of which the parameter values are calculated to maximize the probability of obtaining the observed data, and not, as it is the case with OLS, goodness of fit. The Akaike Information Criterion is a numerical model selection criterion which aims at optimizing the trade-off between parsimony and fit. It takes into account that each additional estimated parameter entails both a benefit (fit improvement) and a cost (increase in parameter uncertainty). AIC has better small sample property than the Bayes Information Criterion (Enders 2010, pp.71–72). Finally, given the limited size of our sample, we set an arbitrary upper bound of nine parameters to the size of our model, in order to stay above a minimum ratio of five observations per estimated parameter.

Beyond the balance between parsimony and fit, a good model should extract as much information as possible from the data and provide estimates of high quality. We tested the residuals of each model to ascertain whether they presented any serial correlation, heteroskedasticity, or nonnormality (which would all be signs of systematic components erroneously not considered in the model specification). The quality of the estimated coefficients was evaluated in terms of their statistical and mathematical properties, videlicet, significance and invertibility. We have considered only models whose estimates were all significant at conventional levels and removed any insignificant coefficient from the model specifications. Moreover, autoregressive and moving-average parameters had to imply respectively stability and convergence.

We modeled new-product launches with deterministic series. Since we assume a potential cannibalistic impact on both the level and trend of the iPod sales, we employed multiple deterministic indicator series to represent the simultaneous effects of a given breakdate . Therefore, for each new-product launch, different types of deterministic series were constructed and tested to ascertain the effects on the response variable. For level effects, we constructed step functions (permanent effects) and pulse functions (temporary effects). For effects on the trend, we constructed linear trend series. A step function takes on a value of 0 for $t <$ and of 1 for t . A linear trend function is 0 for $t <$ and $t -$ for t .

We experimented with the design of the deterministic series in order to provide the best representation of an event or a set of events. As a case in point, let us consider the downward extension strategy of Apple between 2004 and 2006. The introductions of entry-level iPod models (Mini, Shuffle, and Nano) happened in a short time span and the models were closely related to each other. In fact, the iPod Nano *replaced* the iPod Mini. We thus modeled all three new-product events jointly with a gradually increasing function, where the change start at the time of the introduction of the iPod Mini and reach unity (i.e., full effect) at the time of the Nano release (Figure 3.10).

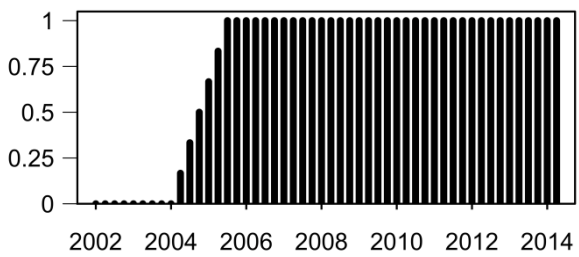


Figure 3.10 Gradually changing deterministic function used to model the effects of the successive introductions of the entry-level iPod models Mini, Shuffle, and Nano between Q2 2004 and Q3 2005

Table 3.11 shows the models we eventually selected and estimated based on the criteria just described. All models have an intercept term and a deterministic trend. From the point of view of autocorrelation, only moving-average (MA) terms were included in the models: the Unit Sales and Nominal ARPU series at lag 4; the Real ARPU series at lag 1. The Unit Sales series have two additional deterministic elements. One is a seasonal deterministic term for the 1st quarter, which takes into account the extra sales in the winter season. The other is an intervention in the quarter in which the iTunes Music Store was launched, an event which produced a jump in the series.

The most important outcomes for our research goals are the statistically significant structural changes detected in the series. The introduction of entry-level iPod models (the 1st generations of iPod Mini, Shuffle, and Nano) corresponds to a highly significant break in all series. It produced a jump in terms of unit sales and a drop in terms of ARPU. In the Real ARPU (1) series, a significant decrease in the trend slope was found as well. Further breaks in the trend of the Unit Sales series were the market launches of the iPhone and iPad Mini, both of negative sign. All three average revenues series experienced a positive increase in the trend slope when the iPod Touch was released.

The diagnostics prove that these model estimates produce residuals which are uncorrelated (as the Ljung-Box and Durbin-Watson tests testify) and normal (Jarque-Bera and Kolmogorov-Smirnov tests). Therefore, we might be relatively confident to have extracted most information from the series. The significant Jarque-Bera statistic for the Unit Sales series is the only contradictory results. However, we judge it a spurious result, since both the Kolmogorov-Smirnov test and a perusal of histogram and normal Q–Q plots of the residuals indicate an approximately normal distribution.

Table 3.11 Estimated models

	Unit Sales[a]	Nominal ARPU	Real ARPU (1)	Real ARPU (2)
Coefficients[b]				
a_0	4.35*** (.069)	390*** (4.23)	391*** (12.87)	386*** (6.61)
b_0	0.081*** (.012)	-3.68*** (.679)	6.22** (2.41)	-2.50* (1.05)
θ_1			0.443** (.148)	0.329* (.151)
θ_4	0.398*** (.109)	-0.293* (.145)		
c_{Q1}	.703*** (.061)			
Structural breaks				
Breaks in level				
iTunes Music Store	1.21*** (.098)			
Entry-level iPods	2.25*** (.165)	-142*** (11.76)	-182*** (25.76)	-144*** (18.05)
Breaks in trend				
iPod Mini			-6.56* (2.61)	
iPhone	-0.108*** (.014)			
iPod Touch		3.94*** (.816)	4.80* (2.00)	3.43** (1.27)
iPad Mini	-0.158*** (.026)			
Diagnostics[c]				
Q(4)	0.899	0.601	0.599	0.611
Q(8)	0.944	0.325	0.429	0.473
DW	0.722	0.327	0.954	0.907
JB	0.000	0.318	0.764	0.492
KS	0.730	0.401	0.628	0.625

Notes:
Standard errors in parenthesis.
(*) denotes significance at the 5% level, (**) at the 1%, (***) at 0.1%.
a) estimated on the logged unit sales series
b) a_0 is the intercept term; b_0 the slope of the deterministic trend; θ_L is the MA coefficients at lag L; c_{Q1} is the coefficient of the seasonal deterministic series for the 1st quarter.
c) For all diagnostic tests, p-values are reported. *Q(n)* is the Ljung-Box tests for residual autocorrelations at lag *n* (Ljung & Box 1978); DW is the Durbin-Watson test for 1st order serial correlation (Durbin & Watson 1950); JB and KS are the Jarque-Bera (Jarque & Bera 1987) and Kolmogorov-Smirnov (Massey Jr 1951) tests for normality.

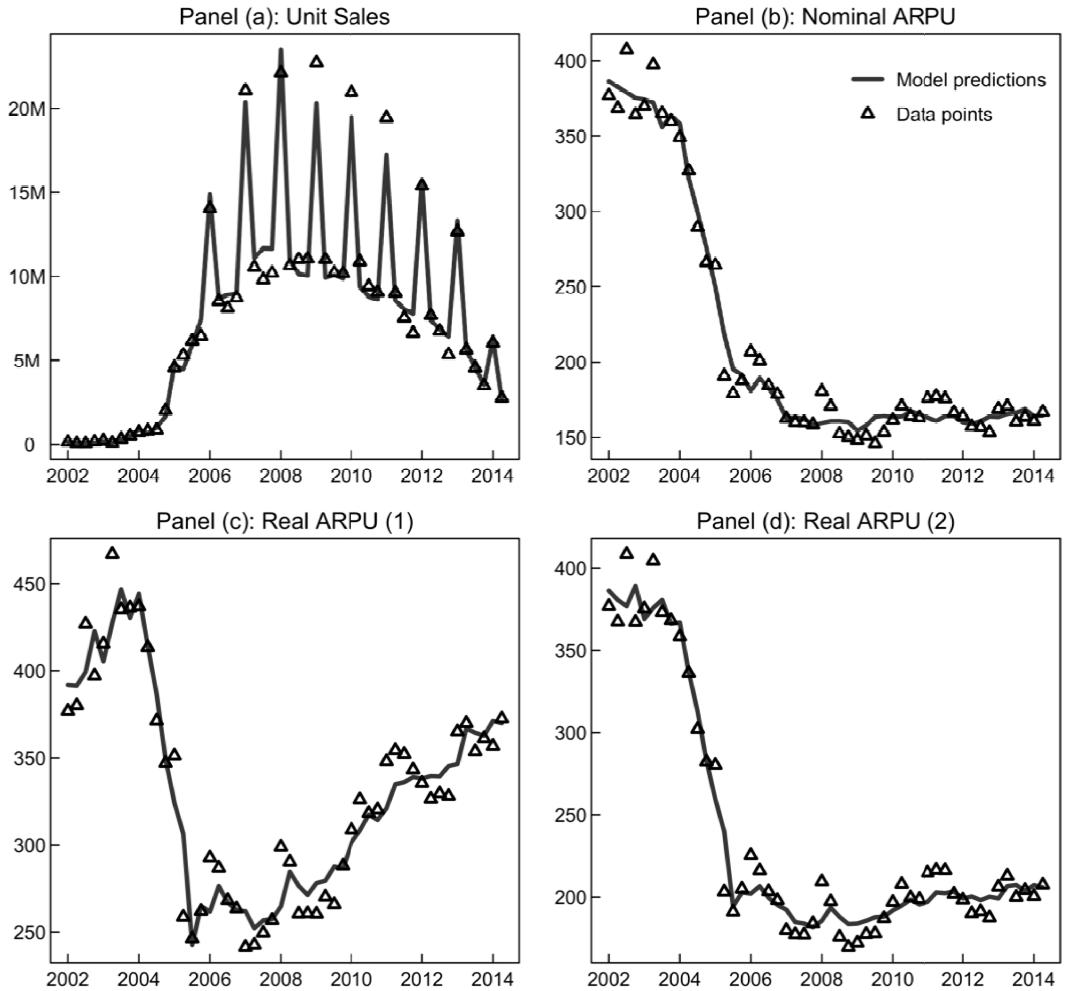


Figure 3.11 Time plots of the original data points vs. predictions by the estimated models

3.6.3. Cannibalization Effects and Market Penetration

We now turn to the effects of the structural breaks we identified. The introduction of Entry-level iPods is an event which produced highly significant effects on all series. From the point of view of volume, entry-level models appear largely responsible for the expansion in unit sales experienced by the whole iPod product line (Figure 3.12, Panel *a*). The market launch of entry-level models namely amounted to an increase of ca. 311 000 units in total over the whole time span considered by our analysis. This equals 79% of total unit sales for the whole iPod product line. The volume expansion came at the cost of average revenues, which dropped significantly (Figure 3.12, Panel *b*), the more the product mix shifted towards these cheaper iPod models. The overall effect on total revenues was positive (Figure 3.12, Panel *c*) and cumulatively amounted to about 40 billion USD (in nominal terms) or 61% of total revenues for the whole product line.

The launch of a premium iPod model – the iPod Touch – also affected financial results. We could ascertain a positive impact on average revenues (Figure 3.13, Panel *a*) and consequently total revenues for the line (Figure 3.13, Panel *b*). Since its introduction, the effect of the iPod Touch could account for 14.6 Billions USD in total revenues (22% of the whole product line revenues).

The effects of Apple products in adjacent product categories could also be verified. Both the iPhone and the iPad Mini seem to have caused significant breaks in the unit sales series. By our estimations, the iPhone could have cumulatively cannibalized up to 597 million iPod units (Figure 3.14, Panel *a*), the iPad Mini up to 13 million iPod units (Figure 3.14, Panel *b*).

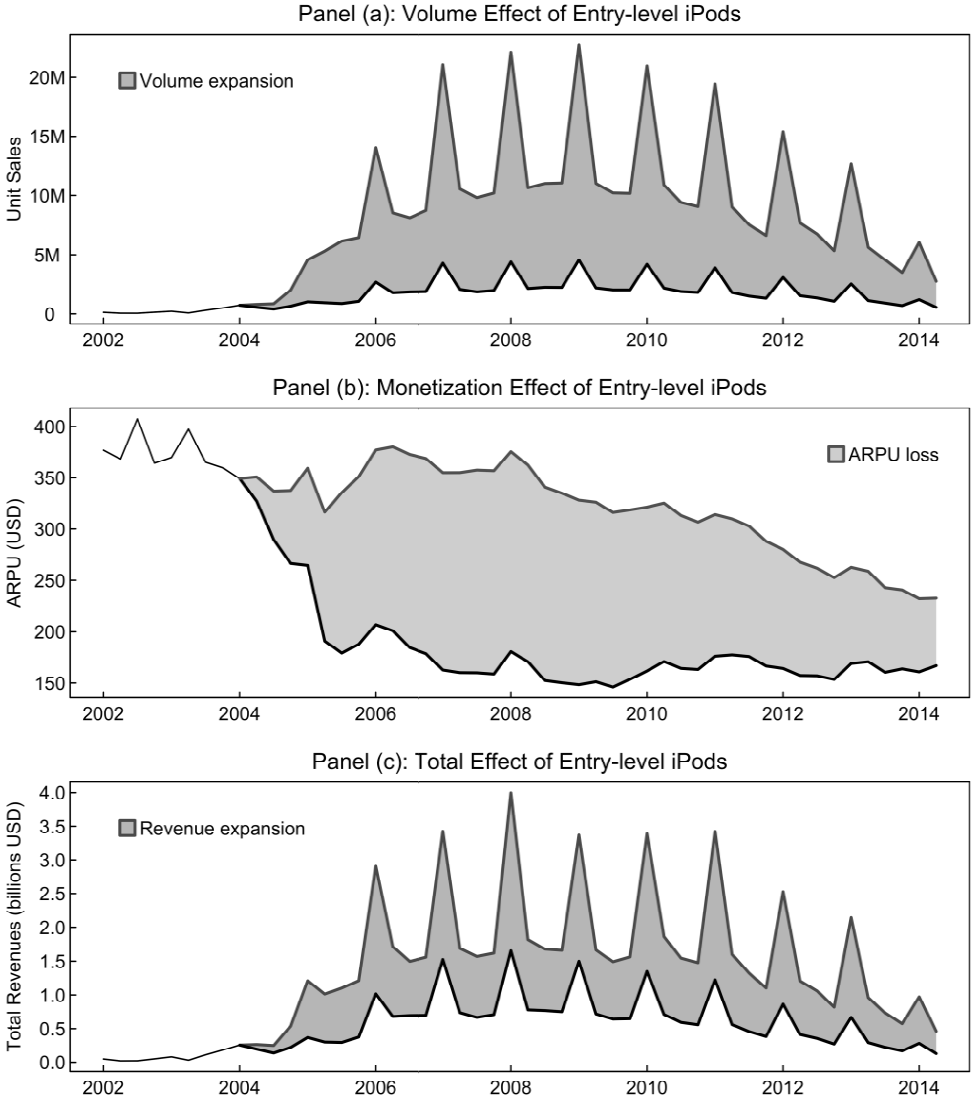


Figure 3.12 Effects of the introduction of entry-level iPod models on total unit sales, average revenues, and total revenues of the whole iPod product line

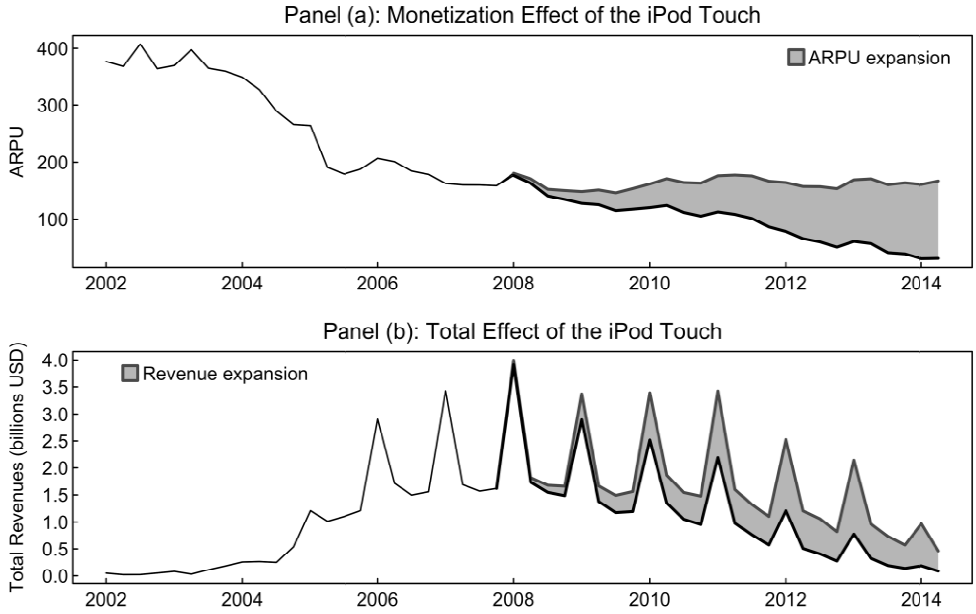


Figure 3.13 Effects of the introduction of the iPod Touch on average and total revenues of the whole iPod product line

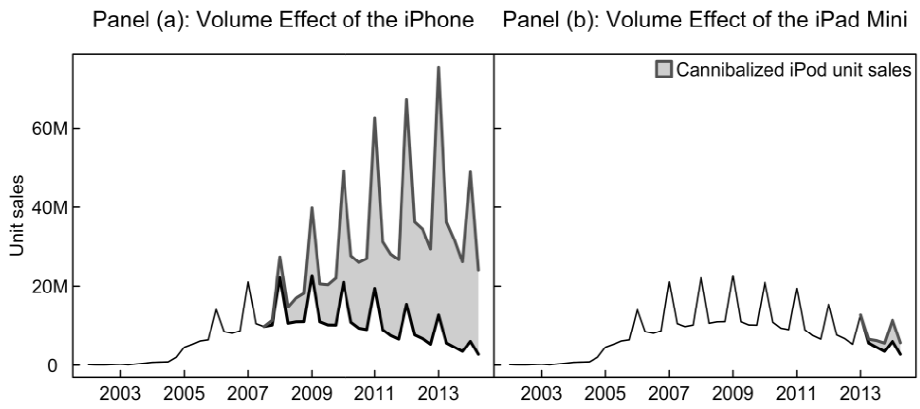


Figure 3.14 Effects of the introduction of iPhone and iPad Mini on total iPod unit sales

3.7. Discussion of Results

3.7.1. Interpretation of the Empirical Results

The trend of our fitted unit-sales model is consistent with the classical bell-shaped curve of a Product Life Cycle (PLC) from the marketing literature. The modeled iPod unit sales follow the PLC path through the phases of introduction (ca 2002-2004), growth (ca 2004-2007), maturity (ca 2007-2010), and decline (2010 to present). We were able to identify and estimate plausible inflection points which correspond to major new-product events and lead the development of the series from one phase to the next. This relationship between product launches and the observed PLC shape is consistent with the interpretation of the PLC that sees it as the result of both environmental factors and marketing actions taken by the manufacturer rather than a predetermined course of events (Wood 1990). A company can actually shape the PLC through its competitive decisions and Apple seems to have done so thoroughly.

We could verify the volume and monetization effects of the downward line extensions, which Apple introduced between 2004 and 2006. The cheaper iPod Mini (later replaced by the Nano) and iPod Shuffle allowed Apple to penetrate the market for portable digital music player and increase its total revenues significantly by selling way more units albeit at a lower average price. Apple balanced this

with upward extensions as well, such as the iPod Touch, whose positive effect on average and total revenues we could ascertain.

Moreover, we could verify the occurrence of inter-categorical cannibalization in the Apple product portfolio. Both the introduction of the iPhone and the iPad Mini namely happened in periods in which structural breaks negatively affecting volume sales could be identified in the iPod sales-generating process. In our estimations, sales diversion towards the smartphone product category was especially high. This is a very reasonable result if we consider the way the iPhone was presented to the market by Apple itself:

"*Apple today introduced iPhone, combining three products—a revolutionary mobile phone,* a widescreen iPod with touch controls*, and a breakthrough Internet communications device with desktop-class email, web browsing, searching and maps—into one small and lightweight handheld device*."[29]

Taking into account form factor and target usage, the cannibalistic repercussions of the iPad Mini are also quite reasonable. The iPad Mini is very similar in size to an iPod Classic or Touch, and was conceived as a portable device dedicated to digital content consumption.

3.7.2. Validity and Limitations

Some limitations may have affected our empirical findings and are discussed here to put our conclusions in the right perspective. First of all, the exogeneity assumption underlying the selection of the breakdates may be questioned. Under this assumption, the researcher conducts a subjective selection of tentative breakdates. Events occurred in such dates that, by the researcher's own judgment, could have plausibly had an impact on the response variable. The candidate breakdates in this case study were selected by the researcher from a rather large set of new-product events (reported in the Appendix) and then thoroughly tested for significance with an ad-hoc procedure. In the next two Chapters, we describe two case studies in which the exogeneity assumption is relaxed and the breakdates identified endogenously, that is, by means of formal analysis steps within the implemented methodology.

A remark is required with regard to our estimations of intra-categorical effects. Since we performed our analysis on aggregated data for the whole iPod product line, we could only provide evidence for the effects on the total unit sales for the whole line and on the average revenues over all models in the line. In other words, we could not determine whether, while expanding overall sales, the entry-level model displaced potential sales of the parent model, and nor whether the iPod Touch displaced potential sales of parent and entry-level models.

The quarterly temporal aggregation of our data constrained the level of granularity of our analysis and may have smoothed or confounded the effects of originally distinct shocks. One example is the absence of volume effects ascribable to the iPod Touch and monetization effects ascribable to the iPhone. Their market launches are only two quarters apart. So close to have possibly hindered our econometric modeling attempt from discriminating between them. The features and performances of an iPhone are so close to those of the later introduced iPod Touch that some effects may have just been cancelled out by the preceding or following structural break. In that case, our procedure has plausibly intercepted the dominant break only and estimated its *net* effect.

The causal link between the new-product events selected as candidate breakdates and the structural changes we statistically detected and measured must be weighted carefully. What we statistically proved as highly probable is that the sales-generating process of the iPod changed significantly during the fiscal quarters in which those new-product events took place. Whether such events should be treated as the only factors is debatable. We surely believe that they represent key factors in the

[29] From the press release of January 9, 2007, source: https://www.apple.com/pr/library/2007/01/09Apple-Reinvents-the-Phone-with-iPhone.html

observed developments. However, we cannot exclude the possibility that our estimations are recording some other contemporaneous causes as well, such as simultaneous product market launches by competitors. As a case in point, our numerical estimation of the iPod units diverted by the iPhone slightly exceed the total iPhone shipments over the same time span, and probably includes some units actually drawn away by other competitive offering in the market. Therefore, our figures ought to be realistically treated as upper bounds to the actual magnitude of each phenomenon of diversion analyzed.

A further limitation of our analysis is that we did not consider the possibility of feedback between the product lines, that is, we ignored sales diversions towards the iPod from the iPhone and iPad product lines. This assumption could be relaxed by employing a different econometric model, such as a vector autoregression (VAR).

4. Case II – Platform Cannibalization: Portable Navigation Devices and Navigation Apps

4.1. Introduction

Leading information technology (IT) vendors have thoroughly embraced platform design principles as the foundation of their product strategies (McGrath 2001) and incentivize complementary innovation in the surrounding ecosystems (Gawer & Cusumano 2002). As a consequence, the competitive game can now be played within a platform (inside competition) and between platforms (outside competition) (Roson 2005). This has turned skirmishes among few competitors within homogeneous product categories into vast confrontations engaging whole ecosystems across the product space.

The outcome of "platform wars" may be platform substitution by customers, complementors, and – in what we judge an intriguing instance – even platform providers themselves. The vendor of a platform trailing behind in the competitive game might even be induced to cannibalize its own platform. Such a platform cannibalization process may for example manifest itself in the competitive race between a general-purpose computing platform and a single-purpose rival, whereby an incumbent provider of a single-purpose platform becomes a complementor in the ecosystem of an innovative general-purpose platform by a third party, and thus positions itself in potential competition with its own proprietary single-purpose platform.

A competitive landscape of this sort is epitomized by the recent developments in handheld computing devices, where mobile general-purpose computing platforms such as smartphones and tablets have been catalysts for change in several IT markets. Among the affected single-purpose incumbent platforms we can find portable navigation devices (PND, also called personal navigation devices), whose sales were supposedly displaced by GPS-enabled smartphones capable of offering turn-by-turn navigation through appropriate navigation applications (O'Brien 2010). PND manufacturers have themselves developed smartphone applications which replicate the navigation functionalities of their own standalone devices[30], thus running the risk of cannibalization. Figure 4.1 illustrates this competitive scenario, where device sales are possibly affected by both inter-organizational sales diversion due to the competition by third party navigation apps and intra-organizational diversion due to apps developed by the PND manufacturers itself.

Using time series econometrics, we intend to provide *significant evidence* of whether smartphones affected PND sales. In particular, this chapter investigates the presence of structural changes in the underlying sales processes of two leading PND manufacturers and verifies whether these changes can be ascribed to the phenomena of platform substitution and cannibalization. Methodologically, we arrange the study in the two phases of exploratory and confirmatory data analysis (Tukey 1977), i.e., we first look for qualitative clues of the aforementioned structural changes and then employ rigorous statistical techniques (econometric models and test procedures) to identify them formally.

The existence of a structural shift in the sales-generating stochastic processes can be detected early in the exploratory stage. By means of an appropriate test procedure (Zivot & Andrews 1992), it is subsequently dated at the third quarter of 2008, that is, the quarter in which the iOS and Android marketplaces were launched. Taken alternative explanations into account, this finding confirms, we believe, that the PND manufacturers' predicaments have started with the rise of the most recent smartphones ecosystems. Instead, although the potential for sales cannibalization inherent in the navigation "apps" offered by PND manufacturers cannot be fully neglected, no significant cannibalization effects could be identified in terms of additional structural shifts in the sales-generating processes.

[30] According to TomTom 2010 annual report (p. 25), the offered iPhone app is based on the same navigation application embedded in dedicated standalone devices.

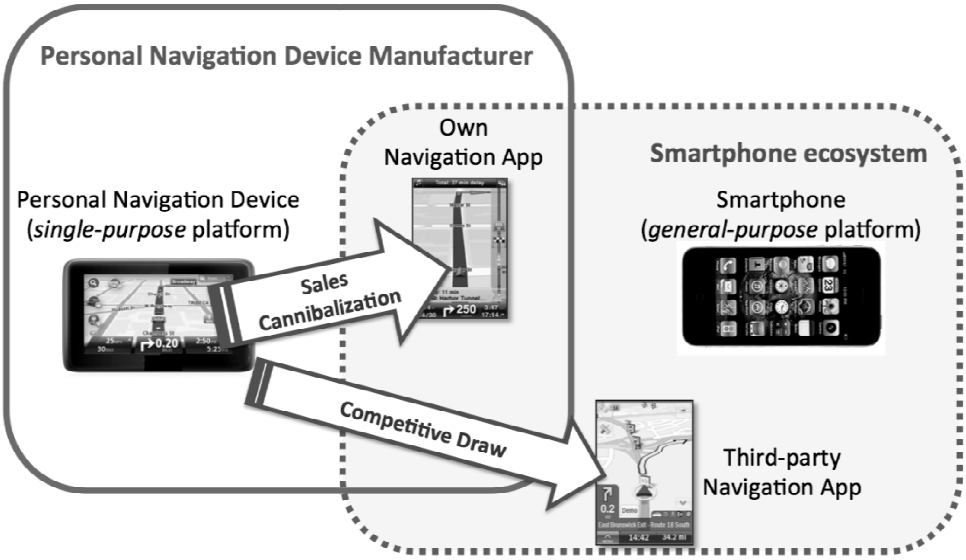


Figure 4.1 Sales cannibalization and competitive draw affecting device sales of a PND manufacturer in the "navigation platform war"

The chapter is organized as follows. We first describe the case by sketching the historical development of the personal navigation market up to the present (Section 4.2). We then review the literature which specifically addresses the case topic and supplements the generic material surveyed in Chapter 2 (Section 4.3). We detail the research methodology and data employed in this case study (Sections 4.4 and 4.5). We subsequently proceed with the data analysis and illustrate the main empirical results (Section 4.6); eventually, we discuss meaning and limitations of the findings (Section 4.7).

4.2. Case Description

The US military began testing a satellite-based navigation system in the 60s, conceived the now commonly called Global Positioning System (GPS) in the successive decade, and completed it in 1995. The system was open to nonmilitary uses from the beginning, but it was not until the year 2000 that a civilian GPS market could surge, since the military henceforth ceased to guard the higher quality signal for security purposes (Feanny Corbis 2009). This, coupled with the industry ride down the experience curve[31], has fueled the explosive growth of the world GPS market: from $4 billion in 1998 (Anon 1998) to the current $110 billion (Dee Ann 2011).

The focus of this study lies in the personal navigation segment, represented by handheld devices with navigation functionalities based on a GPS-positioning capability. This set of electronic products comprises dedicated devices – so-called personal (or portable) navigation devices (PND) – and GPS-enabled phones equipped with a software application offering comparable navigation functionalities.

If we consider dedicated devices alone, the market structure has been relatively stable since 2006, with the PND manufacturers Garmin and TomTom dueling for market primacy. According to industry estimates[32], Garmin has a 40-50% market share in North America and TomTom follows with 20-30%. The opposite is true in Europe, where TomTom takes the largest market share. The PND segment enjoyed notable growth rates until 2008, when sales started to plateau. As already mentioned in the

[31] The cost of a commercial GPS receiver, for instance, has dipped from $150,000 in 1983 (Anon 1998) to less than $50 today.

[32] Figures based on estimates by the independent market research company NPD, from quarterly TomTom earnings presentations.

introduction, this slowdown is explained by some analysts as the result of smartphones with equivalent navigation functionalities becoming more appealing than a standalone PND (O'Brien 2010).

Table 4.1 Chronology of the events which marked the PND/smartphone clash

Date	Event	Platform
9 January 2003	Televigation launches North America's first mobile navigation service	Java
29 June 2007	Apple releases the iPhone	iOS
10 July 2008	Apple opens the iTunes App Store	iOS
28 August 2008	Google announces the Android Market	Android
22 October 2008	Google opens the Android Market	Android
17 August 2009	TomTom releases its iPhone navigation app	iOS
4 November 2009	Google releases Google Maps Navigation (free-of-charge)	Android
22 January 2010	Nokia releases Ovi Maps 3.03 (free-of-charge)	Symbian, Windows Phone 7
5 January 2011	Garmin releases its iPhone navigation app	iOS

In fact, Java-based mobile phones started offering turn-by-turn navigation in 2003 already, with so-called off-board solutions (i.e., data were downloaded on the phone at each route request) tied to the network carrier by specific extra-fees. Standalone software applications (on-board solutions) for the then most popular mobile operating systems followed suit. However, the impact on the PND market apparently became disruptive only with the most recent generations of smartphones.

Apart from the technologic evolution (and a certain fad, one may claim) which made such phones intrinsically more attractive to consumers, two other factors can be mentioned. First, coherently with the scenario sketched in the introduction, today's successful smartphone platforms are the pivot of rich and innovative software application marketplaces, in which navigation is indeed a renowned segment. Second, Google and Nokia have dropped the price floor for turn-by-turn navigation to 0 by respectively releasing Google Maps Navigation and Ovi Maps (now Nokia Maps) free-of-charge. Smartphone-related events relevant for the evolution of the PND market are listed in Table 4.1.

4.3. Related Work

The research contributions on sales cannibalization from the Marketing and ISR disciplines are presented in Sections 2.3 and 2.4 respectively. In this section, we supplement these generic streams of research with additional studies which expressly address the case at hand and its context, or similar ones.

Since we assess the impact of an innovative technologic artifact (smartphone) on the sales of an incumbent (PND), this case represents an addition to the multidisciplinary array of studies about the race for technological dominance – the process by which a technology attains market ascendancy (Suarez 2004). However, since both the considered artifacts can be categorized as computing platforms, we judge the platform competition stream to be the most relevant.

The term platform has commonly two purports: with an engineering connotation, the core components shared by a set of products (Meyer & Lehnerd 1997); with a microeconomic connotation, a multisided market serving different groups of interacting agents (Roson 2005). These perspectives can overlap since, on the one hand, a modular product platform may naturally lend itself to the creation of a multisided market whereas, on the other hand, a multisided market may require an underlying product platform.

Competition between platforms ("outside competition") is inherently multidimensional, for it involves competition on both sides along the dimensions of pricing, service differentiation, agent differentiation, network size, and the possibility of multihoming (Roson 2005). From a dynamic perspective, the chances for a late entrant to successfully take over a platform market (or for an incumbent to defend it)

depend on the relative quality and network size, mediated by the level of indirect network effects and consumers' expectations for future applications (Zhu & Iansiti 2012).

The form of platform competition which most closely relates to the present work is that of platform envelopment, whereby a platform functionality is incorporated by a rival in a multi-platform bundle (Eisenmann et al. 2011). The occurrence of an envelopment scenario is determined by a vendor decision to alter its platform boundaries. Plasticity of platform boundaries can be interpreted as a response to the tension between the conflicting inclinations to integrate or to outsource components depending on the coordination complexity and network effects they may generate (Boudreau 2006).

A recent study investigated the relationship between the pace of substitution among competing technologies and the respective challenges or opportunities in building an ecosystem around them (Adner & Kapoor 2010). The rate of substitution is found to be the highest when the ecosystem emergence challenge for the new technology is low and the extension opportunity for the old technology is low as well.

The sales cannibalization study closest to this case study is (Deleersnyder et al. 2002), where a Dickey-Fuller unit-root test is extended by the authors and employed to assess whether the revenues of a national newspaper are negatively affected by launching a web companion. However, our research issue is different in that the structural-break date is *endogenous* (i.e., unknown), and we, therefore, adopt a different statistical test designed to identify breaks at unknown dates: the Zivot-Andrews unit-root test (Zivot & Andrews 1992). As far as we know, this represents the first microeconomic application of such a test.

4.4. Research Methodology

As in the previous case study, we operationalize cannibalization detection and measurement through the concept of parameter instability of a stochastic process of sales generation (cf. Section 2.3.2) and model this process with time series econometrics. The reader unfamiliar with the terminology of time series analysis can find a glossary of the most relevant terms in the Appendix (p. 177), as an aid to understanding our application of this quantitative approach.

Following (Tukey 1977), we arranged our study into the two phases of *exploratory* and *confirmatory* data analysis. The exploratory stage consists of detective work to reveal the main statistical characteristics of the time series under screening and to suggest the orders for the ARIMA models to be tentatively estimated (Hipel & McLeod 1994). Therefore, this phase encompasses instruments, such as time-plots, smoothers, autocorrelation and partial autocorrelation functions, which do not assume an underlying formal model fitted to the sample.

In the confirmatory data analysis, we rigorously verify the clues identified by the exploratory procedures and provide statistically significant evidence thereon. The underlying model can be decomposed as follows (Enders 2010, p.181):

$$\textit{Response} = \textit{stationary components} + \textit{nonstationary components} + \textit{noise}$$

where the nonstationary components may entail a deterministic trend, a stochastic trend, and structural breaks, while stationary components and noise can be modeled using the Box-Jenkins methodology.

In the last decades, scholars at the forefront of econometric research have been relentlessly extending the concepts and procedures for modeling and testing nonstationary components, among which structural breaks are a topical research theme. On the one hand, their presence biases the various Dickey-Fuller unit-root tests towards nonrejection of the nonstationarity hypothesis (Perron 1989); on the other hand, they pose challenging research issues of their own, such as testing for a structural change of unknown date and estimating it.

Zivot and Andrews (Zivot & Andrews 1992) proposed a unit-root testing procedure in the presence of a potential structural break. They allowed the date of the change to be unknown and showed that the endogenous determination of this breakdate reduces the aforesaid bias. Following their notation, the null hypothesis to be tested is $y_t = \mu + y_{t-1} + e_t$, that is, an integrated process without structural break. The regression equation used in the test procedure (in its less restrictive form, which allows for a change in both intercept and trend) is the following:

$$y_t = \hat{\mu} + \hat{\theta} DU(\hat{T}) + \hat{\beta} t + \hat{\gamma} DT(\hat{T}) + \hat{\alpha} y_{t-1} + \sum_{j=1}^{k} \hat{c}_j \Delta y_{t-j} + \hat{e}_t \qquad (1)$$

where DU and DT are dummy variables to respectively control the changes in level and trend from the breakdate $\hat{T}$onwards. DU is a step dummy variable which equals 1 if $t > \hat{T}$, 0 otherwise. DT assumes the value $t - \hat{T}$ if $t > \hat{T}$ and 0 beforehand. $\hat{\alpha}$ is the coefficient whose significance determines the rejection of the null hypothesis. The summation component preceding the error term, eventually, tackles the serial correlation in the residuals. The test endogenously estimates the breakdate by running equation (1) sequentially and selecting the point in time less favorable to the null hypothesis.

4.5. Data

We gathered quarterly unit sales figures from the publicly available financial reports of the PND manufacturers Garmin and TomTom. Such reports span the period up to the first quarter of 2012, starting from the first quarter of 2000 (49 observations) in the case of Garmin, and from the first quarter of 2004 (33 observations) for TomTom. A description of the data can be found in Table 4.2.

Table 4.2 Description of the data collected for Case II

Time series	Garmin sales	TomTom sales
Sources	10Q & 10K SEC filings	Quarterly and annual reports
Fiscal year	January to December	February to January
Time span	Q1 2000 – Q1 2012	Q1 2004 – Q1 2012
Data points	49	33
Markets	Global	North America & Europe
Segments	PND & aviation products	PND

Sales figures reported by Garmin refer to total unit sales from all business segments and include, alongside handheld navigation devices, aviation products. The latter probably respond to highly specific requirements and should not compete with smartphones as we instead assume that the former do. The use of these figures may therefore be questioned. However, a closer look at Garmin financial statements reveals that the consumer segment has historically constituted between 70% and 90% of the company's overall net revenues. Hence, we consider these observations representative. Figures reported by TomTom only include sales of portable navigation devices.

4.6. Empirical Findings

4.6.1. Exploratory Data Analysis

The first step in the exploratory phase is the perusal of the time series plots (Figure 4.2). The behavior of the two processes over time exhibits a strong resemblance. Clearly, the two time series share some fundamental attributes: both are nonstationary (in level and variance), show evidence of seasonality, and rise until 2008/2009, where they level off. Garmin unit sales are higher in magnitude (remember, however, that the TomTom time series only includes consumer PND unit sales) and in variance.

In order to investigate the time series further, we applied a robust locally weighted regression smooth (also known as LOESS) and added its trace (the dashed lines in Figure 4.2) to the plots. The smoothed curve highlights the trend component and a decline in sales which was not so obvious in the time series plot alone. The noise left by the smoother (not reported here) also confirms the higher variance of the

Garmin time series. Moreover, we invite the reader to notice that it is not possible to unequivocally identify any structural change based on this visual inspection alone.

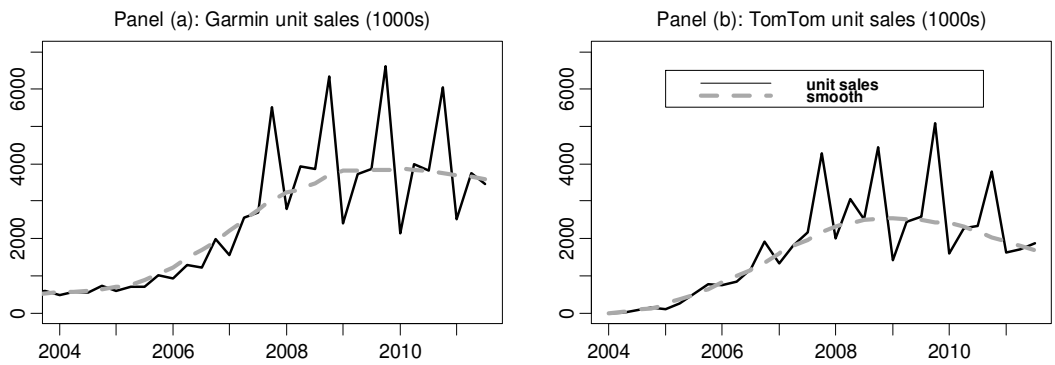


Figure 4.2 Time plots of quarterly unit sales

Before proceeding, a Box-Cox transformation (with $\lambda = 0$ and $c = 0$) is applied to the Garmin series to tame its variance[33], and both time series are differenced with lag 4 (i.e., quarterly) in order to eliminate the seasonal persistence. The seasonally differenced time series now reveal some interesting facets of nonstationarity (Figure 4.3). In fact, a drop in sales can be detected clearly, at least visually, and seems to have influenced the two sales-generating processes somewhere between 2008 and 2009.

The last step of the explanatory phase is the analysis of the sample autocorrelations (ACF) and partial-autocorrelations (PACF) in order to identify candidate p, d, and q orders for the ARIMA(p,q,d) models to be fitted in the confirmatory phase. Examining the autocorrelogram of the original series (Panels *a* and *d* in Figure 4.4), the similarities between the two stochastic processes are highlighted once again, although the ACF for the Garmin series seems to tail off more slowly. Once the seasonal persistence is removed (and the Garmin series is transformed), ACF and PACF for both series display an oscillating decay (Panels *b* and *e*). The Garmin series has a rather significant PACF at the first lag and significant ACF for the first 4 lags, while the TomTom series exhibits an ACF which truncates after lag 2 and a significant PACF at lag 1. Given these clues, we may presume ARMA(p,q) models where both p and q are positive and small. The ACF and PACF of the first-differenced series provide some additional insight (Panels *c* and *f*). In fact, the seasonally differenced Garmin growth series appears to be white noise, thus supporting the claim that this could rather be a difference-stationary process, while the TomTom differenced series exhibits some new autocorrelations, a possible signal of overdifferencing.

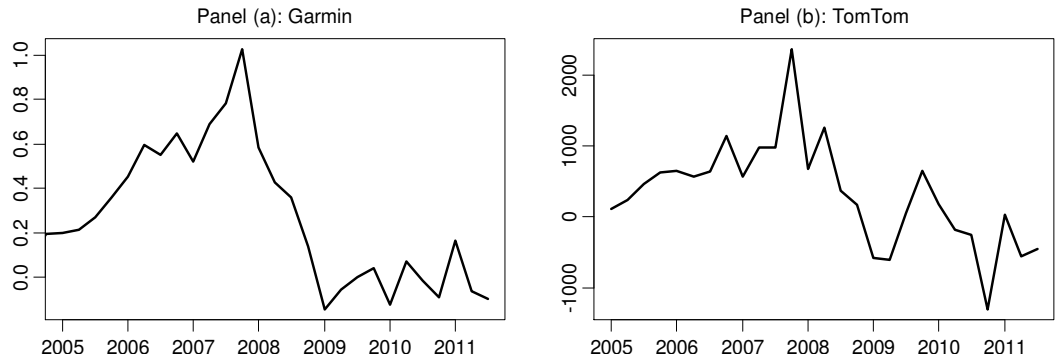


Figure 4.3 Seasonally-differenced time series (Panel *a*: also transformed)

[33] This Box-Cox transformation was applied following the detection of heteroscedasticity in the residuals during the diagnostic checks at the end of a first round of estimations in the confirmatory phase.

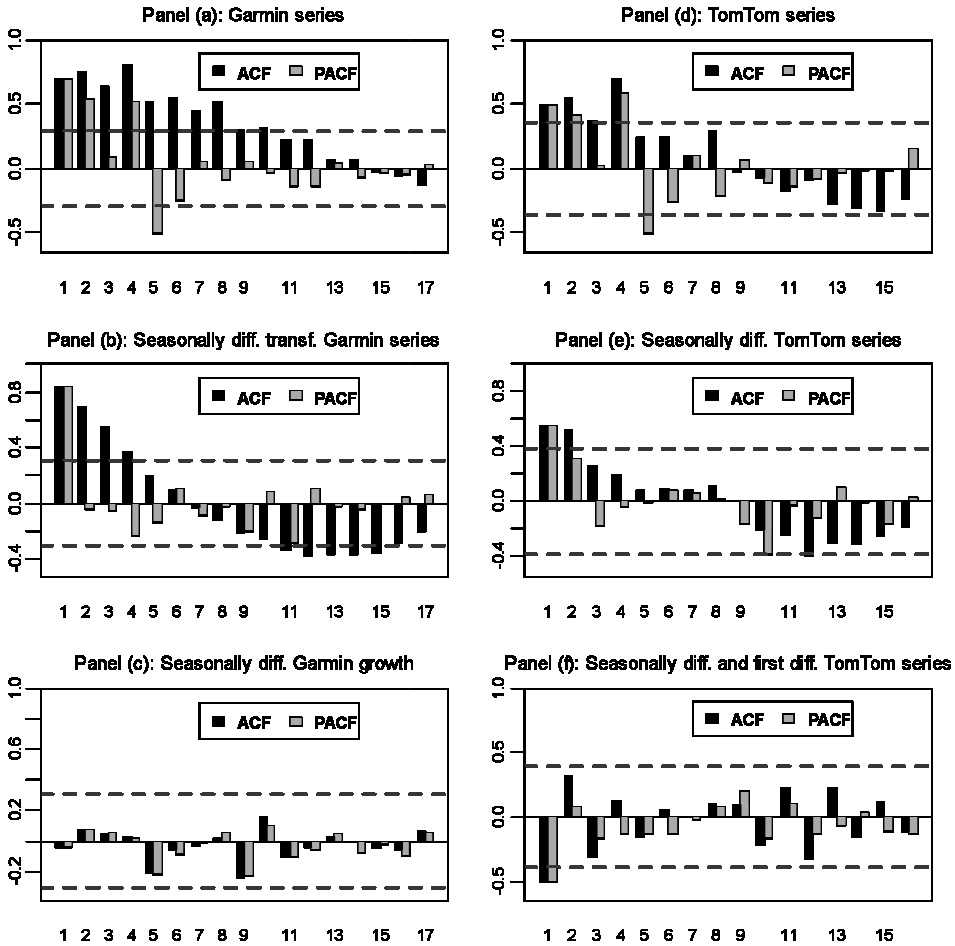


Figure 4.4 Sample autocorrelations and partial-autocorrelations

4.6.2. Confirmatory Data Analysis

From a formal point of view, two are the interrelated facets of nonstationarity whose presence needs to be ascertained: stochastic trends and structural changes of unknown timing.

To illustrate the first aspect, we fit some autoregressive moving-average models with the classical Box-Jenkins methodology. Following the hints given by the exploratory phase on the AR and MA orders, and based on information criteria (both Akaike and Bayes) and standard errors of the estimated coefficients, the best models we can indentify are an AR(2) for the TomTom seasonally differenced series and an AR(1) for the Garmin growth series, both without intercept term.

However, a closer examination of the fitted models reinforces the suspicion of unit-root nonstationarity already arisen in the exploratory phase. Exemplarily, this proximity with a difference-stationary process can be seen in the AR(1) model fitted to the Garmin growth series, (in parenthesis the corresponding estimated standard error). The coefficient .917 is less than 1.4 standard deviations from unity. As a matter of fact, the Augmented Dickey-Fuller unit-root test (ADF) does not reject the null hypothesis (presence of a unit root) for either the Garmin series or the TomTom one. The complication here is the possible dependency of the ADF results on the presence of a structural break, for the latter would bias it towards nonrejection (Perron 1989).

The Zivot-Andrews test procedure allows tackling both issues simultaneously. we conducted tests for the two most plausible scenarios on the basis of the exploratory analysis, that is, a change in the intercept only or a simultaneous change in intercept and slope. All four tests, whose results are gathered in Table 4.3, identify the third quarter of 2008 as the most plausible breakdate. Three of them deliver an estimate for the change in intercept significant at the 1% level, the other one at the 10%

level. On the other hand, one of two gives significant evidence of a change in slope. Eventually, the null hypothesis of difference-stationarity can be rejected only for the model of simultaneous change in intercept and slope applied to the TomTom series, where the test statistic assumes a value of -5.044 (with critical values -5.57, -5.08, and -4.82 for the 1%, 5%, and 10% levels of significance).

Table 4.3 Results of the Zivot-Andrews unit-root tests

Series	**Garmin growth**	**Garmin growth**	**TomTom**	**TomTom**
$\hat{T}$	2008 Q3	2008 Q3	2008 Q3	2008 Q3
$\hat{\mu}$	-.0003981 (.0538270)	-.014260 (.057169)	842.9 ° (403.6)	233.289 (379.4213)1
$\hat{\alpha}$	.5259470 *** (.1347699)	.465224 ** (.157577)	.0535 (.2789)	-0.9427 * (0.3852)
$\hat{\beta}$	.0097486 * (.0040730)	.011732 * (.004865)	-.4134 (31.82)	150.4013* (53.7704)
$\hat{c}_1$	.1168423 (.1518068)	.158732 (.162456)	.008261 (.2376)	0.7361 * (0.2984)
$\hat{c}_2$	N/A	N/A	.2625 (.1957)	0.6984 ** (0.2094)
$\hat{\theta}$	-.3866350 ** (.1236079)	-.378184 ** (.124851)	-1047 ° (528.3)	-1817.1279 ** (492.3040)
$\hat{\gamma}$	N/A	-.010112 (.013373)	N/A	-291.9066 ** (91.2364)
Unit root hypothesis	Non-rejected	Non-rejected	Non-rejected	Rejected °

Note: the symbols °, *, **, and *** indicate significant at the 10%, 5%, 1%, and .1% levels respectively.

The last step of the confirmatory data analysis consists in a series of diagnostic checks on the residuals from the calibrated models. These checks are designed to verify if the residuals are independent, normal, and homoscedastic – in other words, to assess whether all the relevant information was extracted from the data. Appropriate tests (respectively the Ljung-Box, the Shapiro-Wilk, and the Breusch-Pagan) confirm that residuals are roughly white, normal, and homoskedastic. Normality and lack of autocorrelation allow us to qualify them as independent as well.

4.7. Discussion of Results

4.7.1. Interpretation of the Empirical Results

In the previous section, we obtained statistical evidence that the underlying sales-generating processes of the two leading PND manufacturers Garmin and TomTom have indeed been affected by a structural shift of negative sign, and dated it at the third quarter of 2008. Now the question is to identify what determined this shift. Our initial hypothesis was that the break in the behavior of these sales-generating processes can be ascribed to the appearance of GPS-enabled smartphones and navigation apps, which engendered phenomena of platform substitution and/or cannibalization. However, two competing explanations to the slowdown in PND sales exist and must be verified: the effects of the late-2000s financial crisis on consumer spending and a saturation of the PND market.

Financial Crisis and Consumers' Confidence

Lehman Brothers filed for bankruptcy exactly in the same quarter identified by our procedure and kick-started the financial crises which subsequently impacted the economy worldwide (and whose effects have not completely dissipated yet). We assess here the hypothesis of a generalized negative effect on consumers' purchases due to the deteriorating economic climate, which could have affected sales of PND just as well as of other consumer durables or electronic devices.

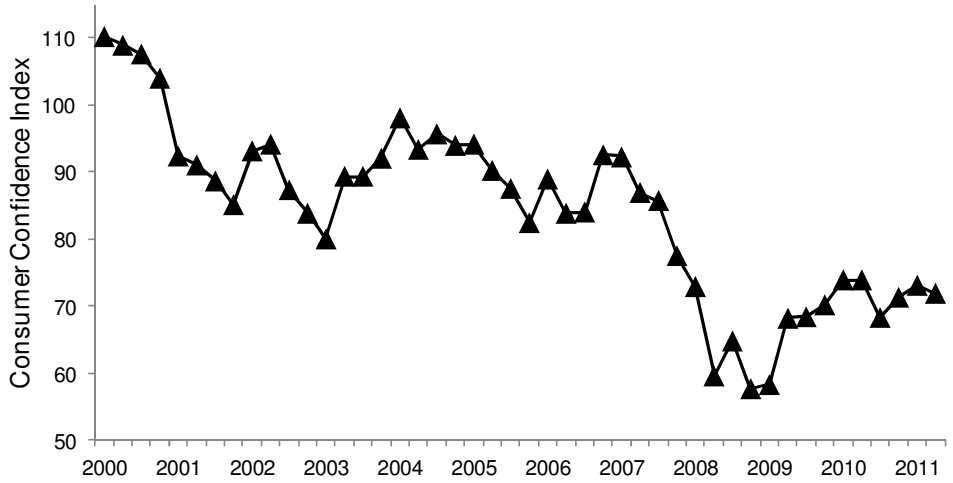


Figure 4.5 Quarterly time series of the Consumer Confidence Index

To evaluate this alternative hypothesis, we decided to conduct a Zivot-Andrews test on a time series representing consumers' confidence. Should a decrease in consumers' confidence be the driving factor in the PND sales slowdown, the test procedure would lead to results analogous to those for the Garmin and TomTom series. We employed the *Consumer Confidence Index* published monthly by Thomson Reuters and the University of Michigan, from which we extracted a quarterly time series over the same horizon as the Garmin time series (cf. Figure 4.5). The Zivot-Andrews test rejects the unit-root hypothesis at the 1% significance level, finds a significant change in the slope, and identifies a different breakdate than the one derived previously. Therefore, we believe that a change of consumer behavior due to the financial crisis does not appear the driving factor in the PND sales slowdown.

PND Market Saturation

Two arguments can be made against the saturation hypothesis. On the one hand, the manufacturers themselves rule out market saturation. In the TomTom annual report for fiscal year 2010 (p. 10) we can read that "*most PND sales are still to first-time buyers*" and *"earlier adopters are starting to trade up*". It is explicitly stated that, outside of North America and Western Europe, market penetration rates are low ("*people are just starting to discover what a navigation device can offer*"). On the other hand, we believe that the behavior of the series is not consistent with the saturation hypothesis. A more gradual change pattern should appear in the stochastic processes and not, as revealed by our analysis, a structural break, which represents by definition a change materializing rather instantaneously.

Smartphones and Navigation Apps

Given the arguments in the previous subsections, competition by GPS-enabled smartphones with navigation apps remains the most plausible explanation. If we look at the chronology reported in Table 4.1, we find a pivotal event which took place exactly in third quarter of 2008: Apple launched the App Store – the online marketplace for software applications running on the iOS platform. Google concurrently announced the Android Marketplace, due to open in the successive quarter. These events testify the rise of a new generation of smartphones which, on the one hand, introduced a form factor more suitable for navigation functionalities (in fact, similar to most PND) and, on the other, are at the centre of comprehensive ecosystems which incentivize and support the development and distribution of advanced mobile software applications.

Our interpretation is also coherent with the most recent findings on platform competition. As hypothesized in Adner & Kapoor (2010), a relationship between the pace of technology substitution and the development in the surrounding ecosystems emerges: although smartphones have offered some navigation functionalities since 2003, it is only with a more mature ecosystem around them that the rate of substitution eventually took off at the expense of standalone navigation devices. At present,

smartphones ecosystems are among the most innovative and successful ones. Contrariwise, PND manufacturers struggle to find differentiating extension opportunities in their ecosystems, for they are forced to replicate every innovation (e.g., live traffic services) in their smartphone applications as well – thus stuck in a vicious cycle where they cannot provide any sustainable advantage to their standalone devices.

Competitive Draw or Sales Cannibalization

If the displacement of device sales due to the presence of smartphones and navigation apps seems the most appropriate explanation, we must then distinguish sales diversion to third party navigation apps from diversion to navigation apps developed by the PND manufacturer themselves. In other words, we must investigate the role played by the phenomena of competitive draw and sales cannibalization (cf. Figure 4.1).

With regard to sales cannibalization, the release dates of Garmin and TomTom iPhone apps can be considered candidate dates for a structural change in the respective sales-generating processes. In fact, neither release date matches the structural-break date identified by the Zivot-Andrews test for the two series. TomTom first released a navigation app in the third quarter of 2009 while Garmin did it at the beginning of 2011, so that the previously identified structural shift anticipates these events by at least four quarters. Since the diagnostic checks on the residuals confirmed that the calibrated regressions fit the data well already, we may conclude that, with the observations at our disposal, it was not possible to detect any significant cannibalization effect.

If the launches of their own navigation apps did not significantly affect these manufacturers' sales, we may thus ascribe the drop which they have experienced in PND unit sales, mostly to the competition by other mobile navigation software providers, rather than to an intra-organizational diversion between app and device. Potential buyers of devices by Garmin and TomTom were diverted by the attractive alternatives of acquiring a third party navigation app (several of which are free or available at a relatively low price) for their smartphone, or a bundle consisting of smartphone and third party navigation app, rather than by the possibility of purchasing a proprietary TomTom or Garmin app.

This does not mean that the potential for sales cannibalization should be wholly neglected. TomTom declares 189,000 and 500,000 downloads of its iPhone navigation app for the years 2009 and 2010[34]. Since in these two years the company experienced a decrease in PND sales of 0.478 million and 1.549 million units respectively, we can estimate a hypothetical cannibalization rate of *at most* 32% (0.5/1.549) for 2010 and 39% (0.189/0.478) for 2009. As a matter of fact, this would be the case only under the extreme assumption that *every* app user would have otherwise bought a TomTom device that year. However, we can reasonably believe that TomTom smartphone offerings drew some customers from the competition as well, or attracted customers who would have never bought a standalone navigation device, amounting to a lower cannibalization effect – actually so low to be undistinguishable from the overall substitution effect in our econometric analysis. In other words, the phenomenon of competitive draw seems to be the major driver in the negative shift in devices' sales, with sales cannibalization taking on possibly a minor (and for our methodology undetectable) role.

As a final remark, the PND manufacturers' launch of applications (but also car kits and subscription services) for the most popular smartphone platforms might be read as a first step towards the redefinition of their platform boundaries in response to a mutated competitive landscape, as described in Boudreau (2006). Perhaps it is the initial phase of a transition to become – shedding skin – suppliers of best-of-breed navigation solutions for mobile computing platforms.

[34] These are the only publicly available figures on the sales volume of either TomTom or Garmin on the iTunes AppStore (from the TomTom Annual Report 2009 and 2010).

4.7.2. Validity and Limitations

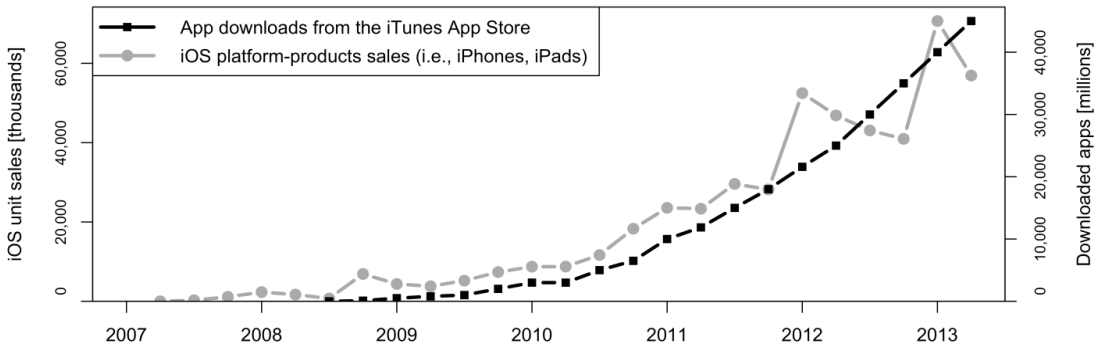
The econometric approach we employed has some obvious limitations. First of all, it tries to identify a unique shift materializing itself at a discrete point in time whereas such a change would rarely manifest itself instantaneously. Moreover, the explanation behind the sales drop could actually be a combination of all the factors mentioned above, and the presented model cannot verify this assumption, nor it can disentangle the individual effects.

Eventually, every test procedure was based on a relatively limited number of observations, and it may be argued that more data points are needed for a representative realization of such stochastic processes. In particular, the quarterly time series do not contain enough information to significantly distinguish the sales cannibalization effect from the overall substitution effect. If sales data with a lower sampling interval were available, a test procedure for a structural change of known date (such as Perron, 1989) might have allowed a more accurate analysis of cannibalization.

5. Case III – Channel Cannibalization: Online and Offline Sales Channels for Enterprise Software

5.1. Introduction

Online sales channels have shaped competition between and within platforms in consumer software markets (an instance thereof is presented in the previous chapter). As a case in point, the success of the Apple iOS platform is intertwined with the fortunes of the online store serving that platform's ecosystem, as Figure 5.1 illustrates, with cumulative downloads of "apps" as a proxy for the online sales channel success.[35] The diffusion of online sales channels for consumer software has acted as a catalyst for the launch of analogous channels in the enterprise software market. Enterprise software vendors are resolute to nurture their own platform businesses by offering complementary software and services on proprietary electronic marketplaces.



Sources: Apple financial statements; Wikipedia

Figure 5.1 iOS platform sales and app downloads

However, it is disputable whether online software purchases are as compelling for organizations as they are for individuals, and whether drivers and barriers of online channel adoption are the same in these two different contexts. Moreover, while in consumer software markets sales channels have started to "dematerialize" as soon as e-commerce established itself, in enterprise markets traditional offline channels based on intermediaries and sales professionals still represent the dominant approach. The channel adoption decision by organizational software buyers and its strategic repercussions for enterprise software vendors are the focus of this work.

In order to establish if sales cannibalization could take place between online and the offline channels in the enterprise software market, we must tackle an explanatory research question: the identification of the relevant factors influencing the channel adoption decision throughout the buying process conducted by an enterprise software buyer (that is, by the buying center of an organizational entity). This research issue can be decomposed into three sub-questions: the identification of the relevant variables influencing the channel adoption decision, the identification of their interrelationships, and the identification of possible changes in the importance of factors in the course of the buying process. In other words, we have investigated at which stage of a software acquisition process and under the influence of which factors the online channel will cannibalize (i.e., be preferred to) or complement (i.e., enhance or be enhanced by) the offline one.

We deemed a qualitative research strategy the most suitable for this endeavor. An online channel for enterprise software represents a novel and peculiar socio-technological context for which the

[35] We have also run some statistical tests to explore the interrelationship of the two time series in Figure 5.1. In particular, we have estimated a Vector Autoregressive Model with unitary lag on both variables. As cautiously as estimations from such a small sample (25 quarterly data points per series) should be taken, in the calibrated model downloaded apps in the precedent quarter are a significant (at the 0.1% level) factor for platform sales and, interestingly, the opposite relationship is not significant.

applicability of preexisting theories ought to be verified. Moreover, it is as yet unclear which channel designs and technologies might establish themselves in the enterprise software market. Therefore, we opted for an open-ended, nomothetic, and inductive approach by combining a qualitative research strategy with a cross-sectional research design to capture the phenomenon's general traits at this stage.

Our empirical results highlight the key role played by software solution attributes (such as specificity, price, implementation/integration effort, scope, and evaluability) in the channel adoption decision. Besides, factors such as contractual aspects and the existence of an already established relationship with the vendor exert an influence which is only thoroughly understood when taking into account the interdependences among factors and their varying relevance in the course of the buying process. Contrarily to consumer software markets, we have found that online channels for enterprise software applications should only limitedly cannibalize offline channels and will rather complement them in multichannel systems with appropriate handover points along the buying process.

This chapter is organized as follows. We first describe the case and its context (sec 5.2). We then review the multidisciplinary literature which expressly addresses the case topic and supplements the generic material surveyed in Chapter 2 (Section 5.3). Subsequently, we present our research methodology (Section 5.4) and the data we collected (Section 5.5). Next, the main empirical results are illustrated and we detail the channel adoption model we have constructed (Section 5.6). Strategic repercussions for enterprise software vendors and validity and limitations of our research endeavor are discussed (Section 5.7).

5.2. Case Description

E-commerce has undoubtedly grown a widely accepted channel in consumer markets. As a case in point, the online retailer Amazon has become the world's leading retailer (ComScore 2011), building on a well-accepted e-commerce model for books and subsequently extending its strategy to turn into a general online store. Something comparable has been happening in the mobile software market with the Apple "App Store". In fact, the "app-store model" has changed the way consumer software is built, packaged, sold, and delivered.

Contrariwise, in the market for enterprise application software – which encompasses standalone business applications such as Customer Relationship Management or integrated ones such as Enterprise Resource Planning – a traditional sales model is still predominantly pursued: that of a long-lasting, personnel-intensive process. Sales cycles of several months up to years are common (Liao et al. 2007; KonradinMediengruppe 2009), and the buying process is often highly centralized and driven by IT staff or purchasing departments. It involves the evaluation of multiple solutions and generates high costs for both the purchasing company and the software vendor (Cusumano 2004). This is not only due to historical and organizational reasons but also determined by the nature of enterprise software itself.

However, spurred by the overwhelming success of mobile "app stores", enterprise software vendors are increasingly embracing the use of own online sales channels. SaaS vendors Salesforce.com and NetSuite introduced theirs, respectively called AppExchange and SuiteApp.com, in 2006 (Burkard et al. 2011). Several other proprietary marketplaces have followed: SAP Store, Deutsche Telekom Business Marketplace, Microsoft Pinpoint, Fujitsu Cloud Store, SugarCRM SugarExchange, and Google Apps Marketplace.[36]

We hereby define an *online sales channel for software applications* (abbreviated to *online channel*) as a set of organizational and technological means constituting a centralized e-commerce infrastructure

[36] SAP Store (www.sapstore.com); Microsoft Pinpoint (pinpoint.microsoft.com); Salesforce.com AppExchange (appexchange.salesforce.com); Netsuite SuiteApp.com (www.netsuite.com/portal/suiteapp); Deutsche Telekom Business Marketplace (apps.telekomcloud.com); Fujitsu Cloud Store (cloudstore.ts.fujitsu.com); Google Apps Marketplace (www.google.com/enterprise/marketplace); SugarCRM SugarExchange (www.sugarexchange.com).

serving a software consumer (i.e., individual consumer or organizational entity) throughout the buying process from information search to purchase and software delivery, with minimum and possibly virtual and asynchronous human interaction. In the consumer software market, online "apps" marketplaces such as the iTunes App Store or the several available Android stores represent the quintessence of such an online channel and boast a purely automatized software delivery to the purchaser's own system.

An *offline sales channel for software applications* (abbreviated to *offline channel*) is instead based on the deployment of a direct sales force and/or a partner ecosystem and heavily relies on personal interactions between the buying company's employees and the salesmen from the vendor or its intermediaries (i.e., system integrators, value added resellers, etc.). In the enterprise market, offline channels still play a fundamental role in most software purchases. Given the complexity of organizational buying behaviors and the novelty of enterprise online channels, it is difficult to assess whether offline channels will be resilient or end up cannibalized, and how factors such as the increasing adoption of on-demand applications can affect these developments.

5.3. Related Work

Organizational software buying from a multichannel sales system is a complex and multifaceted topic spanning fields of study beyond IS Research (IS domains such as technology adoption, diffusion of innovation, design of electronic/online channels, software procurement). For that reason, our multidisciplinary literature review considered also research streams in Industrial Marketing (organizational buying behavior) and Marketing Science (sales cannibalization, multichannel system design). Given the abundance and diversity of articles identified this way, this section only sketches the most important contributions in each research stream, put in perspective from the specific point of view of our research. Please refer to the cited articles for a more thorough treatment of each subtheme.

The online channel can be seen as an information technology (IT) innovation and, therefore, adoption and diffusion of technological innovations are relevant fields of research. The most important technology acceptance theories are the Technology Acceptance Model (Davis et al. 1989), the Theory of Planned Behavior (Ajzen 1991), and the Unified Theory of Acceptance and Use of Technology (Venkatesh et al. 2003). They all focus on the individual, that is, on the single user's acceptance of IT. However, the process of buying enterprise application software is conducted by multiple interacting individuals in different roles and ought to be analyzed at an organizational level. The Theory of the Diffusion of Innovations (Rogers 1995) tackles the innovation adoption process by social systems and can be applied to organizational domains. Although it provides a generic framework of factors influencing the adoption of the innovation, it does not recognize the singular technological context. Other scholars came to a similar conclusion by applying the DOI to the adoption of EDI technology (Lyytinen & Damsgaard 2001). Finally, the Technology-Organization-Environment framework (Tornatzky et al. 1990) states that innovation adoption decisions are influenced by the technological, organizational and environmental context. This model has been widely applied within IS Research, but IS researchers had to identify unique factors specific to their object of investigation within each of the three aforementioned contexts (Baker 2012).

From an Industrial Marketing point of view, software procurement is a particular instance of organizational (or industrial) buying. A first comprehensive approach to formally investigate organizational buying situations was the "buyclass" framework (Robinson et al. 1967). It is based on three dimensions (newness of the problem, information requirements, and consideration of alternatives) and identifies three "buying classes" or specific patterns of purchase behavior (new task, modified rebuy, and straight rebuy). Subsequently, the variables influencing the buying decision process were identified: individual, social, organizational, and environmental (Webster & Wind 1972). The buying process is carried out by a buying center – the set of all the individuals from the buying organization taking on a role in the decision (influencer, gatekeeper, approver, etc.). Based on those seminal publications, many authors have investigated factors of influence in organizational buying processes. Sheth (1973) has distinguished individual, environmental, and group-organizational aspects.

The influence of organizational actors is the focus of the analysis by Ronchetto et al. (1989). An extensive literature review on the topic has ascertained that the most investigated constructs among the determinants of organizational buying behavior are the characteristics of the purchase, organization, group, participants, process, seller, and information (Johnston & Lewin 1996). Recent publications have analyzed the change of buying center structures between different situations and phases (Järvi & Munnukka 2009).

Few scholars have focused on organizational buying in the context of software purchases. Based on the organizational buying framework, Verville and Halington (Verville & Halingten 2002) have investigated the acquisition of an ERP system and classified influencing factors into environmental (e.g., technological, cultural), organizational (e.g., project management approach), group/interpersonal, and individual (e.g., acquisition team's composition, individual leadership). In a second study (Verville & Halingten 2003) they have decomposed the ERP acquisition process into the phases of planning, information search, selection, evaluation, choice, and negotiation. Loebbecke (2010) has identified information-related drivers (i.e., customer references, expert network recommendations, and demonstration team presentations) and feature-related ones (i.e., price performance, functionality, sales team service) impacting organizational software purchases. Palanisamy et al. (2010) have uncovered five factors influencing the enterprise software acquisition process: enterprise-systems strategy and performance, business process re-engineering and adaptability, management commitment and users' buy-in, single vendor solution, and consultants, team-location, and vendor's financing.

With regard to the design of online/offline multichannel sales systems, one key success factor is the "Supplement and Support Channel Strategy" (Heinemann 2010): to complement or support the online channel with the other (offline) sales channels. An optimal multichannel sales system ought to let individual sales channels cross-fertilize each other and exploit each other's strengths (Cespedes & Corey 1990; Schögel et al. 2004). A key design parameter is whether the sales channels should complement each other by supporting different tasks along the sales process or remain independent. In case of an interdependent sales system, the sales channels are supporting the sales process as an integrated system. Tasks are assigned to one or both with dedicated handover points. If the channels are independent, each sales channel can support every task along the sales process. Dependencies are avoided by restricting each channel to a certain domain (such as a geographical region or a product category).

5.4. Research Methodology

We have opted for an open-ended, nomothetic, and inductive research approach by combining a qualitative research strategy with a cross-sectional research design. A cross-sectional study relying on qualitative interviewing and qualitative content analysis is a typical instance of such a combination (Bryman & Bell 2007, p.71). A simplified representation of our research process is depicted in Figure 5.2.

During the pilot phase of our research project, a tentative set of questions was assembled drawing from the relevant literature through some preliminary deductive categorization. A first version of the interview guide was tested at the renowned ICT trade fair CeBIT in March 2012. There, ten test interviews of about 30 minutes each were conducted with four customers and six providers from the enterprise software market, and allowed us to optimize the questions' order, phrasing, and graphical support ahead of the actual data collection phase. A revised version of the interview guide was thoroughly discussed with an experienced and high-ranked enterprise-software sales executive as well. Thereafter, the interview guide was only subject to minor adjustments in wording and appearance.

Semi-structured interviews were our chosen means of primary data collection. On the one hand, relying on an interview guide with predefined questions and illustrations guaranteed a shared understanding between interviewer and interviewee of the numerous aspects to be considered in the discussion: the sales channels' distinctive characteristics, the buying-process phases, and the various enterprise

software products and services (the schematizations we employed are detailed at the end of this section). On the other hand, open-ended questions let each interviewee enrich the discussion with the idiosyncratic elements of enthusiasm or concern of the person and his/her organizational environment. Interviews were scheduled between March and September 2012. Seven were conducted face to face, the other nine telephonically. Every conversation took place in German – the mother tongue of all participants – and was digitally recorded (for a total 939 minutes of recording) and subsequently transcribed by German native speakers familiar with the subject matter and terminology. The transcribed qualitative material amounted to about 111,000 words.

Repeated coding iterations of the transcripts (represented by the recursive arrow for the coding task in Figure 5.2) were at the core of our analysis phase. Concretely, we employed several first-cycle coding and second-cycle methods (Saldaña 2009, pp.45–101). Among the first-cycle methods: *attribute* coding (to annotate the interviewee's profile and that of his/her organization), *structural* coding (to index the different macro-parts constituting an interview), *descriptive* coding (to index relevant text passages, with *subcoding* when necessary), *values* coding (to label the participants' attitudes and values). Second-cycle coding methods (which are applied to text portions already coded) were *magnitude* coding (to formalize aspects such as the perceived marginal impact of a change in a previously identified variable, or to enable counting – cf. below) and *evaluation* coding (to denote participants' judgments and evaluative comments). *Simultaneous* coding was employed throughout as well, i.e., multiple codes and coding methods were applied to the same portion of text when necessary. Table 5.1 lists some illustrative examples, in terms of codes and quotations, of the coding methodologies we employed.

Three researchers coded the same interview in parallel and compared coding decisions until a common codebook was finalized. Subsequently, different interviews were randomly assigned to the researchers and independently coded. At the end of the research project, the codebook consisted of 62 codes used to index more than 1,500 quotations (viz., coded textual passages).

Notwithstanding the importance of the coding act itself as an analytical tool, codes and quotations were employed as input for further analysis steps. Descriptive and values codes were categorized to produce a coding hierarchy, and, as our research progressed, we developed code dimensions, that is, properties of a code representable on a continuum, such as frequency or intensity (Gibbs 2007, p.76). Quotations were systematically retrieved to fill qualitative summary table for case-by-case comparisons.

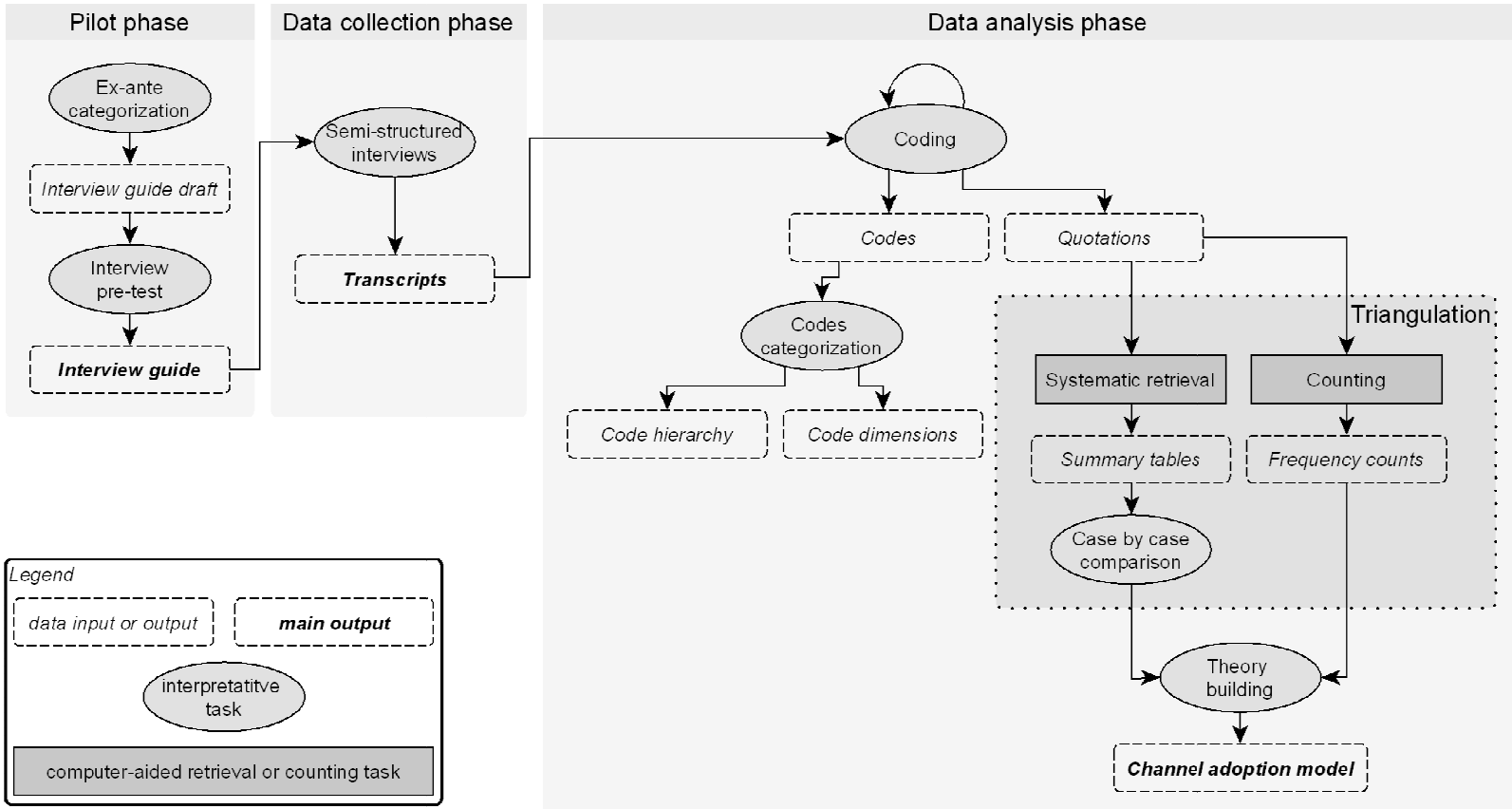


Figure 5.2 Research process conducted for this case study

In addition to this purely qualitative form of interpretation, we conducted counting – the process of assigning numbers to non-numerical data (cf. Hannah & Lautsch 2010 for a survey on the use of counting in qualitative research). The production and use of quantitative data in qualitative research is controversial and debated within the qualitative research community itself. However, we believe that, as stated by other scholars as well (Maxwell 2010), there are noteworthy reasons to make use of it: "internal generalizability", identification of patterns not apparent in the unquantified qualitative data or even to participants themselves, and as means to synthetically present evidence for the researchers' interpretations ("*to counter claims that you have simply cherrypicked your data for instances that support these interpretations*", as Maxwell puts it). We applied different forms of counting to the quotations. Proximity analysis – the analysis of the spatial relations between quotations – was the most prominent form thereof and allowed us to discover relevant patterns of code co-occurrence. Please note that, since we employed non-random sampling, frequency counts presented throughout this work are not accompanied by any indicator of statistical significance.

Table 5.1 Coding methods employed in the study and code examples

Coding method	Code example*	Quotation example[37]
Attribute	PROFILE INFO: ORGANIZATIONAL ROLE	*"I am in global sourcing […] and I do strategic projects on how to further develop our sourcing department."*
Structural	PROCESS PHASE: INFORMATION SEARCH	*"I believe information search somewhat depends on the need of explanation of the respective products."*
Descriptive (with subcoding)	SOLUTION DEPLOYMENT | ON-PREMISE	*"For an on-premise solution, one has probably still the traditional mindset and will raise a request directly to the company."*
Values	BARRIER OF ADOPTION	*"On-premise rather via the traditional channel because the initial investment is higher and the scope is more complex. This does not fit very well for the electronic channel."*
Simultaneous	PRODUCT TYPE: CORE | PRICE	*"Yes, the price does have a significant impact, especially when we talk about large and expensive solutions like ERP."*
Magnitude	NUMBER OF USERS | EFFECT DIRECTION (-)	*"If I had to buy 2000 Windows licenses, I would definitely try to reach out to the sales person and negotiate the price."*
Evaluation	IMPLEMENTATION-INTEGRATION EFFORT | BARRIER OF ADOPTION | EFFECT DIRECTION (–)	*"If you must customize the software highly, you will have intense personal contact and this will not work in an automated fashion."*

Note: The pipe character "|" separates multiple codes applied to the same datum; the colon ":" separates a code family label (e.g., process phase) from the specific code instance in the quotation (e.g., information search).

Counting and interpretation were combined depending on the specific research question. We sometimes exploited a triangulation approach by addressing the same research question with both techniques in parallel (referred to as "corroborative counting" in Hannah & Lautsch 2010). However, the researchers' interpretative tasks (such as the perusal of qualitative tables) always preceded counting to avoid that the results of the latter may influence the researchers' judgments involved in the former. In other contexts, counting was used to *select* a subset of cases for further interpretative tasks. In fact, we argue that an interviewee's view on a complex topic can be thoroughly understood and faithfully interpreted by the researchers only if sufficient textual material is available to them. Case selection was based on the number of occurrences or co-occurrences of certain codes (an example is detailed below where we describe how we have investigated the interdependences among adoption factors). We believe this to be an exemplary use of numbers to ensure that interpretations are grounded in the data and not just the result of selectively picking data to support them.

[37] Quotations throughout the chapter were translated from the German (and anonymized) by the author.

Finally, all along the research process, memos tracked methodological and conceptual developments: methodological notes focused on coding issues; theoretical notes recorded the emergence of relevant variables and their interrelationships. Most analytical tasks were performed with the (precious) support of the CAQDAS application Atlas.ti.

5.5. Sampling and Data Collection

We employed a combination of convenience sampling and snowball sampling to exploit our networks of professional relationships within a globally operating enterprise application software vendor (from now on referred to as "ESV"). Potential interviewees were identified – directly among our acquaintances or indirectly by inquiring them for further contacts – and subsequently approached via e-mail and telephone. As exhibited in Table 5.2, the first four interviews were conducted with sales executives from the ESV organization, the following twelve with managers from a highly diversified set of organizational contexts (in terms of area of responsibility, company size, and industry), mostly at the middle and top management level.

Table 5.2 Sample details

#	Personal profile		Organizational profile			Date	Sampling
	Level	**Role[a]**	**Relationship with ESV**	**Industry**	**Size**		
1-4	Interviews with ESV sales executives					March-April 2012	Snowball
5	Middle manager	LoB	Customer	Manufacturing	LE	April 2012	Snowball
6	Middle manager	LoB	Customer	Manufacturing	LE	May 2012	Snowball
7	Top manager	CEO	Partner	IT product and services	SME	May 2012	Snowball
8	Middle manager	IT	Partner	IT product and services	LE	May 2012	Convenience
9	Middle manager	IT	Customer	Retail	LE	May 2012	Snowball
10	Full-time employee	LoB	None	Consulting services	SME	May 2012	Convenience
11	Middle manager	IT	Customer	Financial services	LE	June 2012	Snowball
12	Middle manager	IT	Customer	Public administration	LE	June 2012	Snowball
13	Top manager	CEO	None	IT product and services	SME	Aug. 2012	Convenience
14	First-level manager	IT	Customer	Telecommunications	LE	Aug. 2012	Convenience
15	Middle manager	IT	Customer	Financial services	SME	Aug. 2012	Convenience
16	Middle manager	LoB	Customer	Manufacturing	LE	Sept. 2012	Convenience

Note: a) Abbreviations for organizational roles: LoB = Line of Business (i.e., any non-IT department, such as procurement, marketing, etc.), IT = Information Technology department, CEO = Chief Executive Officer or equivalent.

All interviewees were German but from international organizations. A governmental agency was also part of the study. All participants declared themselves familiar with organizational software purchases and have participated in organizational software buying processes in one or more of the following buying center roles: influencer (focusing on specifications and information gathering), decider (selecting the supplier and the offering), or buyer/approver (with formal authority to negotiate and close deals). The ESV sales executives (interviews I1-I4) were all experienced account managers responsible for one or more customer accounts.

5.5.1. Interview Design

Our semi-structured interviews consisted of four sections. The first one was an ice-breaking round of presentations and introductory questions on the interviewee's familiarity with online purchasing of software, both in the private and professional spheres. The second part dealt with the buying decision process and investigated the possibility of relying solely on an online channel to complete it. The third section explored the factors influencing the channel decision. In the concluding part, the interviewee was prompted to think of any overlooked aspect he/she had deemed worth including in the discussion. The two central blocks regularly amounted to about two thirds of the interview time. To support the discussion we employed visual representations of the buying process and of the product portfolio. Participants were preliminary made aware of the study's goals (including the realization of a scientific publication) and guaranteed of the anonymous treatment of any personal and organizational reference.

The wide range of products and services offered in the enterprise software market and the high diversity of organizational buying processes are potential sources of complexity in the channel adoption decision. Therefore, we have taken them into account when drafting the interview guide and included appropriate schematizations to tackle them effectively during the discussion. The two schematizations we employed addressed the product portfolio and the buying process.

Stylized Product Portfolio

Given the wide range of products and services exchanged in the market for enterprise software, and since we expected at least some product characteristics to play a role in the channel adoption decision, we devised a stylized product portfolio to be used as a common reference.

Our stylized product & service portfolio comprises four classes of items: core solutions, on-top solutions, usage enhancements, and IT services. *Core solutions* are either company-wide information systems (such as Enterprise Resource Planning) or systems spanning one functional area (such as Customer Relationship Management). *On-top solutions* are software components which provide core solutions with additional functionalities, business-process support, or front-ends. *Usage enhancements* are post-purchase goods enhancing a solution without modifying its code base, such as user licenses, usage contingences, and service level agreements. *IT services* are professional services related with the solution (e.g., implementation, data migration, and training).

Buying Process.

Furthermore, we have conceived a generic buying decision process for enterprise software. This buying decision process was derived from the ERP buying process in the ISR literature (Verville & Halingten 2003) and slightly simplified in order to comprise five phases: problem recognition, information search, evaluation, negotiation and purchase, and aftersales. In the *problem recognition* phase, the organization gains awareness of an opportunity or threat which can be dealt with by acquiring an enterprise solution. The *information search* covers the acquisition of information material and it is followed by the *evaluation*, where selected solutions and vendors are ranked. The *negotiation and purchase* phase encompasses finalizing the terms of the transaction, stipulating contracts, and executing the purchase. Furthermore, the *aftersales* phase covers additional purchases (i.e., the above-mentioned usage enhancements).

Each phase was treated similarly in the course of the discussion. The interviewee was asked to describe the generic enactment of the phase as-is in her organization. Hereupon, the possibility of performing the phase in the online channel was evaluated covering also the advantages and disadvantages of the channel. Whenever the interviewee did not mention the existence (or absence) of product specificities, she was reminded of the portfolio structure and prompted to think of any difference which may arise in sourcing the items online.

5.6. Empirical Findings

In this section, we report the empirical results obtained analyzing the semi-structured interviews. We detail the three components of our qualitative channel adoption model, which answers the explanatory research issue on the factors influencing the channel adoption decision.

Consistent with the way in which we decomposed the explanatory research issue, and given the nature of a qualitative research strategy, we have constructed our channel adoption model progressively: (I) we have identified the relevant variables influencing the channel adoption decision, (II) we have investigated their interrelationships, and (III) we have verified whether a factor's relevance may change in the course of a typical software buying process. We first describe how the factors influencing the online channel adoption decision have emerged from the data through coding and case-by-case comparison.

5.6.1. Dimensions Influencing the Adoption of Online Channels

An intermediate goal of the case study was to identify the relevant dimensions which influence online channel adoption as either barriers or drivers. A list of tentative factors devised from the relevant literature was part of the interview guide we employed. However, to let additional decision criteria emerge, it was discussed with the participants only in the interview's last section. The final list of factors is reported in Table 5.3 and comprises three categories of attributes (column A): those characterizing the purchased software solution, those inherent in the buying organization, and those reflecting the singularity of the transaction with the vendor in a given setting.

All factors are well grounded in the data, as shown by the frequency counts of how many participants judged the factor relevant for the channel adoption decision (column D). Using proximity analysis, it was also possible to determine how many participants mentioned a factor without being prompted by an interviewer's explicit question (the numbers in brackets in column D). The fact that more than half of the participants autonomously mentioned most of the factors is *another* proof that the list is grounded in the data and should accurately reflect the interviewees' perspective.

An assessment of the factors' impact on the adoption of respectively the online and offline channel was performed using qualitative tables and proximity analysis, and is reported in column E and F in Table 5.3: the "barrier" and "driver" labels identify the effect – respectively negative and positive – of one incremental unit of the factor on channel adoption. It was possible to elicit a clear tendency for most factors with regard to their perceived impact on the adoption of either channel. Since interviews dealt with the channel adoption decision *given* that a software purchase of some sort is to be conducted and *given* that the buyer is confronted with just the channel pair as choice set, the impact on the adoption of the two channels will go in opposite directions for each factor which does actually play a role in the channel adoption decision. Should this not be the case, the identified factor may actually be acting at some other level, for example, be a barrier or driver of software purchase in general. Therefore, the fact that most factors actually take on opposite roles with regard to the two channels further corroborates their relevance.

Only three particular cases in Table 5.3 cannot be explained as unambiguously. Although a positive direct experience with the channel provider may increase the attractiveness of the online channel, personal relationships developed in that context (e.g., the assignment of a dedicated sales account manager) are then seen as preferred means of communication and information gathering, and as a possibility for negotiating better prices and terms, thus possibly hindering the adoption of the online channel in favor of the offline one. In a related matter, mixed results were evident in the judgments expressed over contracts' standardization. While a standardization and simplification of contracts is seen as a prerequisite for completing online transactions, some interviewees stated that individually negotiated terms and conditions (for example, agreed volume-discounts) should be taken into account in online transactions, since, in the presence of standard contracts, the offline channel would be preferred in order to negotiate new terms and conditions. The involved agents' reputation and

trustworthiness drive the adoption of both channels and is therefore to be interpreted as a factor in the vendor selection decision rather than in channel selection. However, building trustworthiness between the vendor and the buyer is easier through the activities involved in an offline (and often personal) interaction than through online transactions. Therefore, the entry barriers in terms of trust are higher for the online channel.

Table 5.3 Factors influencing the channel adoption decision

A	B	C	D	E	F
Factor		**Description**	**Grounded-ness[a]**	**Impact on…**	
				online adoption	**offline adoption**
Solution attributes	Criticality	Importance of the supported business processes for the organization	11 (11)	Barrier	Driver
	Evaluability	Extent and easiness to evaluate the solution relying on the online channel's capabilities	12 (11)	Driver	Barrier
	Implementation/integration effort	Effort (in terms of time and financial investments) needed to have the application wholly implemented and integrated with pre-existent systems as needed	16 (8)	Barrier	Driver
	On-demand delivery	Possibility to deliver the application on-demand	10 (5)	Driver	Barrier
	Price level	Price of the purchased application	14 (10)	Barrier	Driver
	Scope	Breadth and depth of the supported functionalities.	11 (9)	Barrier	Driver
	Specificity / customization	The degree to which the supported functionalities are peculiar to a specific organizational domain or need to be adapt to it	13 (8)	Barrier	Driver
	Number of end-users	End-users to which the application is delivered	10 (8)	Barrier	Driver
Customer attributes	Innovativeness	Customer's attitude towards innovation and technology	3 (3)	Driver	Barrier
	IT competences	Availability of in-house IT know-how and personnel	11 (5)	Driver	Barrier
	IT control over the buying process	Level of control exerted by the IT personnel on software purchase decisions	12 (10)	Barrier	Driver
	Prior experience with the online channel	Past experience with a similar channel	5 (5)	Driver	Barrier
	Prior experience with the solution	Past experience with a similar solution	9 (9)	Driver	Barrier
Transaction attributes	Involved agents' reputation	Reputation and trustworthiness of the involved agents (vendor, channel provider, etc.)	7 (7)	Driver	Driver
	Buying center size	Number of people playing a role in the software purchase decision	12 (10)	Barrier	Driver
	Prior experience and relationship with the provider	Past experience and pre-existent relationships with the channel provider	11 (11)	Mixed	Driver
	Contracts standardization	Level of standardization of the contracts formalizing the software purchase	9 (9)	Mixed	Barrier
	Online purchase legal barriers	Breadth and depth of environmental legal requirements to be fulfilled in the online software purchase	7 (6)	Barrier	Driver

Note: a) Frequency counts of the interviewees qualifying the factor as relevant for the channel adoption decision. In brackets the number of participants who mentioned the factor without being explicitly prompted by the interviewer.

5.6.2. Static Channel Adoption Model

Considering both the direct and indirect effects which emerged from our data analysis allowed us to sketch an overall adoption model, illustrated in Figure 5.3. The diagram depicts a causal model with directed links illustrating cause and effect (Kirkwood 1998). Each single node represents a factor, with incoming edges from all other related factors. The links are further characterized as positive ("+") or negative ("-"). A causal link from one factor A to another factor B is positive if a change in A produces a

change in B in the same direction. It is negative if a change in A produces a change in B in the opposite direction. In the following paragraph, we will briefly discuss only the main aspects of the model.

Some factors relationships are not surprising: an increase in solution scope will likely increase the number of end-users served, on the contrary an increase in specificity will likely reduce it. In turn, the number of users will likely influence the total solution price (pricing models in the enterprise market are usually per-seat). In-house IT competences are viewed as a proxy for familiarity with online channels and platforms. More interestingly, maturing experience with the online channel is likely to reduce the IT personnel's weight in the software procurement process just as the level of integration and implementation effort is likely to increase it. Mitigating effects on the price as a barrier to adoption are exerted by prior experiences with channel or channel provider. Contract standardization appears once more an interesting case, since it is negatively impacted by three other factors: a pre-existent relationship with the provider (as hinted at above as well), the buying center size (determining the number of diverse requirements to be addressed in the contract terms), and the price level (increasing the need for direct off-line negotiations). Factor categories are also highlighted to appreciate how solution attributes impact transaction and customer attributes without being affected by them. This is one of our most important findings: solution attributes are at the root of adoption influences, and changing these attributes will in turn have a broad effect on the adoption, both directly and indirectly.

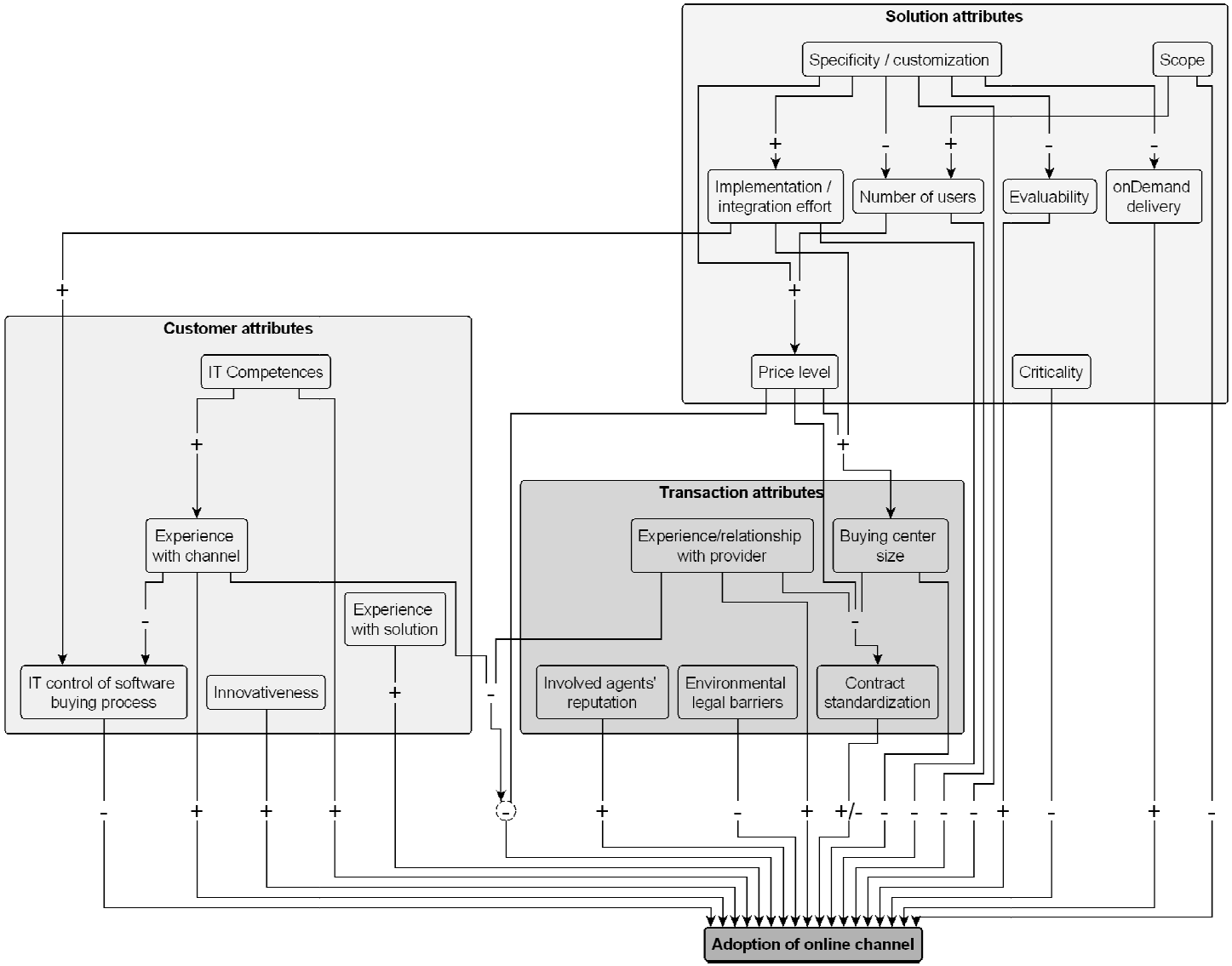


Figure 5.3 Static channel adoption model for an online channel in the enterprise application software market.

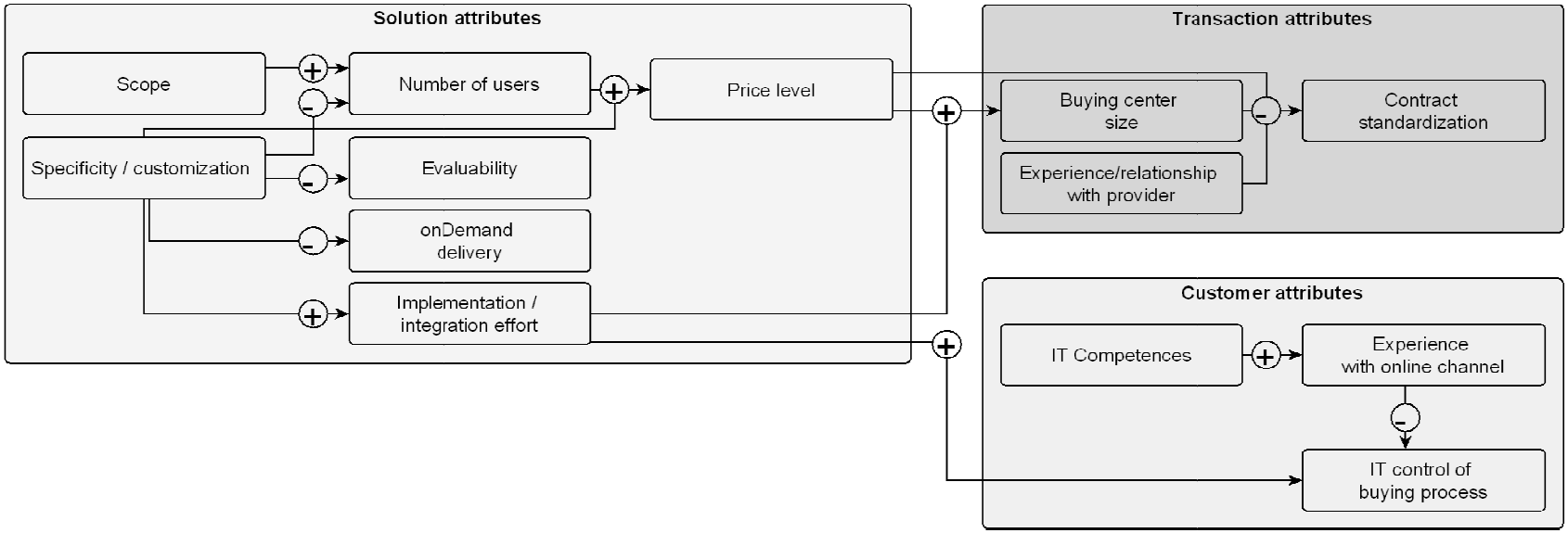


Figure 5.4 Detail from the static channel adoption model showing the interrelationships among channel adoption factors.

As the discussion of the individual factors lets imagine, the channel adoption decision is more complex and encompasses interdependences between the individual factors, which we tried to uncover to present a more thorough adoption model. Therefore, we have investigated the relationships between individual decision criteria further. This is an exemplary part of our research where counting was used to feed the interpretative work and not to corroborate it. We performed proximity analysis to obtain co-occurrence frequencies of all possible factor-pairs combinations and used these to select candidate pairs about which we had enough data (in terms of available quotations) to express a qualitative assessment. There were 101 factor co-occurrences appearing at least once in our data. We employed a threshold of four co-occurrences, that is, we selected factor-pairs for which quotations coded with one factor code overlapped to some extent with the quotations coded with the other factor code at least four times. We selected this threshold both to produce a manageable set of candidate relationships (37) and to ensure that we had enough qualitative material (*videlicet*, at least four statements per relationship) to faithfully interpret the interviewee's opinion.

While Table 3 presents the adoption factors and their direct influence on the channel decision, Figure 3 illustrates the interrelationships among the channel adoption factors, which we now discuss. Some factor relationships are not surprising. An increase in solution scope will likely increase the number of end-users served and, on the contrary, an increase in specificity will likely reduce it; in turn the number of users will likely impact the total solution price (pricing models in the enterprise market are usually per-seat). In-house IT competences are viewed as a proxy for familiarity with online channels and platforms.

More interestingly, maturing additional experience with the online channel is likely to reduce the IT department's influence in the software buying process, just as the level of integration and implementation effort is likely to increase it. Mitigating effects on the price as a barrier to online channel adoption are exerted by prior experiences with the online channel or with the channel provider. Contract standardization appears once more an interesting case, since it is negatively impacted by three other factors: a pre-existent relationship with the provider (as hinted at above already), the buying center size (proportional to the number and diversity of the requirements to be addressed in the contract terms), and the price level (which increases the need for direct off-line negotiations). Factors' categories are also highlighted to emphasize how solution attributes impact transaction and customer attributes without being affected by them.

5.6.3. Dynamic Adoption along the Buying Process

The last step in the construction of our qualitative adoption model was to investigate the factors' relevance along the buying process. In this section, we relate the adoption decision factors we have identified to the buying process phases and examine the possible change in the relevance of a factor from one buying process phase to the next. We first detail how the factors act in each step of the buying process. Table 5.5 and Table 5.6 provide an overview of all the barriers and drivers with short descriptions of their effects along the buying process.

Problem Recognition

In the problem recognition phase, the online channel should act as an external stimulus to arouse the needs of the customer-companies by proactively recommending additional products and signaling adoption trends. While this role was positively seen by the majority of the interviewees across all product categories (Table 5.4), issues where raised as to whether the online platform would be capable of targeting the right recipients in a trustworthy manner (Table 5.5).

A crucial barrier in this phase is complexity, partly inherent in the marketed software solutions and partly due to the diversity of user-profiles targeted by the channel, making it a daunting task to deliver the appropriate message or recommendation to a specific user. Other vendor's electronic marketing initiatives may also be inconsistent or confusing for online channel's users. Generally, unfocused and/or uncoordinated communication in an organizational context could annoy members of the buying center,

especially when they internally aim at conflicting organizational goals. Prior experience with the channel also represents a barrier, in that unprompted Internet messages are mainly associated with advertisement.

These issues notwithstanding, an online platform represents a unique opportunity for the vendor to extend its reach within the relevant buying centers (Table 5.6). It namely allows bypassing gatekeepers, that is, the buying team members (usually IT personnel) who filter the information flows and grant the vendor access to key employees. The platform could be accessed in all autonomy by any initiator, influencer, or decider, who may in turn use the published information to persuade others. In case recommendations were integrated into the vendor's own software applications, the users base itself could be leveraged. Two interviewees further believed that some disseminated information be of value to customers by itself, for it allows benchmarking against competitors and industry trends.

Instruments mentioned during the interviews mainly dealt with overcoming the complexity threat, the difficulty in targeting appropriate recipients, and the distrust attached to Internet media. A number of technical solutions were suggested which could help reducing the complexity by easing the navigation to the wanted piece of information. Among those the use of dedicated stores for different buying centers, search capabilities for customer references, success-stories, and best-practices. Recommenders which intelligently utilize the user's contextual information and take into account similar users' decisions could more effectively couple recipients with the appropriate recommendation. The sales personnel's knowledge of the customer's organizational environment could also be employed to fine-tune or personalize the messages. Coherently with the marketing literature, messages may be legitimized by exploiting the customer's attention to third parties' opinions, and, therefore, the channel's trustworthiness would be increased by using social networking components to involve experts and other users.

Information Search

In the information search phase, the online channel acts as one-stop shop for all the information requirements potential customers may have. Most points raised with regard to problem recognition apply just as well to this phase. As a matter of fact, interviewees often tackled both phases simultaneously or developed their remarks further from one to the other. Being free of any contractual binding for the channel user and given the already widespread acceptance of the Internet as a means of information retrieval (especially for on-demand solutions), there is an overall positive attitude towards the online platform as a source of information (Table 5.4).

Complexity and channel conflicts are the main barriers for the channel's adoption at this stage (Table 5.5). Both portfolio complexity and solution complexity may negatively affect the user's satisfaction with the channel. The latter complexity issue is more acute when the solution is large in scope or demanding in terms of integration, or when multiple decision criteria (and thus information requirements) are considered at once. This may be worsened by the customer's lack of in-house knowledge of the solution and its underlying technologies.

Partly as means of addressing this complexity, and partly out of established habits in the enterprise software market, an online channel is seen as competing with third parties and the vendor's own marketing and sales to win the customer's attention. While the autonomy and anonymity guaranteed by the online platform is valued by some, a direct contact point, such as a sales representative or a consultant, may still be considered a more convenient, comprehensive and reliable source, especially as the solution's criticality increases.

All instruments listed for the problem recognition phase apply to the information search as well, although the piece of information to be effectively retrieved, communicated, or legitimized revolves around the solution to the problem. For that reason, potential consumers require hands-on experience

with the solution in the forms of demos and trials. Moreover, new media could be employed to lessen or circumscribe the need for consultancy (e.g., video-conferencing and online seminars).

Evaluation of Alternatives

In the evaluation phase, the channel should allow an in-depth analysis and comparison of selected solutions. Whereas the general tendency was positive, responses varied considerably depending on the type of product under investigation. Most interviewees dismissed online evaluation of core solutions and services, but all contemplated it for on-top solutions (Table 5.4).

These different attitudes towards different product types are determined by multiple factors. Overall, the interviewees mentioned 16 of them, influencing the channel choice positively (drivers, Table 5.6) or negatively (barriers, Table 5.5) towards the online evaluation. The major barriers appear to be solution complexity, scope, and evaluability, mentioned by the lion's share of interviewees. Functionally complex products with breadth and depth of features, such as ERP, are rather considered suitable for traditional enterprise software channels where direct contacts with the vendor's sales force can take place. Furthermore, the evaluation of solutions may be hindered by the absence of customer data to produce meaningful test-scenarios. Whereas the latter may not exclusively be a barrier for online channels, the provision of interactive tools for easier online evaluation is boosted by online channels. Moreover, functionally limited solutions may be a driver of online channels. Thus, the limited solution scope or the limited integration are mentioned as driver in conjunction with the prior experience with the solution, the evaluability of solution in general and the integration/implementation effort. Concerning IT and professional services, the interviewees responded rather unfavorably to the online channel as means of evaluation given the intangible nature and the relevant human component of services.

The interviewees stated instruments and methods to overcome barriers mentioned above. Many proposed instruments address the evaluability (e.g., demos, trials, expert contact). Furthermore, the complexity / the scope of the solution may be reduced, for example, with guided tours or a wizard (i.e., answering questions on customers' needs and getting product recommendations). One Interviewee remarked that the online channel should address different information requirements: *"The executive board has another information demand what the solution does and how this is explained. They won't go into detail. … Of course, a member of the financial accounting … has to know whether dunning processes or credit vouchers can be done. That means, there is a layered information concept for different information requirements*".

Negotiation and Purchase

In the negotiation and purchase phase, the online channel should support the settlement of contracts, billing and payment, and the delivery of the solution. When analyzing whether the interview participants could imagine conducting this phase via an electronic channel, the results are rather heterogeneous (Table 5.4). Whereas the general tendency is almost balanced between pro and contra positions, most interviewees would not conduct this phase online for core solutions. However, some of them did distinguish between integrated solutions (like ERP) and more self-contained solutions (e.g., travel expense management) – the latter category perceived as better suited for an online channel. Contrariwise, on-top solutions were perceived as highly suitable for online purchases. Online-suitability was also attributed to standardized IT services (like training or maintenance services). IT and professional services with high personal components, however, are preferred to be purchased traditionally.

The identified influence dimensions for negotiation and purchase are broadly spread. Similar to the information and evaluation phases, multiple factors relating to the nature of the purchased solution were mentioned, e.g. solution complexity or integration and implementation effort. However, in contrast to these previous phases, a greater focus was given to contracts and pricing models as adoption

barriers (Table 5.5). Complexity in contracts and pricing models, as well as the need for individual contract conditions to comply with customer's requirements, is seen as a major barrier for purchasing enterprise software and services online. Further barriers mentioned by the interviewees included complexity in the solution deployment, and incompatibility with customers' internal purchasing policies and processes. Lack of integration with internal purchasing systems would lead to undesirable replication duties to maintain synchronization between the records.

Furthermore, the recognition of customers' individual contract conditions and existing frame contracts (covering online purchasing conditions) were mentioned as enablers for the online channel. The fact that online stores foster transparency in pricing and discount mechanisms is perceived as intrinsic advantageous to the online channel.

To counter the mentioned barriers, the interviewees proposed multiple instruments to address contract issues (e.g., frame agreements and standardization of contracts) and also pricing ones (e.g., online acknowledgment of individual discounts). Another group of proposed improvements dealt with customers' internal purchasing policies, processes and systems (e.g., support of budget allocation and approval, license management, integration with the customer's purchase system) and to handle the complexity of deployment processes (e.g., automatic deployment of the solution). Finally, tools to enable personal consultation with experts (such as chat, phone support, video conferencing) and certifications to build the solution provider's online reputation.

Aftersales

In the aftersales phase, the electronic channel should allow purchasing additional non-executable goods related to already acquired solutions, and managing them together with other solution aspects such as service level agreements. Most interviewees agreed on the viability of conducting this phase through an electronic channel (Table 5.4) and coherently focused on adoption drivers when discussing it. In particular, the possibility to perform license management online may be a driver for the online channel. Interviewees proposed online contract management (e.g., online availability of existing contracts) as a helpful instrument.

Table 5.4 Attitudes towards the online channel's support of the buying process

Buying process phase	Product class	Online channel adoption decision			
		Positive	Neutral	Negative	N/A
Problem recognition	*Overall assessment*	*11*	*2*	*2*	*1*
Information search	Core Solutions	8	2	5	1
	On Top Solutions	15	0	0	1
	IT Services	11	2	2	1
	Overall assessment	*8*	*4*	*0*	*4*
Evaluation of alternatives	Core Solutions	1	3	8	4
	On Top Solutions	9	1	0	6
	IT Services	2	3	3	8
	Overall assessment	*5*	*2*	*3*	*6*
Negotiation and purchase	Core Solutions	0	2	10	4
	On Top Solutions	6	2	1	7
	IT Services	3	3	4	6
	Overall assessment	*4*	*3*	*5*	*4*
Aftersales	*Overall assessment*	*8*	*1*	*2*	*5*

Table 5.5 Barriers to the adoption of the electronic channel along the buying process *(table continues on the next page)*

(Part 1/2)			Buying process phase				
			Problem recognition	**Information Search**	**Evaluation of alternatives**	**Negotiation and Purchase**	**Aftersales**
Dimension	**Solution**	**Complexity**	Breadth and depth of information make the platform impractical, ineffective, or overwhelming for the user to navigate		Negative impact on evaluability and integration, leading to offline consulting needs	Solutions are not just software, but a bundle of software and consulting services	Ecosystem complexity limits post-purchase services by the provider
		Criticality		The more critical the solution, the lower customers' willingness to employ the electronic channel			
		Evaluability		Software purchase a decision based on multiple criteria, each with particular information requirements	Available online information not sufficient; proliferation of variants; customer-specific data needed for test-scenarios; services especially difficult to evaluate and compare online		
		Scope		Breadth and depth of core solutions' functionalities lead to consulting need			
		Pricing			Prices to be put in context with value-added assessments, risk measures, and business cases, thus requiring personal consultations; current pricing models too complex		Current pricing models too complex
		Specificity	Most enterprise solutions require customization to be of interest for the potential customer				
		Implementa-tion & integration effort		High integration requirements will translate into high requirement for information on that regard	Establishing and testing integration requirements with the customer's own technological landscape is a prerequisite	High integration and implementation effort reduce the online channel's appeal	
		Deployment			Evaluation of on-premise solutions technically more difficult (it requires installation or hosting)	No support for building individual software packages and deploying upgrades/service packs; deployment from different vendors not standardized	
		Number of end-users				High volumes not purchased online	

Table 5.5 (Part 2/2)

			Buying process phase				
			Problem recognition	**Information Search**	**Evaluation of alternatives**	**Negotiation and Purchase**	**Aftersales**
Dimension	**Relationship**	**Provider's reputation & trust-worthiness**		A must, but building them requires personal contacts and thus a traditional sales channel			
		Existing relationships	Personal relationships a prerequisite to trust recommendations; only an account manager knows which is the right target for a certain message	The lack of existing business relationship with the provider increases perceived risk; in presence of a dedicated account representatives, the customer may find it more convenient to inquire or act through that channel			
		Contracts			Contracts contain complex elements to evaluate (e.g., pricing models, data hosting for on-demand solutions)	Nonstandardized contracts with individual SLA and price arrangements are demanded by customers	Customers want to avoid lock-in of long-term contracts and subscriptions
	Customer	**Prior experience with the solution**		Customers with limited or absent in-house expertise with regard to the solution will rather rely on third parties (experts, consultants and partners)			
		Prior experience with the channel	Automatic online recommendations perceived just as ads; confusion with corporate marketing web pages; erroneously targeted messages annoy users; lack of awareness of the online platform	Confusion with the provider's other electronic marketing initiatives	Customers not yet used to advanced online instruments such as wizards or system configurators		
		IT competences		Customers with limited or absent in-house IT expertise rather rely on third parties' consultancy	Low IT affinity negatively impacts evaluability	Lack of IT competences increases perceived risk	
		IT governance & procurement	Uncoordinated messages to multiple persons with conflicting stakes cause irritation	Customers advised by consultants or partners who fulfill their information requirements	Opposed by decision makers or forbidden by existing procurement processes	A plethora of people, hierarchies, and customer-specific policies and processes to be considered	The online platform do not reflect the customer's own license management
		Innovative-ness	A conservative attitude (generally associated with European customers) will delay adoption				

Table 5.6 Drivers for the adoption of the electronic channel along the buying process

			Buying process phase				
			Problem recognition	**Information Search**	**Evaluation of alternatives**	**Negotiation and Purchase**	**Aftersales**
Dimension	**Solution**	**Complexity, criticality, scope, specificity, Implementation & integration effort**		Simple, standardized, functionally-focused and self-contained commodity applications will be a driver for the electronic channel			
		Pricing			Availability of free-of-charge trials	Transparency of pricing models and discounts	
		Deployment		Information on on-demand solutions is already collected online	On-demand solutions more readily evaluated online	Automatic deployment	
		Number of end-users				Low sales volumes	
	Relationship	**Provider's reputation & trustworthiness**		A strong brand will drive adoption			
		Relationships with the provider	Possibility for the vendor to bypass gatekeepers and reach out to relevant customer's employees; possibility for the customer to avoid personal contacts and act in anonymity				
		Contracts in place	Freedom from any contractual binding at this stage		Short-term contracts	Frame agreements and recognition of customer-specific contractual conditions	
	Customer	**Prior experience with the solution**	Integrated with the vendor's own applications to leverage user base	Customers with solution expertise will be keen to inform themselves online	Positive prior experience with smaller or similar solutions encourage deploying larger solutions from the channel		
		Prior experience with the channel		Internet already used to collect information	The more activities and instruments are moved online, the more customers will get used to perform them there		
		IT in-house competences		Customers with IT expertise keen to inform themselves online			
		IT governance & procurement	Buying center members use online information to persuade other decision makers		Online channel as an instrument to enforce governance		
		Innovativeness	A pioneering attitude (generally associated with American customers) will drive adoption				

We now investigate the factors' possible change in relevance along the buying process. We performed this step by applying proximity analysis to detect the degree of overlap between codes for factors and codes for process phases. This allowed us to readily see in which phase or phases a factor was judged to play a relevant role (the co-occurrence with the values-codes "barrier of adoption" or "driver of adoption" was a criterion in the query). Results are detailed in Table 5.7, which presents the frequency counts of the participants in the sample for whom the specific factor-phase overlap was detected.

Table 5.7 reveals some interesting insight when read horizontally in terms of a factor's relevance across the whole process. Past experiences with the vendor, the channel, and the solution, solution specificity, and the degree of control over the process by the IT department are the only factors which are judged relevant by at least one participant in every phase. Not very surprisingly, solution evaluability is a relevant factor only during the phases of information search and evaluation of alternatives. Legal barriers to online purchases, contracts standardization, and price level are heavily influencing and rather specific to the negotiation and purchase phase, as intuition would suggest. Reading the table vertically (per phase), the tails of the process (problem recognition and aftersales) are less impacted by the set of factors than the body of the process, where the seven strongest factor-phase interdependences, detected in at least five interviews, are found.

Table 5.7 Factor relevance across the buying process (frequency counts)

Factors		Buying process phases				
		Problem recogni-tion	**Informa-tion search**	**Evaluation of alterna-tives**	**Negotia-tion & purchase**	**Aftersales**
Solution attributes	**Criticality**	0	4	2	1	0
	Evaluability	0	8	7	1	0
	Implementation/integration effort	0	2	4	4	0
	On-demand delivery	0	2	3	2	1
	Price level	0	5	3	10	6
	Scope	0	4	4	1	1
	Specificity / customization	1	5	5	2	1
	Number of end-users	0	3	1	1	1
Customer attributes	**Innovativeness**	0	1	1	2	1
	IT competences	0	2	0	2	0
	IT control over the buying process	4	6	3	4	2
	Prior experience with the online channel	1	5	1	4	1
	Prior experience with the solution	1	5	2	1	2
Transaction attributes	**Involved agents' reputation**	1	2	1	1	0
	Buying center size	0	0	1	0	0
	Prior experience and relationship with the provider	2	6	3	6	3
	Contracts standardization	0	0	1	9	2
	Online purchase legal barriers	0	1	0	3	0

5.6.4. Stylized Product Classification and Appification

We have exploited triangulation to analyze channel adoption in the light of our stylized product classification (cf. Section 5.5.1). On the one hand, we have qualitatively assessed solution types along the previously identified solution attributes (for instance, Core Solutions are associated with high criticality), obtaining profiles which could be fed into our adoption model to determine an overall tendency (Table 5.8). On the other hand, we have evaluated the interviewees' own judgments of the items' suitability for the online channel (Table 5.9).

The outcomes of both methods corroborate each other: Core Solutions' attributes are less suitable than On-Top Solutions and Usage Enhancements for online purchases. Uncertainty remains for IT Services

where no final statement could be made. An explanation could be the extreme variety of IT Services the interviewees referred to, ranging from large implementation projects to small training sessions.

Given their characteristics, On-Top Solutions could be qualified as "appified". This neologism recalls the distinguishing characteristics of today's mobile software applications, so-called "apps". The process of applying these characteristics to other software domains or even non-software contexts (for example, media and automotive) is referred to as "appification" (Hay 2010), and we believe that the appification trend will also impact Core Solutions in the near future.

Table 5.8 Portfolio items ratings against solution attributes (Low, Mid, High) and impact on online channel adoption [positive (+), negative (–)]

	Portfolio items			
Solution Factors	**Core Solutions**	**On-Top Solutions**	**IT Services**	**Usage Enhancements**
Criticality	High (–)	Low (+)	Mid (–)	Low (+)
On demand (OD) / On premise (OP)	OP / OD	OP / OD	N/A	N/A
Evaluability	Low (–)	High (+)	Low (–)	High (+)
Integr./impl. effort	High (–)	Mid (–/+)	N/A	Low (+)
Price level	High (–)	Low/Mid (+)	High (–)	Low/Mid (+)
Scope	High (–)	Low (+)	Low (+)	N/A
Specificity / customization	High (–)	High (–)	High (–)	N/A
Number of users	High (–)	Mid (–/+)	N/A	N/A
Overall adoption tendency	**(–)**	**(+)**	**(–)**	**(+)**

Table 5.9 Interviewees' judgments on the suitability of the channel for the different portfolio items

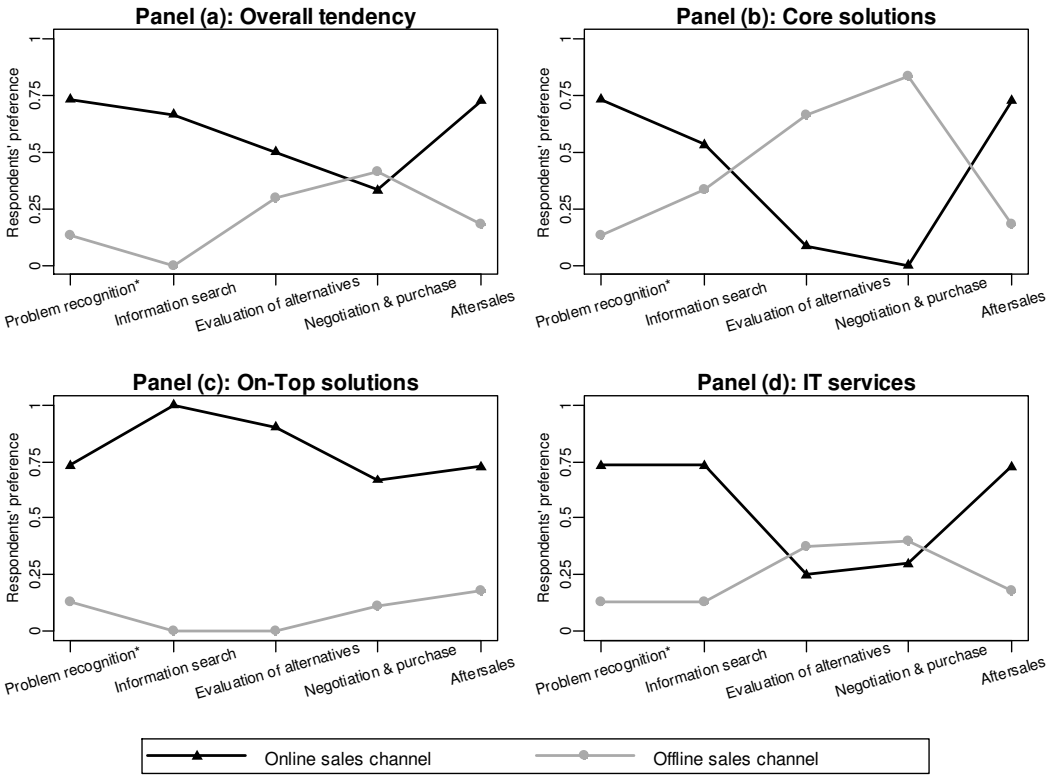
	Portfolio items			
Judgment	**Core Solutions**	**On-Top Solutions**	**IT Services**	**Usage Enhancements**
Positive (p)	4	11	5	7
Negative (n)	9	1	6	1
Unclear (u)	3	4	5	8
Tendency $\frac{p-n}{p+n+u}$	Negative -0,31	Positive +0,63	Neutral -0,06	Positive +0,38

5.6.5. Channel Adoption Profiles of Enterprise Software Offerings

Figure 5.5 depicts the interviewees' channel preference along the buying process – first overall and then per category of enterprise offering. This analysis was performed independently from the factor analysis in the previous section and can therefore serve as a test to corroborate it (triangulation). The vertical axis in the graphs indicates the percentage of the interviewees preferring the online or the offline channel, whereas the horizontal axis represents the buying process. Panel *a* shows that, for the initial three phases of problem recognition, information search and evaluation, the interviewees have a higher preference for the online channel, with a declining trend from problem recognition to evaluation. This trend continues in the negotiation & purchase phase where the interviewees have a higher preference for the offline channel instead. In the aftersales phase the trend reverses towards a higher preference for the online channel. The pattern of declining online preference towards the negotiation & purchase phase is largely shared across all product types; it differs only in magnitude and curve progression.

Panel *b* details the channel preferences in the case of core products. Whereas the online channel is still slightly favored in the information phase, the offline channel is preferred from the evaluation phase already. This could be due to the larger scope and lower evaluability of core products, partly resulting from higher customization needs. As one interviewee puts it: "*For core solutions, the more broad and*

complex the scope, the more a physical meeting with physical sales staff is required, because the decision makers are not so knowledgable to self-assess such a solution." For the negotiation & purchase phase, nearly all interviewees argued for the offline channel. Major barriers for online purchases are corporate guidelines that require contract customizations and the high price of core solutions: "*These are very individual agreements between customer and software supplier. We want our own clauses to be included. This is then a wrestling battle among lawyers*". The results in Table 4, where contracts and price have been identified as the most important factors for a channel decision in this phase, are in line with these findings.



Note: The material collected on the problem recognition phase was not sufficient to discriminate between product classes in that phase. The overall tendency is thus reported in all panels.

Figure 5.5 Channel preference along the buying process

In the aftersales phase, the interviewees argued again for the convenience of an online channel: "*Additional user licenses and usage contingents – this is a very good assortment for online shops. […] It is clear what you get, no technical customizations required, mostly just a license file to be uploaded or some contract value like SLA to be increased*". Additional purchases of usage enhancements for already owned products do not require extensive decision-making: contracts are already in place, costs are often marginal compared to the initial purchase, and involved risk is reduced due to the matured experience with the solution and the provider.

The channel preference for on-top solutions, presented in Panel *c*, shows a preference for the online channel throughout the buying process, with a slight decline in the negotiation & purchase phase. Compared to core solutions, this is due to the smaller scope, customization need, better evaluability, lower price and therefore lower risk and need for contract customization: "*Add-ons – I can imagine this very well – to download them somewhere and ideally upload it to the system and it works. It is anyhow an encapsulated limited functional scope*".

Panel *d* presents the channel preference for IT services. The information search phase would mainly be conducted online, whereas the evaluation and negotiation & purchase phases rather offline. Personal consultancy in these phases is required as services have often a broad scope and are highly customized.

Furthermore, interviewees argued that the human resources involved in most IT services can be better evaluated in a personal, offline interaction.

5.7. Discussion of Results

Our findings contribute to multiple streams of research at the crossroad between IS Research and Industrial Marketing. From an IS perspective, an online channel is the pivot of today's' software ecosystems and a pillar of the "app economy". Moreover, the technology adoption process *by organizations* is a scarcely explored topic. From a marketing point of view, we supplement the empirical research on organizational buying behaviors – where software buying is rarely considered – and contribute to the literature on online channel adoption (which, however, mainly neglects enterprise markets in favor of consumer ones). Therefore, we repute our findings academically relevant and able to spur further inter-disciplinary developments among scholars in the above-mentioned fields. Moreover, we offer a novel methodological alternative based on qualitative research to detect cannibalization in a market phase in which econometric methodologies cannot be applied due to the uncertainty produced by the ongoing innovation process.

Through our results, enterprise software vendors can have a glimpse into their customers' complex channel selection process. On the one hand, our findings may allow practitioners to design more effective multichannel sales systems and to diagnose hindering factors for the adoption of online and offline channels. On the other hand, they allow them to understand the interdependence between sales channel adoption and product characteristics, and thus to ascertain which multichannel configuration best suits the different classes of products and services in the portfolio of an enterprise software vendor.

5.7.1. Multichannel Sales System Design

Our findings can help to address the normative issue of whether an enterprise software application vendor ought to exploit a multichannel (online plus offline) system, and how it should be configured. Sales channels are indeed among the major choices in designing a vendor's sales system (Buxmann & Diefenbach 2008). However, this question must be put in perspective with the diverse set of enterprise software products and services, each of which may imply a different optimal strategy.

Based on our empirical results, we can derive some basic design recommendations for a multichannel sales system for enterprise software. Generally, we can state that the online channel is a highly relevant sales channel, especially for certain product types (i.e., on-top solutions), and at the beginning and ending stages of the buying process. At the same time, the offline channel is not only still needed due to certain complexities involved in the enterprise software purchase, but highly desired by customers due to its value-adding, consultative characteristics, especially for initial purchase scenarios (i.e., core solutions), and in the more formally binding buying phases. Given the different preference patterns for the different product types, we propose an integrated sales channel system with individual channel strategies for each product group and a separate channel strategy for the after sales phase across product groups. This way the online and offline channels will best cross-fertilize each other and exploit their respective strengths.

Core solutions have the highest offline suitability across the buying process. Yet, most interviewees argued favourably for the use of an online channel in the early stages of the purchase. Therefore, initially online and offline channel should be setup with equal priority. The online channel should offer dedicated handover points towards the offline channel along the buying process: for example, via online reservations for individual product presentations (i.e., "channel hopping" in the evaluation phase), or via "quote requests" for switching the channel in the negotiation phase. The data we have analyzed suggest that mainly changes towards the offline channel are required (excluding the after sales phase). However, in the negotiation & purchase phase, major consulting support is required to align the terms of the contract via iterative quote requests and proposal generation. Thereafter, the actual transaction could again be done online, i.e., accepting the proposed quotation. Even if this phase

is largely goverened by personal sales staff, the online channel could contribute by conducting "non-consultative" tasks.

For on-top solutions, an exclusive online channel, largely replacing the offline channel, makes sense if the sales and distribution model of such on-top solutions supports a highly standardized contractual model and the deployment and implementation efforts are reduced to a minimum. Especially for new types of solutions, like mobile business solutions, there seems to be the desire for an "app-store" kind of model: "*Mobile, online apps, yes, you buy these online because they are standardized and use them right away*." For premium customers or customers that cannot close the transaction online (e.g., due to customization needs for the contract in the public sector), there should be an exit path in the negotiation & purchase phase towards the offline channel to reduce drop-off rates.

In addition, deals for IT services can be initiated by the online channel. The high customization need and the involvement of human resources demand a traditional offline channel for many IT-services scenarios. Therefore, the online channel should support standardized, packaged IT service products or bundles for the entire transaction, and provide exit points towards the offline channel in the evaluation and purchase phase for buying scenarios that go beyond the standard service products (in terms of scope, price, customization need or where human resources need to be evaluated).

The aftersales phase is often a simple transaction without new buying decision parameters to be evaluated. Therefore, after sales products merely enhancing running contracts and/or usage scenarios should be supported by the online channel for the entire product portfolio. If the initial purchase was conducted offline, a process should be in place to handover the customer to the online channel for simple upsell scenarios. The offline channel can act as supporting channel when the initial deal is closed by personal sales staff and the customer is not inclined to change the channel, or in case of larger, more complex upsell scenarios requiring contract adjustements.

5.7.2. Comparison with Other Theoretical Models

When comparing our results with the buyclass model (Robinson et al. 1967), some of the factors we have elicited ("experience with provider", "experience with solution") identify the buying class, while others (evaluability, integration/implementation effort, as well as customization need) are determined by it. Though both our model and Robinson's share similar factors, our findings do not fully support the deterministic relationships between the factors outlined by the latter. Our stylized product portfolio can be partly mapped to the canonical three buyclasses. Purchase of "Usage Enhancements" will mostly be classified as a straight rebuy while the acquisition of "On-Top Solutions" or "IT Services" can relate to either the new task or modified rebuy buyclasses. However, contrarily to the buyclass model, we have found out that the characteristics of the purchased product or service need be considered to thoroughly explain software buying situations.

As the target of our research is not only to understand the buying situation for enterprise application software, but how the buying situation impacts the adoption of an online or offline sales channel, we compared our results with the TOE-Framework (Tornatzky et al. 1990). Our attribute categories partially map to the TOE-framework's contexts: customer attributes can largely be compared with TOE's organizational context; solution attributes do have minor overlaps with the TOE's technology context; transaction attributes are only slightly related with TOE's environmental context. Although the TOE-framework might explain parts of the adoption process, in our case it does neglect the specifics of enterprise software purchases. These findings are in line with the conclusions by Baker (2012): the general framework has proven valid, but unique factors peculiar to the specific context studied are necessary to model the adoption there.

5.7.3. Validity and Limitations

Different frameworks for evaluating qualitative research have been proposed, either trying to adapt the meaning of existing criteria from the quantitative tradition or generating brand-new ones for

qualitative research. We have selected one from each approach to have an overall and hopefully balanced assessment of our research study.

Wearing lenses closer to those of a quantitative researcher, we must confront the criteria of reliability and validity (Goetz et al. 1984). With regard to external reliability (i.e., the possibility to replicate our research endeavor), as commonplace in qualitative research, replicability is low, since our research process was influenced by the organizational context – the ESV – in which it was conducted from its earliest stages (e.g., the convenience and snowball sampling techniques). Nonetheless, we have detailed our research methodology as much as possible. Internal reliability (the consistency between researchers) was ensured by repeated daylong workshops where interpretative tasks were performed together, and by the use of standardized and agreed-upon coding-related artifacts. Among those: a common codebook and the same software tools (please review the research methodology Section for details).

We took internal validity aspects into consideration during both the design and execution of our research. The interview guide was iteratively tested and discussed with subject-matter experts. The transcripts were produced by researchers' assistants who are native German speakers familiar with the themes and terminology. The interdependence between different research techniques was also taken into account: purely qualitative analysis tasks strictly preceded counting whenever possible to let the researchers' theoretical sensitivity unaffected during interpretative acts. External validity (i.e., generalizability) could be questioned because of our non-random-sampling design but, as no qualitative study is generalizable in the probabilistic sense (Marshall & Rossman 2006, p.42), we believe our sample to be adequate, both in terms of size – it lies within the range of what is commonly considered acceptable for a qualitative study (Luborsky & Rubinstein 1995, p.105) – and representativeness, given the range of personal and organizational profiles. On that respect, some sample members were experienced sales executives with a broad view of the topic beyond specific organizational boundaries.

Evaluation criteria conceived specifically for qualitative research are instead trustworthiness and authenticity (Guba & Lincoln 1994). Trustworthiness comprises the four criteria of confirmability, credibility, dependability, and transferability. The latter three parallel the above-mentioned criteria of internal validity, reliability, and external validity. The same arguments thus apply. Confirmability (objectivity) could be put in question, since the authors are affiliated with a private organization with political interests in the research outcomes. Adhering to academically respected and well-known research standards and practices should mitigate that risk. With regard to authenticity, we believe to have represented different viewpoints (e.g., different buying-center roles were part of our sample) and to have provided some additional insight of a socio-technological context ("ontological authenticity"), which may be of interest to other members of such settings ("educative authenticity"). Since the research project was initiated and conducted in an organizational environment with stakes in the future development of the enterprise software market, catalytic and tactical authenticity (i.e., being spurred and empowered to engage in action) were assured.

6. Case IV – Business Model Cannibalization: from on-Premise to on-Demand

6.1. Introduction

The appearance of a technological or organizational innovation should always be scrutinized closely by market leaders, for overlooking disruptive changes may seed their demise (Christensen 1997). The rise of the on-demand delivery model in the enterprise software market is increasingly regarded as a case in point and has indeed exhibited some of the defining attributes of disruptive technologies. The first generation of on-demand solutions (so-called Application Service Providers) was underperforming in comparison with on-premise counterparts, both in responding to customers' needs and in generating the high-margins software vendors were used to. Moreover, it targeted the fringe price-sensitive market segments (medium-size companies). The following generation of on-demand software solutions has been bridging the performance gap, increasingly appealing to the mainstream business software customers (viz., to large enterprises), yet remaining less profitable than packaged software.

The above-mentioned interpretation is a basic tenet of the plethora of verdicts from the business and technology press prompting incumbents to transition to on-demand and cannibalize their customer-base on the premise of certain advantages: market expansion, economies of scale, and revenue predictability. Yet, academic research which would rigorously verify these claims and examine the nature and the consequences of such a strategic move is scarce. A vendor's transition from an on-premise to an on-demand delivery model is, therefore, a topical theme for academics and practioners alike. Relying on a mixed-method research strategy, we have conducted an explorative study focusing on two of the very few software companies which already turned into pure on-demand players after an on-premise market debut. Specifically, we used qualitative analysis to identify the milestones within such a transition and the most salient organizational issues they raise, and time series econometric analysis to assess the statistical significance of their impact on the vendors' financial performances.

This chapter is organized as follows. We first describe the case by sketching the historical development of enterprise on-demand computing (Section 6.2). We then review the multidisciplinary literature which expressly addresses the case topic and supplements the generic material already surveyed in Chapter 2 (Section 6.3). We detail the research methodology and data employed in this case study (Sections 6.4 and 6.5). We subsequently proceed with the data analysis and illustrate the main empirical results (Section 6.6); eventually, we discuss meaning and limitations of our findings (Section 6.7).

6.2. Case Description

In the last decade the software industry has witnessed the emergence of the on-demand/SaaS delivery model, whereby vendors provide web-based, outsourced software applications (SIIA 2001), dispensing customers with most installation, operation and maintenance activities otherwise needed at their premises. Moreover, SaaS solutions are usually coupled with subscription or usage-based pricing models (Lehmann and Buxmann 2009), lowering the initial investment in comparison with packaged software.

As a matter of fact, several beholders of the software industry agree that the adoption of SaaS applications has gained momentum: Information Systems researchers (Benlian, Hess, and Buxmann 2009), IT market analysts (Gartner 2010), and investors, who, in the first quarter of 2011, gave SaaS public companies an average market evaluation 6.5 times their annual revenues. This trend, in turn, urges incumbent vendors, which built their dominant market positions on the on-premise delivery model, to launch SaaS counterparts to their established software products, in coexistence or as replacements.

It is indispensable for the incumbent to understand the dynamics of revenue cannibalization and its consequences on profitability and on the positioning of the firm vis-a-vis the competition. Cannibalization is an issue of paramount importance for an incumbent vendor venturing into SaaS,

given the intrinsic degree of substitutability between the already established on-premise products and their SaaS siblings. This may indeed put pre-existent revenue streams and market shares at stake.

As a case in point, let us consider how competition is unfolding in the office automation market. Microsoft is the dominant player with 6 billion dollars revenue from that segment in the second quarter of 2011 (as a term of comparison, 5 billion was the revenue from the Windows OS). However, the entry into the market of free online office applications (such as those by Google) has pushed Microsoft to respond with the development of two SaaS alternatives to its well-known Office suite: a free, ad-supported one with limited functionalities and a subscription-based one with enhanced collaboration features. The delicate challenge is for Microsoft to tame the cannibalization effect this move may engender, i.e., to avert a financially harmful drift of on-premise customers to its own SaaS offerings.

Cannibalization may also represent a deliberate, offensive product strategy, pursued by the software vendor to drive growth (McGrath 2001). As a matter of fact, some on-premise vendors have successfully managed the transition to a hybrid or purely SaaS model. Concur Technologies, for instance, paired its on-premise offerings with the Application Service Provider model (the predecessor of SaaS) in the late 90s already, and then transitioned to become a purely SaaS player just as this delivery model emerged (Warfield 2007). Analogously, Ariba started the transition in 2006 and gradually ported all its applications to a SaaS model, now the generator of most of its revenues (Wainewright 2009). Both companies initially went after a SaaS-enabled market expansion aimed towards the mid-segment but eventually – in sharp contrast with the Microsoft scenario – found it profitable to deliberately cannibalize their on-premise customers along the way.

6.3. Related Work

During the late 90s and early 2000s, three concurrent phenomena paved the way to on-demand. First, enabling technologies such as server-based computing and the Internet became widely accepted (Kern et al. 2002). Second, on the demand side, large enterprises manifested the intention to reconsider their IT-sourcing strategies in order to reduce overheads and focus on core competences (Kern et al. 2002). Third, on the supply side, software vendors grew conscious of the middle-market's hunger for affordable enterprise software (Currie & Seltsikas 2000).

As a response to such demands, the Application Service Providing model (ASP) was introduced: renting and remotely accessing a software solution hosted and managed by a third party (outside of the customer's premises). Over time, the SaaS moniker displaced ASP, but whether something substantially differentiates SaaS from ASP is a source of debate. we will adopt today's seemingly more common view that the distinguishing characteristic of SaaS from ASP be multi-tenancy – i.e., the one-to-many cardinality between software instances and software customers (Stuckenberg & Beiermeister 2012). Multi-tenancy supposedly yields economies of scale while increasing the development cost (Katzan 2010).

The economics of on-demand software have attracted the scholars' interest from both a theoretical and an empirical point of view. From a microeconomic perspective, on-demand software shares the characteristics and complexity of both services and information goods. Therefore, analytical approaches must rely on simplifying assumptions and abstract the differences between on-demand and on-premise. In a duopolistic model where the SaaS provider can guarantee customers lower implementation/installation costs than its on-premise rival but must bear the expenses for the needed IT capacity, quality is shown to have a more decisive role in the long run than the lower costs (Fan et al. 2009). With different modeling choices (abstracting all but the licensing terms), it has been shown that, in a monopoly setting, in the presence of network externalities, renting is more profitable than selling (Choudhary et al. 1998). Besides, a SaaS monopolist has an incentive to invest more in software quality than an on-premise one and, whenever its cost of quality is not much greater than the latter's, will earn a higher profit (Choudhary 2007).

The economics of on-demand have been investigated empirically. An analysis of the quarterly financial results of a sample of software companies (with 158 firm-quarter observations of SaaS companies between 1994 and 2006) revealed that on-demand providers had significantly higher costs of goods sold and higher levels of sales, general and administrative costs (i.e., lower gross and operating margins) than their on-premise peers (Hall 2008). The estimation of Cobb-Douglas production functions from the annual financial results of another sample (with 284 firm-year observations of SaaS vendors between 2002 and 2007) has revealed significant *diseconomies* of scale in the on-demand model as opposed to the on-premise or hybrid one (Huang & Wang 2009).

To our knowledge, the *transition* from on-premise to on-demand has barely been touched upon by scholars, and only from a software engineering perspective: traditional software engineering practices devised in the on-premise paradigm cannot support the service-oriented business model and need to be re-aligned with it (Olsen 2006). Moreover, the "willingness to cannibalize" established products and related assets has been found to be an organizational trait which distinguishes enduring market leaders (Tellis & Golder 2002), but strategies of deliberate cannibalization are a rather underinvestigated topic. We believe this to be an urgent research gap in the field of Information Systems, since successful software vendors are those exhibiting higher-than-average cannibalization rates and the ability to successfully introduce a new product already during the growth phase of the previous one (Hoch et al. 2000).

6.4. Research Methodology

To comprehensively investigate the transition from on-premise to on-demand, we relied on a *mixed-method* research approach. A mixed-method research approach combines qualitative and quantitative strategies of research into one research process. In this case study, we combined them sequentially, using the output of a qualitative analysis step to feed the subsequent quantitative analysis (cf. Figure 6.1).

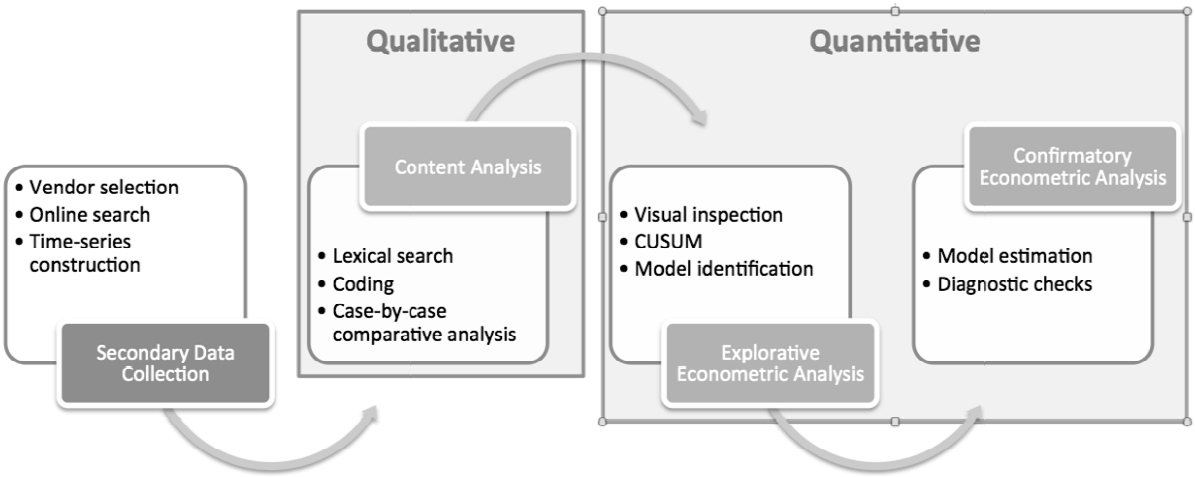


Figure 6.1 Research process for Case IV

Qualitative Research Steps

The qualitative component of the research process implemented in this case consisted in the interpretation and analysis of publicly available written accounts on the way the transition was conceived and conducted by the two organizations. This encompassed coding and systematic comparisons of codes and quotations.

Relevant paragraphs in the SEC filings were preliminarily identified through computer-aided lexical search. Special characters such as "*"could be used to search for a family of derived terms, given the root of the word. Moreover, the keywords for the lexical search were arranged in a hierarchy designed to allow the researchers a flexible way of detecting topics within the document. As an illustrative

example, consider the ASP topic, associated with keywords "*application service provid*, ASP*". We first searched for it in a subset of earlier financial reports (those filed until 2002). Next, we searched it in combination with the additional keywords set "**aaS, as a service, multi-tenan*, cloud*" for filings until 2006. Finally, we ignored it for searches in later reports, since the ASP technology and related terminology was not relevant anymore at the time of their publication. The full hierarchy of keywords employed for the lexical search is reported in Figure 6.2.

Figure 6.2 Keywords hierarchy for the preliminary lexical search

The coding techniques employed were *Descriptive*, *Simultaneous*, *Hypothesis*, and, to a lesser extent, *In-Vivo* coding (Saldaña 2009). An initial series of codes was derived from the literature and iteratively revised while coding the texts. All lexical search and coding tasks were performed with the CAQDAS application Atlas.ti. Figure 6.3 shows an example of a coding task performed with such an application. On the left side, the text is displayed and can be marked with prespecified codes or in-vivo with new ones, which subsequently appear on the right of the text in correspondence of the quotation they relate to. A hierarchy of the major codes developed during the qualitative analysis is reported in the Appendix. Codes, coded passages, and thematically related sets of elements were compared systematically across vendors, speakers, and publication dates to identify the transition milestones and to extract the qualitative input for the quantitative phase.

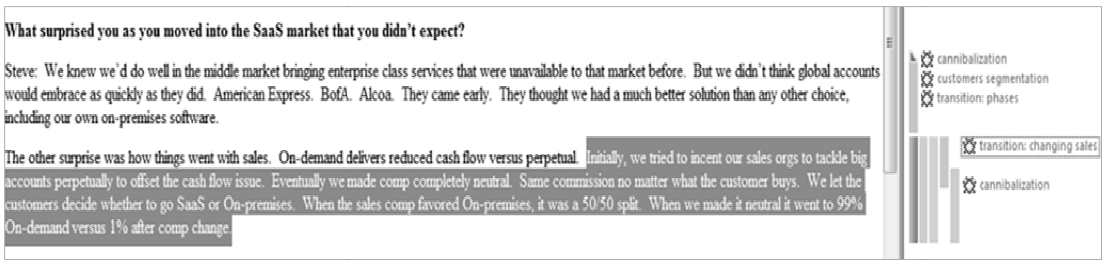


Figure 6.3 Example of coding with the CAQDAS application Atlas.ti

Quantitative Research Steps

The quantitative component of the research process implemented in this case relied on time series econometrics. The reader unfamiliar with the terminology of time series analysis can find a glossary of the most relevant terms in the Appendix (p. 177), as an aid to understanding our application of this quantitative approach. The econometric analysis was structured into an *exploratory* and a *confirmatory* data analysis stage, as already done in Case I and Case II too. However, in the context of this mixed-

method research instance, the exploratory analysis (i.e., "detective" work to reveal the main statistical characteristics of the time series) also bridges the qualitative and quantitative research phases.

In the confirmatory data analysis, clues from the qualitative data analysis and from the exploratory procedures are rigorously verified by estimating appropriate econometric models. Specifically, intervention models allow for a statistical description of changes in the mean of a time series due to either natural or man-made causes (Hipel & McLeod 1994, p.653). In its most general form, an intervention model has the following structure (see Enders 2010, pp.273–280; Hipel & McLeod 1994, chap.19 for a detailed account of intervention analysis):

$$y_t = a_0 + A(L)y_{t-1} + c_0 z_t + B(L)e_t \tag{1}$$

where the response variable y_t is the product of an auto-regressive moving-average process (whose two components are respectively $A(L)\ y_{t-1}$ and $B(L)e_t$) plus an intervention term $c_0 z_t$. The intervention series z_t is a dummy variable, of the same length of y_t, modeling the occurrence of the intervention. It assumes a value of 1 if the intervention is taking place (or is in effect), and a value of 0 otherwise (i.e., intervention not yet started or stopped). The coefficient c_0 is the intervention's impact effect.

It should be now clear why the qualitative component is an important preliminary step to the subsequent quantitative analysis: it enables to devise circumstantiated hypothesis around candidate interventions produced by the transition, which might have influenced the vendors' cost and revenue generating stochastic processes. In other words, it suggests possible shapes and anchor-dates for the indicator series to be used in the intervention models. Besides, it provides an historical perspective on the organizational and technological context in which decisions and events took place.

6.5. Data

All documents and numerical observations are from secondary data collection. The software vendors considered for this study are the US public companies Ariba (provider of solutions for enterprise spend management and sourcing) and Concur Technologies (provider of employee spend management solutions). The documents are SEC filings (available from the vendors' corporate websites) or transcripts of interviews and earnings calls with the participation of senior managers from the two vendors (published on specialized websites). A description of the data can be found in Table 6.1.

Table 6.1 Description of the data collected for Case IV

	Ariba	Concur Technologies
Qualitative Materials		
10Q SEC filings	47	41
10K SEC filings	22	14
Other SEC filings	22	1
Earnings call transcripts	11	21
Interview transcripts	22	7
Quantitative Data		
Data points	53	56
Time span	Q2 1999 – Q2 2012	Q3 1998 – Q2 2012

Four time series for each vendor were constructed from the collected quarterly observations: sales revenue (SR), gross profit margin (GM, gross profit over sales revenue), operating profit margin (OM, operating profit over sales revenue), and asset turn (AT, sales revenue over total assets). Sales revenue is an absolute measure of business scale; the profit margins summarize a vendor's ability to make a profit from its operations; the asset turn testifies of the vendor's efficiency in employing its assets. Revenue figures were converted to constant dollars using the Producer Price Index for Software Application Publishing of the US Bureau of Labor Statistics.

6.6. Empirical Findings

6.6.1. Qualitative Analysis

Analyzing the transcripts and financial reports, it is possible to elicit some generic phases and milestones which may characterize the transition from on-premise vendor to pure on-demand service provider (cf. Figure 6.4 and Table 6.2 throughout the following paragraphs). An initial phase poses the basis for the decision to transform the business and is therefore called *gestation*. Senior managers from both vendors declare that the strategy was mainly elaborated as a response to the way organizations were expected to buy enterprise software in the future, especially the middle market, seen as an untapped source of growth. Both firms had *ante-litteram* on-demand offerings in the market already (i.e., web-based, hosted, or ASP) which, though amounting to a minority of revenues, exposed the vendors early on to distinctive on-demand characteristics and challenges: scalability, subscription-pricing, potential cannibalization of license revenues and reduction of cash flows, integration requirements, and continuous enhancement.

The formalization and internal dissemination of the decision to embrace on-demand as the main delivery model for the company's future represents the beginning of the *transformation* phase. This phase affects all of the company's assets: the developed IT artifacts as well as the organizational capabilities needed to market, deploy, and service them. Apparently, the vendors realized early the need for a multi-tenant architecture underlying the new on-demand business, and built it mostly organically, re-engineering pre-existent technology and establishing new hosting organizations. Acquisitions and merges with ASP/SaaS pioneers, however, also played a role in making the needed technological assets and organizational capabilities available (the 2004 merger of Ariba with FreeMarket and the 2002 acquisition of Captura by Concur). The underlying multi-tenant platform is not the only technological novelty. Since subscriptions move the revenue barycenter farther away in time compared with traditional licensing, on-demand products must be built to simplify and thus speed up deployments, so as to accelerate revenue recognition.

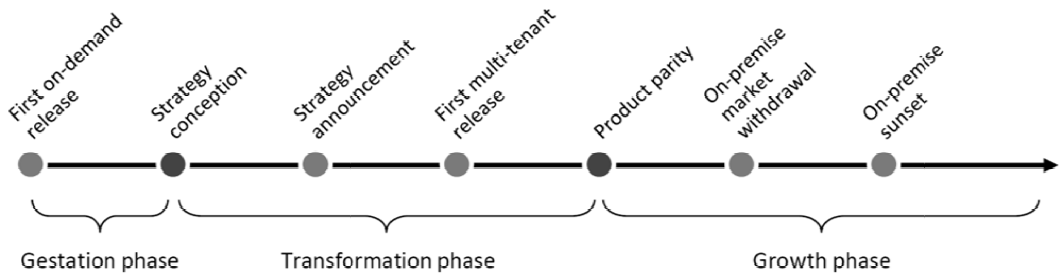


Figure 6.4 Generalized timeline of a vendor's transition from on-premise to on-demand

Table 6.2 Historical timeline of the examined vendors' transition

Milestone	Concur Technologies	Ariba
First on-demand release (i.e., web-based or ASP)	October 1999 (Concur eWorkplace.com; ASP)	April 1999 (Ariba Supplier Network; web-based)
Strategy conception	March 2000	May 2004
Strategy announcement	June 2000	November 2005
First multi-tenant release	not disclosed; est. 2000 – 2003	October 2005
Product parity	not disclosed; est. 2003 – 2007	April 2008
On-premise market withdrawal	2010[a]	Q1 2008[a]
On-premise sunset	Q1 2011, ongoing*	not disclosed

Note: a) Approximations based on our analysis of publicly disclosed information.

The primacy of platform and product development efforts lasts approximately until the first multi-tenant on-demand application or module is launched, shortly following or coinciding with the public announcement of the strategy shift to all external stakeholders (customers, analysts, investors, etc.). The most prominent goal then becomes adapting the organization. This is judged an even greater challenge than the technologic transformation, and it namely impacts the company's leadership as well (e.g., all but two executives were replaced at Concur over 9 months after the decision to transition was taken). In particular, services and sales must bear the most radical changes.

In the transition to on-demand, both the service mix and the nature of individual services change. Consulting services must be optimized for the deployments' higher volume and lower average complexity and length. Specialized services and expertise must be added to complement a solution which grows commoditized in its technological component. As a case in point, Ariba's system integration services, mainly linked to on-premise installations, have declined as professional services around sourcing and spending have increased. A customer management department must be established, which focuses on customers' satisfaction to drive usage – a recurrent theme, probably owing to the transaction-based pricing employed by both providers. With regard to sales, under the on-demand paradigm these tend to be more transactional, with shorter cycles and lower upfront commitment than on-premise. Therefore, salesmen should quickly close many small opportunities and build from there in a so-called "land and expand" model instead of aiming at only few large deals as they used to with on-premise products.

As the transition progresses, a fundamental turning point is reached when the on-demand solutions equal the on-premise counterparts' performances: product parity. As an Ariba's senior manager put it: "*This is the milestone that marks our successful transformation to an on-demand company. […] we are entering the* growth phase *for subscription and on-demand software*". Starting from product parity, the on-premise business is overtaken. The on-demand organization rides the learning curve and builds capacity to sustain growth. Amongst the vendor's challenges at this stage, organizational aspects are once more predominant: a bottleneck may namely arise whenever the balance between the capacities of the sales, deployment, and research and development organizations is lost.

The way legacy on-premise applications and their customers are managed in the growth phase deserves closer examination. Ariba and Concur have ceased offering on-premise solutions to new customers, and revenues from perpetual-licenses have accordingly grown smaller until the corresponding GAAP financial measure stopped being reported altogether. Nevertheless, this now finite universe of on-premise customers appears resilient – caught in the lock-in effect of sunk costs and customizations – and spontaneous conversions to on-demand are qualified as the exception rather than the norm. Discussing the results for the third quarter of fiscal year 2008 in a conference call, Ariba's CFO Jim Frankola declared: "*we do see a handful of customers go to on-demand […] but it is not strategic and it is not significant*". Nonetheless, self-cannibalization is expected to increase with the growing acceptance of SaaS and the aging of past IT investments.

Ariba devotes on-premise customers a business unit and last delivered a new on-premise software release in the third quarter of 2008. Concur stated in 2010 being in the process of "sunsetting" some legacy systems and migrating their customers to the on-demand platform. However, this is a delicate move from a competitive point of view, and, therefore, the disclosed information is merely sufficient to sketch the transition's end. Interestingly, Ariba managers declare that they refrain from any such self-cannibalization plan, although it would supposedly be attractive to both the customer (through total cost of ownership reduction) and Ariba (the subscription fee being higher than the maintenance one).

Theoretically, any of the above-mentioned transition milestones may represent a candidate intervention which could alter the stochastic processes underlying the vendors' performances. Concretely, the dates in Table 6.2 could anchor indicator series with a variety of patterns: a step function with a sudden level change coincident with the identified date, a gradually increasing or decaying level change, a temporary level change, a trend change. A perusal of the time series is thus required.

6.6.2. Econometric Analysis

In the *exploratory* stage of the econometric analysis, the collected observations were visually inspected to determine the stochastic processes' main characteristics and detect apparent interventions. A few illustrative examples of the undertaken procedures are given, before summarizing the overall findings.

Level changes unambiguously relating to a transition milestone are not easy to identify on time-plots alone, for other complex nonstationary components (seasonality, deterministic and stochastic trends) may confound their effects. An exploratory investigation tool specifically suited for intervention analysis is the "CUSUM chart": a plot of the cumulative sum over time calculated for a tentative intervention date (see (Hipel & McLeod 1994) for a formal account). The CUSUM follows an upward (downward) slope whenever the mean increases (decreases), and a sudden change in direction or steepness may signal the occurrence of an intervention.

Consider the CUSUM charts in Figure 6.5, used to investigate the effect of four transition milestones on Ariba's GM series. While strategy announcement and release of a fully-multitenant software version do not seem to produce any effect (there is no apparent change in the CUSUM in correspondence with the intervention date), strategy conception and product parity *might* be turning points in the profit-generating process (a change in the CUSUM may be spotted). Transition milestones identified as interventions by such exploratory procedures are gathered in Table 6.2.

In the *confirmatory* stage of data analysis, econometric models are fitted to the time series, and the interventions' significance could thus be statistically assessed. For every time series/milestone pair, we estimated intervention models with an array of alternative ARIMA configurations (namely AR1, AR2, MA1, MA2, ARMA11, and constrained AR2 and MA2 – with and without first differencing). For each intervention, three possible effects were simultaneously estimated, that is, three shapes of z_t were used in the response equations (cf. Eq. 1): pulse, step, and trend. Formally:

$$y_t = a_0 + A(L)y_{t-1} + c_0 z_{0t} + c_1 z_{1t} + c_2 z_{1t}(t - T + 1) + B(L)\varepsilon_t \tag{2}$$

where the c's are the intervention terms' coefficients, whose significance would corroborate the transition milestones' impact in the vendors' performances. z_{0t} is a pulse indicator series entirely made up of 0's, except for a 1 at time T (the intervention date). z_{1t} is a step indicator series made up of 0's until T, and then 1's thereafter.

This main round of estimations served the two purposes of selecting the significant effects among the three considered for each intervention/time series pair, and of screening the best fitting ARIMA configurations. Subsequently, the insignificant terms were removed from the equations before re-estimating the more parsimonious models. The first round of estimations resulted in discarding most candidate interventions (not producing any statistically significant impact), and keeping a few which produce multiple concurrent (significant) effects. Results of the second round of estimations are shown in Table 6.3.

Table 6.3 Interventions detected in the *exploratory* data analysis

		Ariba				Concur Technologies			
		SR	**GM**	**OM**	**AT**	**SR**	**GM**	**OM**	**AT**
Milestones	**First on-demand release**				✓		✓		
	Strategy conception	✓	✓		✓		✓		
	Strategy announcement			✓			✓	✓	
	First multi-tenant release			✓		✓			
	Product parity	✓	✓						✓
	On-prem. market withdrawal								
	On-premise sunset	N/A	N/A	N/A	N/A				

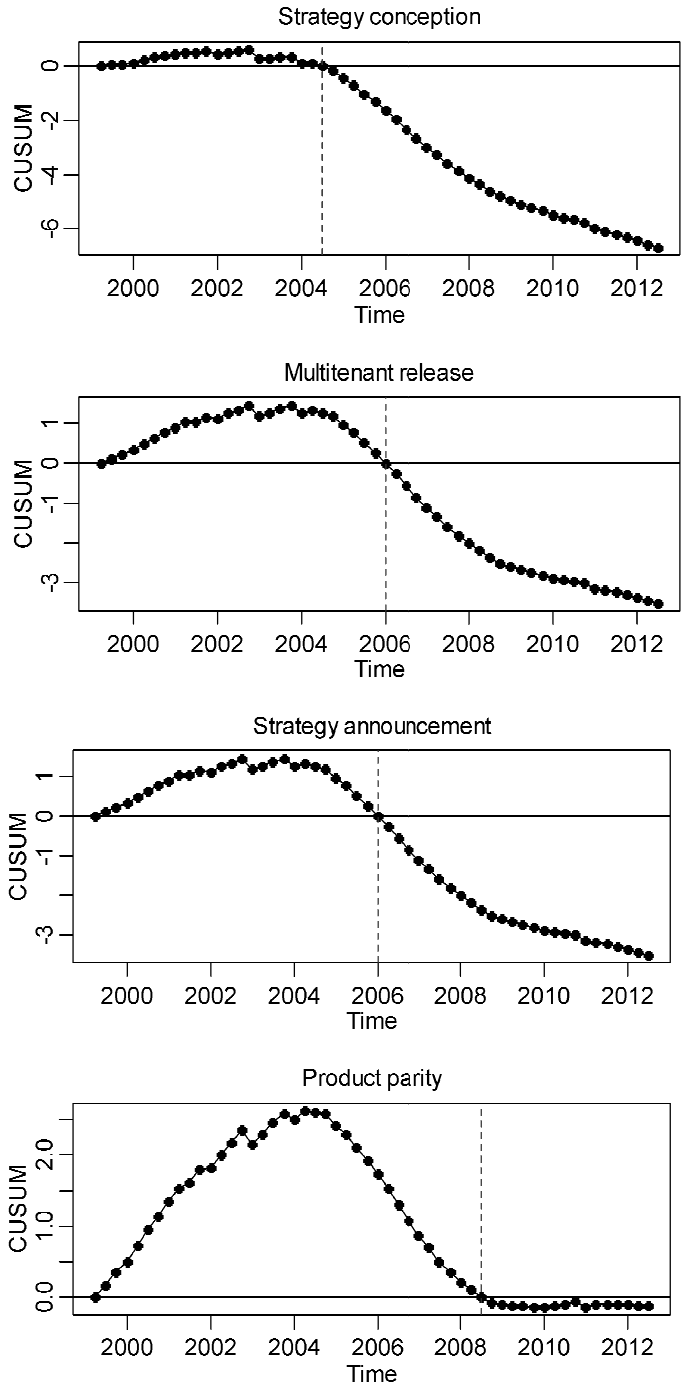


Figure 6.5 CUSUM charts for candidate interventions in Ariba's GM series

Table 6.4 Interventions ascertained in the *confirmatory* data analysis

		Significant intervention	Pulse effect[a] $\hat{c}_0$	Step effect[a] $\hat{c}_1$	Trend effect[a] $\hat{c}_2$	ARIMA best fitting conf.
Ariba	**SR**	(None)				AR1
	GM	Strategy conception	- 0.37124	0.05527	- 0.00275	ARIMA(0,1,1)
	OM	(None)				ARIMA(0,2,1)
	AT	First on-demand release	3.03762	- 4.69899	0.03697	ARMA11
Concur Tech.	**SR**	First on-demand release	- 0.37914	- 0.16106	- 0.1263	MA2
	GM	Strategy announcement	- 3.75797	- 0.39184	0.00723	ARMA11
	OM	Strategy announcement	- 6.14422	0.16008		MA2
	AT	First on-demand release	0.50136	0.23668	- 0.00654	ARIMA(0,2,1); constrained

Note: a) Significance level 5%.

6.7. Discussion of Results

6.7.1. Interpretation of the Empirical Results

The processes underlying the on-demand transformation are complex and difficult to manage for a vendor, both from a technological and from an organizational point of view. The latter is an often overlooked aspect shaded by the attention on technological topics, such as multi-tenancy. Yet, the deep changes affecting sales and consulting organizations are amongst the most relevant issues emerging from the qualitative analysis.

Some of the identified transition milestones do appear to produce changes in the vendors' cost and revenue generating processes – changes which can be visually spotted in the time series and confirmed as statistically significant by appropriate econometric procedures. Interestingly, some milestones act on multiple levels and impact in contrasting ways the short-term performances (pulse effect), the long-term ones (step effect), and the rate of change (trend effect) – a further testimony of the high complexity involved in the transformation.

Surprisingly, despite the attention that on-demand attracts on the premise of expanding the market, no significant stimulation of total revenues could be detected in correspondence with any milestone. Moreover, early on-demand experiences (ASP, web-based solutions, etc.) seem to play an unexpected important role: this first milestone has triple significant impacts on the efficiency of assets utilization of both vendors and on the sales revenue of one. Profitability is negatively impacted in the short-term, as hypothesized in the literature (and intuitively reasonable considering the bearing of incremental responsibilities by the vendor). On the long run, the verdict is less clear.

6.7.2. Validity and Limitations

A series of limitations must be acknowledged. First of all, the low number of companies in the sample may hamper generalizability. Moreover, the causal relationship between milestones and financial performances should be examined further, since there may be other phenomena acting in the background, either confounding or amplifying the effects ascribed to the milestones by our methodology. With regard to the identified interventions, interactions and simultaneity should be investigated as well, and patterns of gradual or lagged change could be introduced.

7. An Agent-Based Computational Laboratory for Sales Cannibalization Studies

As we have seen up to now, sales cannibalization bears a prominent role in IT markets, determining the outcomes of competitive upheavals and the fate of products, vendors, or whole industries. Measuring this phenomenon is therefore of crucial importance but involves the problematic comparison of two alternative states of nature. Whether an *actual* sale should be qualified as "cannibalized" namely depends on the buyer's *hypothetical* behavior before a market landscape without cannibal product, ceteris paribus (cf. Section 1.2.3). In this setting, simulation allows an experimental investigation to take place that would otherwise be impossible or impractical as a field experiment or through econometric analysis. Agent-Based Modeling and Simulation, in particular, enables the researcher to observe the customers' internal decision-making and detect whether cannibalization is occurring. This chapter illustrates how to design, implement, and employ an agent-based Computational Laboratory for the study of sales cannibalization through numerical experiments.

7.1. Introduction

Throughout this work, we have shown how problematic it is to operationalize the concept of cannibalization, to ascertain whether an *alleged* "cannibal" product or service may be diverting sales from another existing product or service. To unambiguously assess if a given sale ought to be qualified as "cannibalized", a comparison of two alternative states of the world is required: the *actual* buyer's purchase decision and his *hypothetical* behavior before a market landscape without the cannibal product or service, all other things held equal. Therefore, it may be argued, only an experimental approach – with the cannibal product's market launch as treatment – may shed light on cannibalization effect.

Field experiments in a real shopping environment test the changes in consumers' buying behaviors ascribable to the cannibal's introduction with an experimental methodology (Urban & Hauser 1980, chap.13–14). However, their use as documented in the marketing literature is limited to instances of nondurable consumer product launches, and they thus present issues of generalization. Their practicability in the context of IT purchases is doubtful (cf. Section 1.2.4 and 2.3.4). An alternative is represented by the quasi-experimental design of time series econometric studies based on historical sales data, which we employed in Cases I, II, and IV. Some cannibal-related event (commonly the cannibal's market launch) acts as the natural experiment occurring at a discrete point in time. Calibrated time series models can statistically investigate the impact of such an event on a stochastic sales-generating process in terms of structural changes. Nonetheless, it may be difficult to provide evidence for the causal link between cannibalization and the changes in the sales-generating process.

On this premise, we judge simulation a valuable research methodology for the study of sales cannibalization. It allows the researcher to investigate a market model experimentally – retaining control of the cannibal's presence in the market – and to incrementally/selectively tackle environmental and competitive factors, which may drive, hinder, or mask cannibalization effects. An Agent-Based Modeling and Simulation (ABMS) approach, especially, empowers the researcher to observe the purchasing agent's evolving preference structure and the decision-making processes on top of it. This way, it enables the implementation of alternative operational definitions of cannibalization. We thus judged it most suitable for the purpose of cannibalization detection and measurement and we illustrate in this chapter how to design, implement, and employ an agent-based Computational Laboratory for the study of sales cannibalization.

This chapter is organized as follows. First, we introduce the ABMS simulation methodology (Section 7.2). The foundations for building a valid simulation model for sales cannibalization studies are described next and encompass modeling requirements, design choices, implementation, and verification (Section 7.3). Subsequently, we elaborate on the experimental and architectural aspects of a Computational Lab built around a simulation model (Section 7.4). As an illustrative application, we present a simulation study of cannibalization in the software market (Section 7.5).

7.2. Agent-Based Simulation and Modeling

Among the characteristics of the sales cannibalization phenomenon, we may recall its complexity, the partly inscrutable nature of the buyers' decision making, and its being fundamentally the outcome of economic interactions (or the absence thereof) between autonomous market agents. These characteristics make it a perfect candidate to be investigated by means of a relatively new simulation methodology called Agent-Based Modeling and Simulation (ABMS).

ABMS is a numerical approach which enables modeling and simulating a Complex Adaptive System (CAS), i.e. a system describable as a collection of interacting components. The fundamental notion underlying this way of addressing complexity is that the whole of the system is not necessarily the plain sum of its constituent parts. The system may exhibit emergent properties: properties arising from the components' interactions, which could not be deduced by simple aggregation of the components' own properties. A market represents an excellent example of a CAS, since it is a collection of adaptive agents (e.g., suppliers and customers) concurrently engaged in local interactions (commercial transactions), and local interactions produce higher-level conditions (market prices, bandwagon effects, etc.) influencing in turn the way those same interactions will evolve over time.

Among the paradigms used to investigate such systems, we have chosen ABMS. In ABMS each interacting component is modeled as an autonomous decision-making agent with attributes and rules defining his behavioral characteristics and how those are to evolve or adapt (North and Macal 2007). This approach lends itself neatly to the exploitation of microeconomic constructs in modeling agents' behaviors and interactions (game theory, for instance, to dictate an agent's strategic responses) and is therefore especially suitable to study a CAS populated by economic entities. In fact, the study of economics with ABMS has reached such a respectable status to beget its own specific field of research, called Agent-Based Computational Economics (Tesfatsion 2002).

Later in this chapter, we use ABMS to investigate at a microeconomic level a cannibalistic situation. We simulate a stylized business application software market where a multi-product incumbent vendor runs the risk of revenue cannibalization. As we will see, ABMS suits perfectly the study of this phenomenon since, offering the possibility to observe the behaviors and decisions of individual buyers, it allows disaggregating the diverse sources of demand. This means identifying exactly which customers switch between software applications of the same vendor (cannibalization), leave for a competitor (competitive draw), or enter the market for the first time (market expansion).

7.3. A Simulation Model of Cannibalization

7.3.1. Modeling Requirements

Design choices for a simulation model must be taken to fulfill three requirements: representativeness, parsimony, and theoretical coherence. The simulation model should be representative of a market scenario where cannibalization occurs, i.e., it should allow mimicking a stochastic cannibalization-generating process with the characteristics identified by previous research studies. The simulation model should also be parsimonious in terms of the number of parameters necessary to specify its initial conditions and behavior, in order to be easily controllable across trials and experiments. Finally, all model components should reflect theoretically-sound constructs.

From the point of view of representativeness, the nature of the cannibalization phenomenon is captured once the model is capable of reproducing the phenomenon's characteristic patterns and behavior. This translates into a series of modeling requirements, which were gathered from previous empirical studies on cannibalization. Table 7.1 lists the requirements and the corresponding references.

Prior empirical analysis of cannibalization patterns revealed the possibility of asymmetries and the involvement of items both within and between product categories. These aspects ought to be taken into consideration when designing a simulation model. The model should also allow multivariate

cannibalization within a given set of products. With regard to the temporal dimension, cannibalization may change over time due to customers' heterogeneity in adoption timing and other random disturbances, and the simulation model should thus be able to behave this way as well. Cross-period effects and alterations of the victim product's long-term market performance ought to be specifiable too.

Table 7.1 Modeling requirements from the literature

	Characteristic of the cannibalization process (source)	Modeling requirement
I	Asymmetry of cannibalization patterns (Mahajan et al. 1993)	Sales of one product mix item may affect sales of a second item differently than the other way around.
II	Variation of cannibalization patterns over time (Mahajan et al. 1993)	Diversion of sales between two items in the product mix may change over time (in magnitude and/or direction).
III	Multivariate cannibalization (Carpenter & Hanssens 1994; Mason & Milne 1994; Reddy et al. 1994)	A cannibal may divert sales from multiple victims. Conversely, a victim may lose sales to multiple cannibals.
IV	Stochastic effects (Reddy et al. 1994)	The cannibalization patterns may be subject to temporary nondeterministic disturbances.
V	Long term effects (Deleersnyder et al. 2002)	The addition of the cannibal may change the underlying (base) sales-generating processes.
VI	Cross-period effects (Biyalogorsky & Naik 2003)[a]	Cannibalistic shifts in sales may encompass stockpiling or anticipation and therefore produce lead or lagged effects.
VII	Cross-sectional heterogeneity (van Heerde et al. 2004)	Sales response may differ depending on the considered aggregate data cross-section (e.g., store).
VIII	Customers heterogeneity (Kaiser 2006)	Potential customers may react differently to the presence of the cannibal, in terms of the type of response or its timing.
IX	Inter-category effects (van Heerde et al. 2010)	Cannibalistic sales diversion may take place also among items which belong to different product categories.

Note a) lagged effects only

7.3.2. Model Design

The pseudo-population in a simulated market must include at least two types of agents: suppliers and consumers. They perform the actions required for an economic market to function. Suppliers offer products, with at least one supplier offering multiple products at once – necessary condition for cannibalization to take place. Consumers evaluate products in the market and, based on the computation of utility scores for each product, possibly buy one (paying for it); then, depending on the product's durability and on the evolution of their preferences, they can re-buy or switch to a different offering. Alongside these two agents, the economic entities of product and product category compose a two-tier product hierarchy, which allows sales diversion to occur at either level.

A microeconomic model can be adopted as the deterministic backbone of the simulation model. For instance, a location model of horizontal differentiation (Waterson 1989) responds thoroughly to the criteria mentioned in the previous section:

- Representativeness: it fulfills several of the aforementioned modeling requirements.
- Parsimony: it hinges on just one parameter per entity, that is, its location (as detailed below).
- Theoretical soundness: it is a widely used construct for the micro-foundations of economic models.

A short analytical digression will demonstrate the horizontal model's cogent elegance in formalizing cannibalization.

A Location Model of Sales Cannibalization

In a location model of horizontal differentiation, products are located along a linear characteristic space. The location of each product identifies its peculiar design or implementation. Consumers are distributed along the same linear space. A consumer's position represents his preferred ideal product

design. He will thus buy the product closest to his position, if any is close enough. Mathematically[38], consumer j obtains the following utility from product i:

$$U_{ji} = u_0 - |x_j - x_i|, \tag{1}$$

where the term u_0 represents the consumers' basic willingness to pay for any product in this product category. The modulus – the absolute distance on the horizontal differentiation space between product i's location and consumer j's ideal product location – is the disutility that the consumer bears by getting i in lieu of his preferred design. Each potential customer buys the product providing the highest nonnegative utility or does not purchase if no product is close enough to let the right side of the equation result in a nonnegative value.

To compute product i's total sales, consider that, given the disutility term, i will be purchased only by consumers who are located "close enough" to find its design more attractive than buying a competitor or not buying at all. To formalize this condition, we first define the subsets $\underline{\boldsymbol{x}}_{-i}$ and $\overline{\boldsymbol{x}}_{-i}$ of all rival products $\boldsymbol{x}_{-i}$ ("$-i$" being a handy notation to label the set of all entities in i's class except i itself) which are respectively located on the right side ($\overline{\boldsymbol{x}}_{-i}$) and on the left side ($\underline{\boldsymbol{x}}_{-i}$) of product i on the horizontal differentiation space[39]:

$$\begin{aligned} \overline{\boldsymbol{x}}_{-i} &\stackrel{\text{def}}{=} \{x_j \in \boldsymbol{x}_{-i} : x_j > x_i\} \\ \underline{\boldsymbol{x}}_{-i} &\stackrel{\text{def}}{=} \{x_j \in \boldsymbol{x}_{-i} : x_j < x_i\} \end{aligned} \tag{2}$$

Product i will be attractive only to consumers whose preferred product location lies on the segment $[\underline{x}_i, \overline{x}_i]$, whose endpoints are given by the most stringent of either the linear space boundaries (i.e., the interval [0,1]), the half-length of the overlap with the nearest competitors' segments, or the maximum distance from the ideal variant that a customer would withstand:

$$\begin{aligned} \underline{x}_i &= \max\left(0, x_i + \frac{\sup(\underline{\boldsymbol{x}}_{-i}) - x_i}{2}, x_i - u_0\right) \\ \overline{x}_i &= \min\left(1, x_i + \frac{\inf(\overline{\boldsymbol{x}}_{-i}) - x_i}{2}, x_i + u_0\right) \end{aligned} \tag{3}$$

If we assume that there are M potential customers distributed along the linear space with some density function f, product i's total sales can be obtained by integrating between the two coordinates which we have just derived:

$$q_i = M \int_{\underline{x}_i}^{\overline{x}_i} f(x)dx = M\left[F(\overline{x}_i) - F(\underline{x}_i)\right] \tag{4}$$

Cannibalization will occur whenever the cannibal presence alters the victim's domain of integration used in (4), i.e., the coordinates expressed by (3). This will happen when the cannibal product is located close enough to become attractive for some of i's consumers. Exemplarily, if we place the

[38] We simplify the traditional form of the model by setting the price for all products to zero and a unitary transportation cost (the disutility to bear for the distance between a consumer's ideal variant and the actual location of a product).

[39] In this setup, consumers will choose randomly between identically located products. Therefore, in case n products are colocated with i, the results of this sections in terms of total sales and cannibalization must be divided by n.

cannibal at the right of product i on a random location x_c within the interval $(x_i, \min[1, \inf(\overline{\boldsymbol{x}}_{-i}), x_i + 2u_0])$, i's new right endpoint becomes $\overline{x}_i^c = (x_i + x_c)/2$ (with $x_i < \overline{x}_i^c < \overline{x}_i$). Total cannibalization will then be the difference between the integral on the range $[\underline{x}_i, \overline{x}_i]$ (the one originally employed in (4)) and the integral on the newly derived range $[\underline{x}_i, \overline{x}_i^c]$:

$$\Delta q_i = M \int_{\underline{x}_i}^{\overline{x}_i} f(x)dx - M \int_{\underline{x}_i}^{\overline{x}_i^c} f(x)dx =$$

$$= M\left[F(\overline{x}_i) - F(\underline{x}_i)\right] - \left[F(\overline{x}_i^c) - F(\underline{x}_i)\right] = M\left[F(\overline{x}_i) - F(\overline{x}_i^c)\right] \tag{5}$$

Equation (5) shows that by adjusting one parameter alone, i.e., the position of the cannibal along the horizontal differentiation space, the level of cannibalization can be controlled, thus fulfilling the criterion of parsimony. Moreover, four modeling requirements are met:

- the level of cannibalization will not necessary be symmetric;
- the level of cannibalization will depend on the customers' particular distribution along the differentiation space (in other words, on their heterogeneity);
- the cannibal-driven change can be considered a long-term effect, since it alters the victim product's underlying sales-generating process;
- multivariate cannibalization can take place when three products from the same manufacturer are placed adjacently. However, by virtue of the linear specification of the model, the cannibalistic situation will encompass at most two cannibals and one victim or one cannibal and two victims.

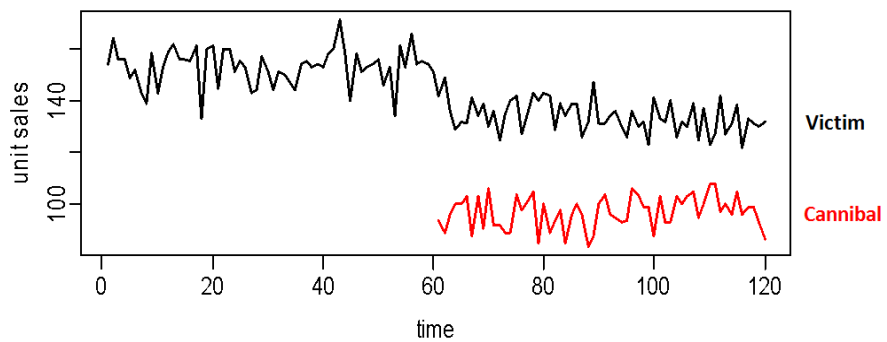


Figure 7.1 Unit-sales time-plot from an illustrative simulation run in which the cannibal product launch takes place in the 60th simulation period

Since, once initial product positions are set, the horizontal differentiation model produces purely deterministic outcomes, stochastic components should be introduced into the simulation model. These encompass the use of random variates to initialize the distribution of customers along the differentiation space, to set the percentage of potential consumers which are selected to shop at each simulation period, and to draw them randomly from the population. A time-plot of the periodic sales of the victim and cannibal products from an exemplary simulation run (Figure 7.1) highlights the stochastic nature of the sales-generating processes obtained by introducing the probabilistic components. Nondeterministic disturbances can be clearly detected in both time series. The structural shift suffered by the victim's sales-generating process in concomitance with the cannibal's market launch is clearly visible.

7.3.3. Model Implementation

ABMS Development Environment

There are different ABMS software environments available (for a comprehensive survey see Railsback et al. 2006; Bergen-Hill et al. 2007). Based on criteria such as the current range of features, the degree of available support (documentation, liveliness of the related community etc.), and flexibility – both in terms of modeling and implementation, we selected Repast Simphony as our development environment.

Repast Simphony is an open-source agent-based development and execution toolkit. It allows both visual and purely java-based (POJO) modeling. The latter is what was more relevant to us and hence at the heart of our exposition here. The main modeling concepts in the Repast ABMS framework are agents and contexts. An *agent* is a Repast autonomous entity with a set of properties and behaviors. Formally, it remains a proto-agent until it gains learning capabilities to become what can be properly called an agent.

The core data structure in Repast is the *context*. It is an abstract environment or virtual world in which agents exist at any given point in the simulation. Technically, it is a container for collections of proto-agents, agents, or any other object playing a role in the simulation. A context holds its own internal state to provide agents with information about the world in which they interact. This internal state consists of data fields which agents can read and modify. These data fields can be associated with a virtual space, that is, a data field can be linked to a set of coordinates. Moreover, a context can have behaviors which affect its internal state, taking an adaptive nature itself.

A high-degree of modularity is also provided by this construct: contexts may themselves contain sub-contexts, each with its own separate state, arranged in a hierarchical structure that eventually defines the granularity of the model. Membership in the hierarchy is inherited, i.e. members of a sub-context are by definition members of the parent context, and flexible, allowing agents to migrate between contexts.

Another key aspect of contexts is how they are used to define localized behaviors for proto-agents, i.e. behaviors they exhibit only under conditions determined by the context in which they are located. These context-sensitive behaviors can be implemented by creating watchers or triggers that monitor the particular circumstances under which a behavior is to be executed (e.g., a reaction triggered when the state of another object in the simulation changes).

Java Implementation

The structure and behavior of the previously introduced model elements were coded in Repast using the Java programming language. Figure 7.2 shows the UML class diagram for the most relevant Java entities in our implementation. As we have seen, a specific instance of a pseudo-population of simulation entities is called a “context” in the Repast jargon. A generic parent class “ContextObject” was introduced to contain methods common to all the entities which were to populate the context, such as initialization of the unique identifier, the removal from the context, etc.

One level below along the class hierarchy, a distinction was made between proper agents, that is, entities endowed with some sort of decision-making (consumers and suppliers), and entities which were only to be manipulated by the former (the items in the product hierarchy). The Java class of each agent type contains the implementation of both the agent’s attributes (the class fields) and behaviors (the class methods).

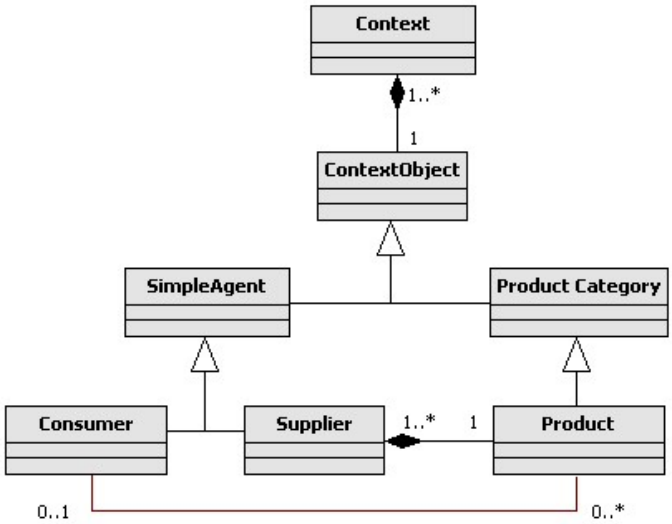


Figure 7.2 Class diagram of the main entities of the implemented simulation model

7.3.4. Model Verification

Several techniques were put in place to ensure that the conceptual model was correctly translated into the set of Java classes composing its implementation, and to quickly debug errors. From a qualitative point of view, we took advantage of the graphical possibilities provided by Repast Simphony to visually inspect individual simulation runs and verify that different parameter configurations produce the expected results. In other words, we checked that cannibalization was actually taking place when the market had been configured to let it occur by initializing cannibal and victim appropriately.

In addition to the perusal of time-plots (as the one in Figure 7.1) and histograms to verify the status and the behavior of variables over time, we employed a visual representation of the differentiation space populated with the agents to readily inspect the development of a specific market scenario. As illustrated in Figure 7.3, such market projections allowed us to check the agents' distribution along the linear differentiation space. Moreover, we could visually follow customers' purchase choices (represented by a predefined color scheme) and quickly see how the cannibal's introduction affected buying decisions (as exhibited in Panel *b*). Diagnostic messages concerning random number seeds and execution times were also printed on the system console to track the execution of simulation batches.

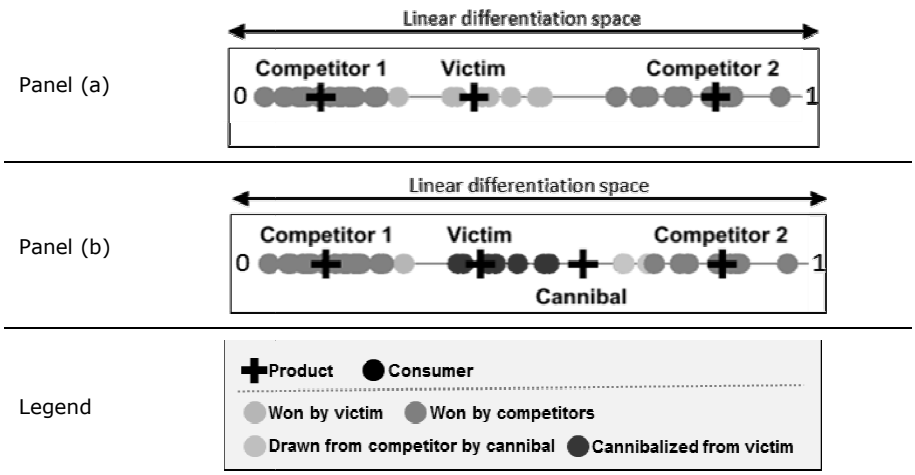


Figure 7.3 Visual representation of a horizontally differentiated market before the launch of the cannibal product (Panel *a*) and after the launch (Panel *b*)

Quantitatively, we compared the outcomes of random simulation runs to the predictions from the pure deterministic microeconomic model of horizontal differentiation (obtained following the analytical procedure described in Section 7.3.2), which, for reasonable settings of the random model components, should be the expected cannibalization value.

7.4. Computational Lab

7.4.1. Operationalizing Cannibalization in Numerical Experiments

We envisaged two alternative ways to operationalize the cannibalization variable in numerical experiments. The first approach entails simulating two alternative states of nature: one in which the cannibal is launched at some point in time over the simulation horizon, and thus coexists for some time with the victim, possibly diverting some of its sales; one in which the cannibal is not launched into the market, all other things held equal. Subsequently, the victim's total sales in the former scenario (with cannibal) are subtracted from the victim's total sales in the latter scenario (without cannibal). A positive difference would represent cannibalization, i.e., the victim has lost sales due to the cannibal's appearance in the market.

The second approach takes advantage of the agent-based nature of the simulation model to quantify cannibalization from the single scenario where the cannibal is launched. This approach draws from the fact that a cannibalized customer is a potential victim buyer and would have bought the victim, had the cannibal not been available (cf. Section 2.3.1). Accordingly, a customer won by the cannibal is qualified as "cannibalized" whenever his/her second best option at purchase time was in fact the victim. By virtue of the agent-based nature of the simulation, we can identify these "cannibalized" customers merely by observing the purchase-decision making each cannibal's buyer performs, and counting those whose product ranking includes the victim as the second best choice.

The latter option obviously requires half the replications needed by the former to quantify cannibalization for any given set of model configurations. Therefore, based purely on considerations of execution time, the choice would be to exploit the agent-based nature of the simulation model and employ the second approach. However, issues not to be overlooked are whether the two alternatives give the same results and under what circumstances they may differ.

As a matter of fact, the two operationalizations are equivalent if the cannibal does not alter the consumers' preferences over the other products in the market, that is, if, apart from the addition of the cannibal, the relative positions of the products in each customer's own preference ranking remain the same. If the cannibal does alter consumers' preferences, different cannibalization levels will be obtained with the two approaches.

The core model elements presented so far do not include mechanisms which will change the consumers' preferences over the preexistent products upon the cannibal's launch into the market. Nonetheless, such extensions can be easily envisioned. As a case in point, the introduction of an "attraction effect" can be mentioned, whereby the cannibal makes some of the preexistent products actually more attractive to customers (Huber & Puto 1983).

Performing experiments with the two operationalization alternatives and comparing their results using model configurations which should have produced equivalent outcomes for both also is an additional quantitative procedure of verification, and complements those already introduced in Section 7.3.4.

7.4.2. Computational Lab Architecture

To perform numerical experiments with the simulation model described in the previous section, a series of software components is needed, depicted in Figure 7.4 as an FMC compositional structure diagram (Keller et al. 2002). As mentioned previously, the implemented model consists of a set of Java objects representing agents and entities of the abstracted market, which can then evolve and interact in the runtime environment provided by Repast Simphony. Repast also provides a GUI to support the

execution of individual runs or sets of independent replications based on parameter "maps" predefined by the researcher. We also took advantage of Repast's possibility to instantiate multiple random number generators.

Around this set of core components, additional software applications are needed to enable or facilitate different phases of the computer-based experimental procedure. First, to initialize the multiple random number generators with appropriately drawn sets of independent random seeds, we used an implementation for the R statistical environment of a uniform random-number generator with multiple streams (Ecuyer et al. 2002). These multiple independent streams are saved in a CSV file and read by the simulation engine at the initialization stage of each simulation run, preserving the synchronization of the different random streams according to the common random numbers implementation. Additionally, since Repast Simphony employs the XML standard to record model parameter settings, a standalone XML editor was employed to facilitate editing these even when running the simulation programmatically (that is, from Java code or from the command-line, without relying on the provided GUI). Eventually, a relational database management system is fed with the performance measures of interest (total unit sales, cannibalized unit sales, etc.) and the model configuration that produced them (a "batch map" in the terminology of Repast) at the end of each replication of each experiment. The same database can be queried from the R environment to perform statistical analysis on the data.

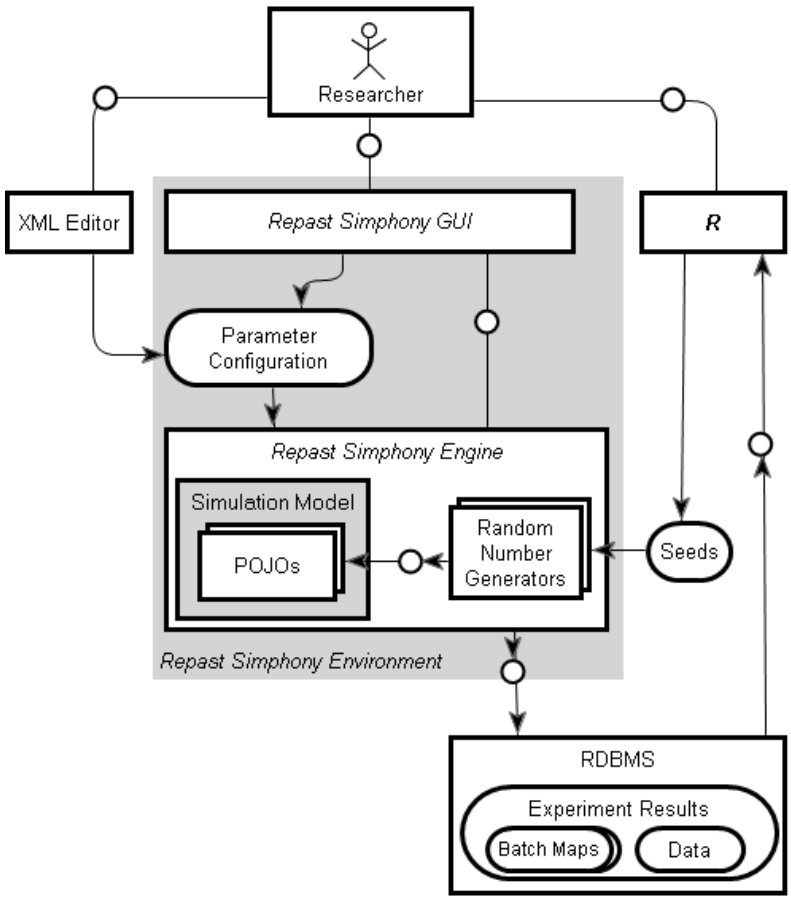


Figure 7.4 Architecture of the Computational Lab

7.4.3. Computational Lab Prototype

Several prototypes of the Computational Lab were developed in the course of this work. Figure 7.5, Figure 7.6, and Figure 7.7 are illustrative examples of GUI components implemented in a prototype of the Computational Lab. Figure 7.5 shows a control panel employed to set the initial configuration for a

simulation batch in an experiment. In Figure 7.6, instead, a debugging panel is depicted. It reports the current state of a market entity during a simulation run.

Figure 7.7 presents four periods of a simulation run in one possible pictorial representation provided by a visual monitoring tool we implemented as the component of a prototype. The top-left panel is the initial simulation state with two victim products (the king and queen shapes) and a series of potential customers (the grey circles) positioned on a two-dimensional grid (where the vertical axe is price and the horizontal quality). This particular spatial configuration is an adaptation of the value-mapping concept – a two-dimensional view of the perceived price-benefit trade-off (Buzzell, R. D. & Gale 1987; Gale 1994; Sinha 1998) – to a multi-attribute utility simulation model. The top-right panel is the market situation after the potential customers performed a round of purchase decisions (customers who bought are represented as filled circles). In the bottom-left panel a low-cost cannibal (the horse shape) is launched into the market, and in the bottom-right panel the price of a victim (the queen) is lowered.

A web-based prototype of a Pricing Decision Support System was derived from our Computational Lab and evaluated within the scope of the research projects *PREMIUM|Services* (funded by the German Federal Ministry of Education and Research) and *FI-WARE* (funded by the European Commission).

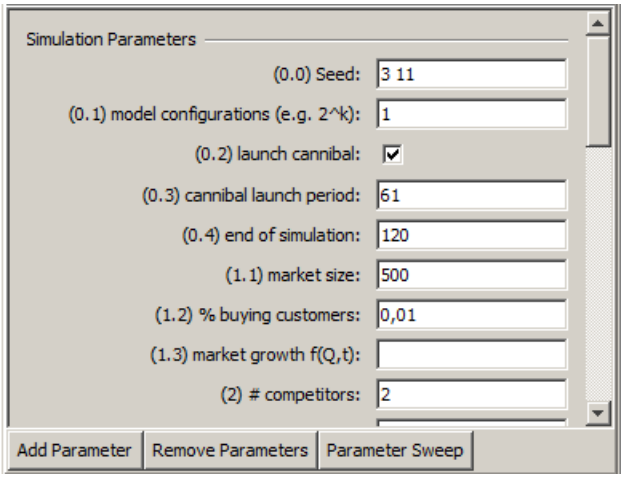


Figure 7.5 Experiment control panel showing the initial configuration for a simulation batch

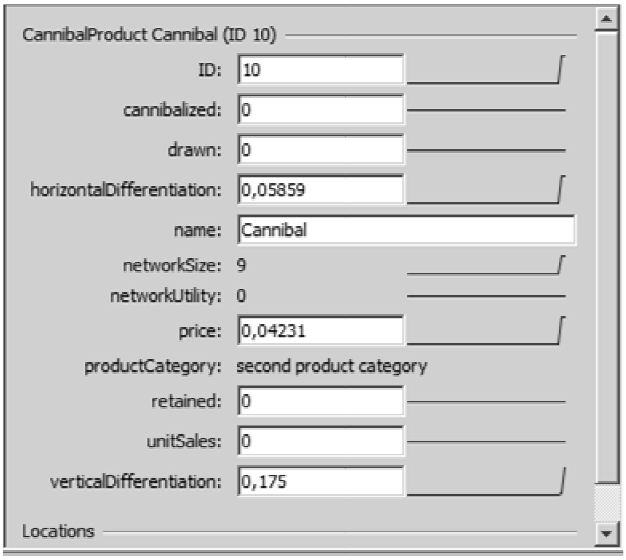


Figure 7.6 Debugging panel showing the state of a market entity in the simulation

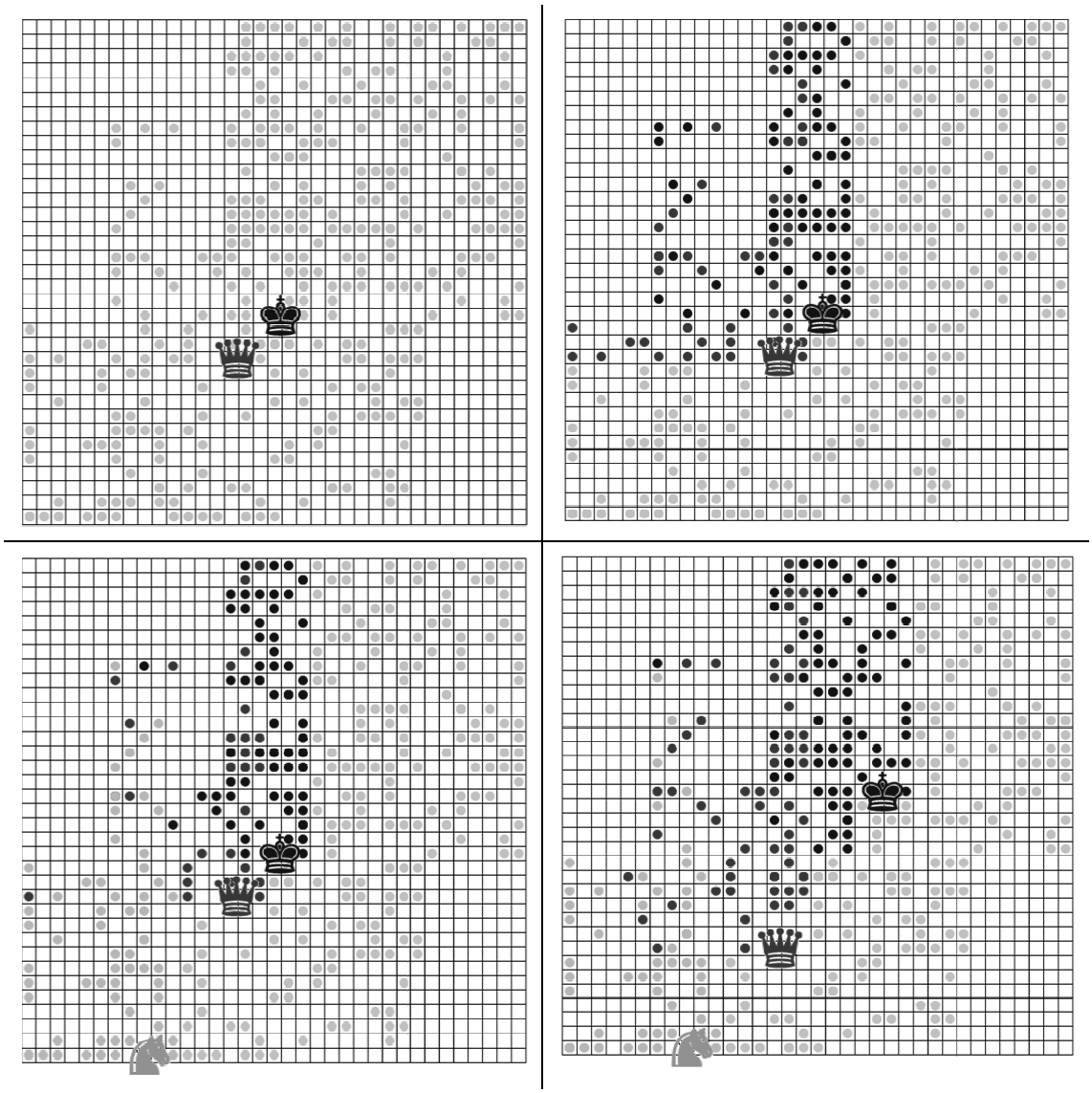


Figure 7.7 Visual monitoring of four periods in a simulation run

7.4.4. Envisaged Applications

We will briefly elaborate on two possible applications for the Computational Lab: an investigation of the drivers and barriers of sales cannibalization among a set of modeled factors, and an evaluation of time series econometric models for cannibalization measurement.

For the first application, the factors of interest (drivers and barriers) should be selected and implemented, possibly extending the simulation model to integrate those not yet supported. Then, a classical 2^k factorial design could be employed to structure the experiments. A set of experiments could be run to study how each factor and the interaction between different factors affect the response, that is, the cannibalization variable (operationalized as described in Section 7.4.1).

The second application would be assessing the precision and error rates of time series econometric estimates of sales cannibalization (such as those we performed in Sections 3.6.1, 4.6.2, and 6.6.2). Monte Carlo methods could be employed to evaluate the econometric estimators of sales cannibalization. A generic Monte Carlo experiment to study a statistic of interest comprises the following phases:

1. Specification of the pseudo-population (i.e., the algorithms for generating set of numbers that resemble samples from the *true* population)
2. Repeated draw of pseudo-samples from the pseudo-population
3. Computation of the statistic of interest for each pseudo-sample
4. Comparison of the behavior of the statistic (i.e., its relative frequency distribution) to the pre-specified pseudo-population (i.e., its known parameter values)

If we contextualize this generic Monte Carlo experiment, the numerical procedure to evaluate econometric cannibalization estimates, represented in Figure 7.8, would become the following:

1. Specification of the artificial sales-generating process to simulate a market where the level of cannibalization can be controlled
2. Generation of random market scenarios
3. Application of the econometric measurement models to obtain cannibalization estimates for each simulated market scenario
4. Comparison of the cannibalization estimates with the *true* cannibalization level recorded from each market scenario

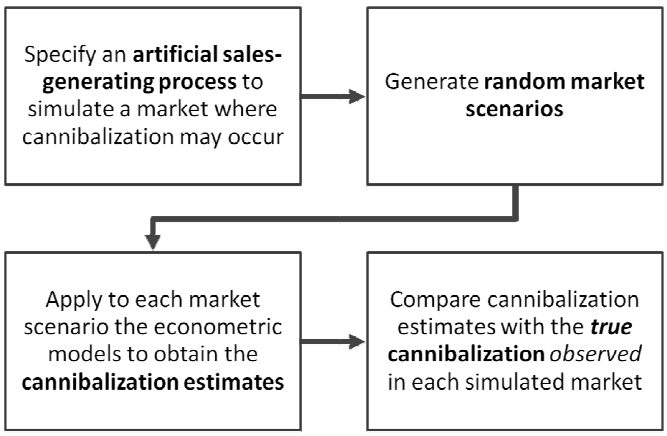


Figure 7.8 Monte Carlo procedure to evaluate econometric estimators of sales cannibalization in the Computational Lab

Table 7.2 Monte Carlo estimates of type I and type II errors for econometric procedures of cannibalization detection and measurement

	Type I error	Type II error
True H0	No cannibalization	Positive cannibalization
Test H0	No cannibalization	No cannibalization
Experiment	1. Setup a model configuration that will *not* generate cannibalization 2. Simulate the market scenario 3. Estimate cannibalization from the artificial data with the econometric procedure 4. Given a nominal significance level, check if estimated cannibalization is significant 5. Repeat	1. Setup a model configuration that will generate cannibalization 2. Simulate the market scenario 3. Estimate cannibalization from the artificial data with the econometric procedure 4. Given a nominal significance level, check if estimated cannibalization is significant 5. Repeat
Error estimate	Proportion of trials for which a significant cannibalization rate was found, i.e., in which the *true* null hypothesis was incorrectly rejected	Proportion of trials for which no significant cannibalization was detected, i.e., in which the *false* null hypothesis was incorrectly *not* rejected

Notes: *True H0* is the hypothesis on which the simulation of the artificial data is based, i.e., what is actually simulated. *Test H0* is the null hypothesis of the significance test in the context of which the error is defined.

To evaluate precision, market configurations that will generate a certain nonzero level of cannibalization would be repeatedly simulated to produce a set of artificial time series. Then, the prespecified cannibalization level could be compared with the estimates obtained by fitting time series

econometric models on the artificial sales data. For instance, the mean squared error of the cannibalization estimate could be calculated.

Monte Carlo estimates of type I errors and type II errors could be readily obtained as well. For an estimation of type I errors, the Computational Lab would simulate scenarios where *no* cannibalization is generated and then calculate the proportion of trials for which *significant* cannibalization was erroneously found. An analogous procedure for type II errors would be based on simulated scenarios with positive cannibalization and calculate the proportion of trials for which *no* significant cannibalization was – again, erroneously – detected. Table 7.2 offers a comparative view of the two Monte Carlo error estimates.

7.5. Illustrative Simulation Study

This section presents an illustrative example of how the agent-based Computational Laboratory can be employed to perform numerical experiments on sales cannibalization in IT markets. In particular, we have chosen the software application market as our reference market and the possible intra-organizational competition between on-premise and on-demand/SaaS applications as our domain of investigation. This simulation study thus complements Case IV with regard to the topical trend previously introduced and put in context in Sections 6.2 and 6.3.

Dominant software vendors, whose applications have been predominantly delivered on-premise so far (i.e., installed, maintained and operated at customers' premises) are challenged by the rising adoption of SaaS solutions, which are outsourced applications delivered through the web under subscription or usage-based pricing terms. As a competitive response, incumbent vendors extend their product portfolios with SaaS offerings. They thus risk engendering sales cannibalization, as a newly introduced SaaS application may attract their own on-premise customers instead of expanding the market or drawing from a competitor's customer base. At the same time, they face the novel, severe scalability requirements of the technological and organizational infrastructure needed for a successful SaaS business. Using an appropriate agent-based simulation model, we study the interdependence between cannibalization and scalability in monopolistic and duopolistic software markets.

7.5.1. Scalability

Understanding the financial and competitive consequences of cannibalization and then attempting to avert it or to ride it are not the only concerns facing incumbents. The SaaS delivery model poses a scalability threat as well, both from a technological and from an organizational perspective.

This threat stems from the peculiarities of this newly addressable market. Since SaaS lowers the technological and financial requirements for a software purchase, the market swells in number of potential buyers while the average financial and technological resources available to them decrease. Since a SaaS offering is hosted and operated by the provider and accessed through the World Wide Web, simple applications that do not demand supplemental integration and customization virtually appeal to any organization meeting the minimum technical requirement of having an available Internet access. From a financial point of view, the SaaS subscription fees dilute over time the investment for the license of a given software functionality. Therefore, small and medium-size companies can, in spite of their usually more limited IT budget and technical personnel, enter application markets once populated by large enterprises only. This is exemplarily shown for the European Union in Table 7.3. It evidently represents a huge market opportunity to be tapped into by software vendors in terms of number of potential new accounts (enterprises) and users (employees).

This opportunity for market expansion has its downsides: though larger, the new potential market is more costly to be reached and to be served.
Figure 7.9 compares the trend in total operating expenditures over total revenues for the two leading business application vendors (SAP and Oracle), which have historically kept it in the 60-70% range,

and two SaaS competitors, unable, even after having successfully ridden a steep learning curve, to lower it under the 90% mark (Salesforce) or to reach operational profitability at all (NetSuite).

Table 7.3 Key indicators per enterprise size class in the EU-27 area (source: Eurostat).

Size class	Small	Medium	Large
Employees	10-49	50-249	250 or more
Number of enterprises[a]	1,408,000	228,000	45,000
Persons employed* **(million)** [b]	27.9	23.4	45.2
% enterprises that employ IT/ICT specialists[c]	9%	25%	53%
% enterprises with an ERP system[#]	17%	41%	64%
% enterprises with a CRM system[#]	23%	39%	54%

Notes: a) as of 2010; b) as of 2008; c) as of 2007.

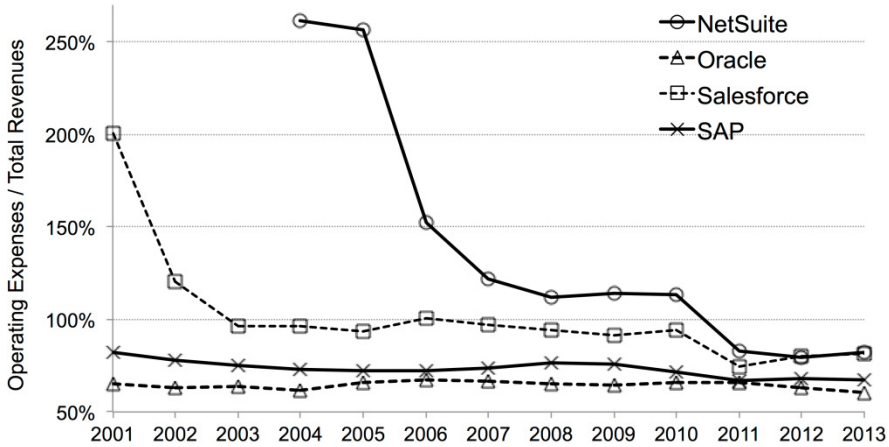


Figure 7.9 Total operating expenses as a percentage of total revenues for selected software vendors (source: corporate financial reports)

A SaaS software vendor must bear the additional costs of setting up and operating the technological infrastructure needed to deliver the SaaS application. Moreover, beyond those technological repercussions, scalability issues engage the SaaS provider on an organizational level as well, for this new, more fragmented segment of software buyers imposes to think a series of processes anew. For instance marketing and sales, where using dedicated sales team for each account as it is the habit with large enterprises is not possible on a large scale, and other means, such as telesales and innovative internet-based funnels, need to be employed.

We illustrate the issue of scalability with a short empirical analysis focused on an incumbent currently facing it – Oracle. Oracle is a leading enterprise software vendor which has traditionally provided on-premise solutions to the market. However, it has started adding SaaS solutions to its portfolio since 2004. Oracle periodically reports the financial results of its on-demand business, so we devised a measure of scalability based on these publicly available data. The measure we devised is a ratio of the quarter-to-quarter incremental costs over incremental revenues:

$$\sigma_t = \frac{TC_t - TC_{t-1}}{TR_t - TR_{t-1}} = \frac{\Delta TC_t}{\Delta TR_t}$$

This "scalability ratio" is the cost of a dollar of incremental revenue from the SaaS business in a fiscal quarter. A ratio higher than one means that generating an incremental dollar of revenue during the quarter has cost more than a dollar to the vendor. A scalable business should be able to grow without a parallel increase in this ratio. Figure 7.10 shows the behavior of this ratio over time together with total revenues and the operational margin of the on-demand Oracle business. The SaaS business is clearly growing steadily in terms of revenues. The ratio was above unity in the first few quarters and has

decreased afterwards. Nonetheless, Oracle has not succeeded in keeping it steadily below unity while the SaaS business grew larger. In other words, the expansion in the SaaS segment generated more incremental costs than revenues in some quarters.

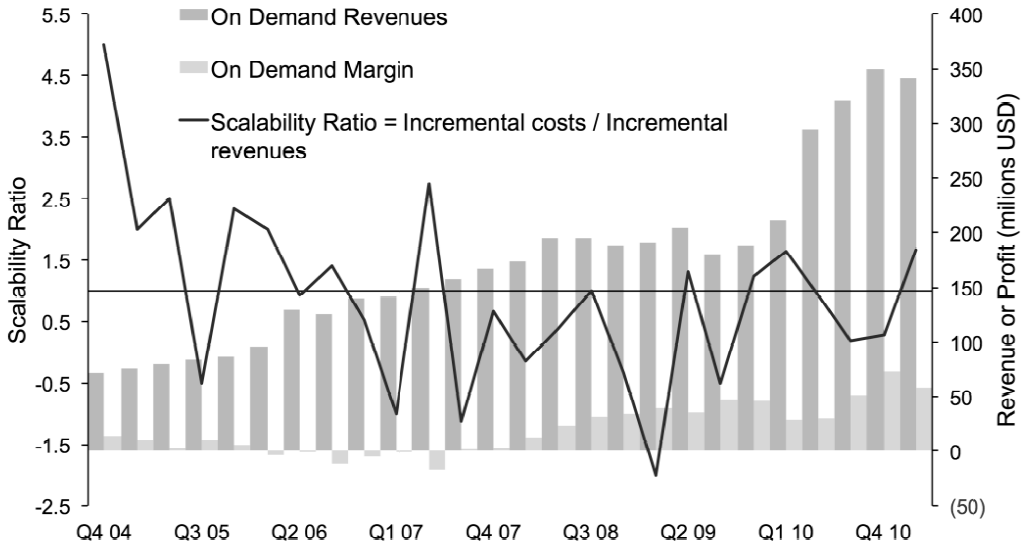


Figure 7.10 Revenues (dark bars), profit margin (light bars), and scalability (solid line) for the on-demand business of the enterprise software vendor Oracle

7.5.2. The Interplay of Cannibalization and Scalability

Incumbent software vendors introducing SaaS are confronted with a typical new-product introduction problem. The new product may divert current customers from other offerings of the same firm, instead of attracting new buyers or drawing from a competitor's customer base. The dilemma is further complicated by the trade-off between a more saturated but highly profitable software market of large enterprises and a fast-growing but less profitable potential SaaS market.

Scalability of the SaaS business is a prerequisite to target market expansion. Without scalability, vendors face the risk of not being able to satisfy their demand. If they fail to build the appropriate level of capacity, they will not be able to ride growth. Even building capacity inefficiently and failing to reach scale economies will make market expansion a weakly profitable endeavor. Reversing the perspective, constraining scalability can be a radical lever to avert cannibalization. It puts an upper bound on the volume of intrafirm switching customers. However, this may expose the incumbent's flank to competition, whereby customers might switch to a competitor when their current vendor cannot serve them.

7.5.3. Market Model

We employ a model of a closed, vertically differentiated software application market. In the first series of experiments, the market structure is a monopoly with a single vendor selling both an on-premise application and a SaaS one. In the second set of experiments, the market is a duopoly consisting of the same vendor of the previous scenario plus a purely SaaS challenger. Figure 7.11 illustrates how the basic market model from the Section 7.3 (cf. Figure 7.2) was modified to represent a simplified software market model.

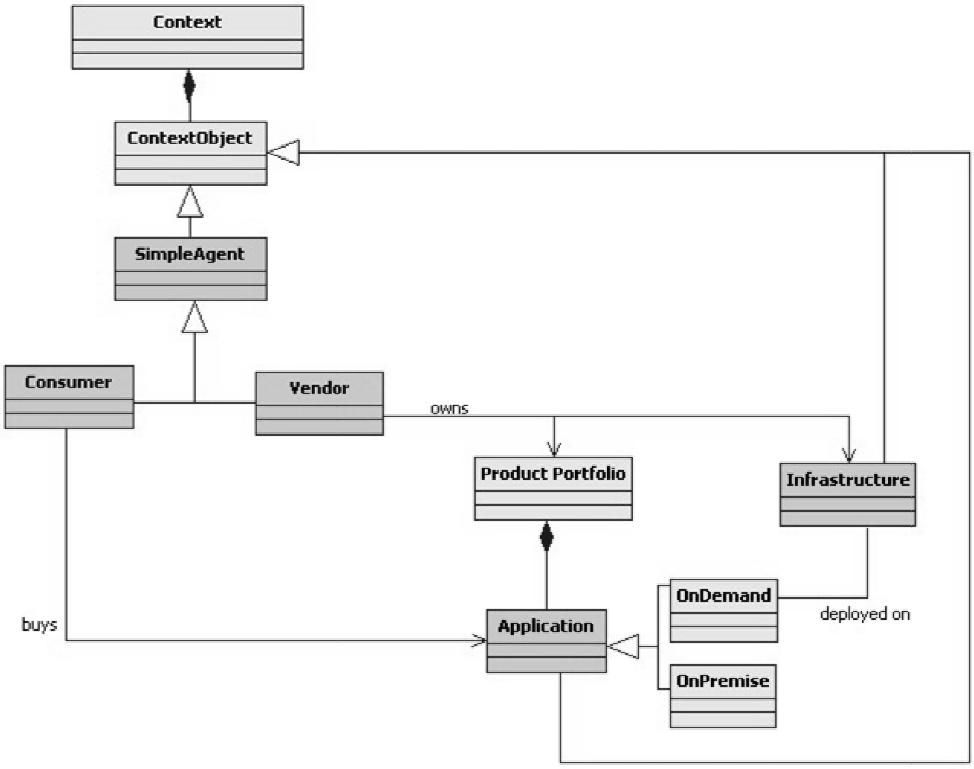


Figure 7.11 Class diagram for a simplified software market model.

Software Application

A software application is characterized by the features or benefits it provides (its "quality") to its users, the price to be paid to obtain those benefits (in terms of amount and distribution over time of the fees), and the infrastructure on which it is deployed. When the application is delivered as SaaS, it will be deployed on an infrastructure operated by the software vendor and priced under subscription terms, with an initial activation charge at the time of purchase and an anticipated, recurrent fee for each period of the simulation in which it is used. When the application is delivered on-premise, the price structure will follow the typical enterprise application pricing model and be once again made up of two components: an initial charge to purchase the licenses and an anticipated, periodical maintenance fee as a percentage of the initial charge.

While the fee structure we employ for the two delivery modes is the same, the proportion between initial and periodical charge differs, with on-premise application weighting more on the front – annual maintenance rates are around 20% of the initial investment for licenses (Buxmann & Diefenbach 2008) – and SaaS diluting the expenses more over time.

Software Application Vendors

The software vendors are price-making suppliers of the same class of business application (for instance, ERP or CRM) but with different price-quality schedules and delivery models. In the case of SaaS, the vendor must also operate the infrastructure on which the application is deployed. In each simulation period vendors collect the due payments from the customers who have adopted one of their applications and bear the costs of the SaaS infrastructure.

SaaS Infrastructure and Scalability

The infrastructure is made up of a set of technological or organizational resources (e.g., servers, sales representatives) characterized by a certain individual performance. The overall performance is, however, not just the sum of these components, and depends on the level of scalability of the

infrastructure. We use Amdahl's law (Amdahl 1967) to account for this issue and formalize the degree of non-scalability of the infrastructure through a so-called contention rate, which exerts a negative impact on the ability to efficiently scale (and, as we will see, to compete). This negative impact grows exponentially with the scale requirement (Shalom & Perry 2008).

Formally, the maximum total capacity K of an infrastructure with N resources of throughput each, designed to have a rate of contention CnR is:

$$\kappa = \frac{\tau}{CnR + \frac{1 - CnR}{N}} \tag{1}$$

Equation (1) gives the total capacity which a specific infrastructure can attain in a given period. For instance, 20 resources with throughput of 1000 customers per period each, arranged in an architecture designed to have a 20% contention rate, would generate a total capacity of 4167 customers per period. Doubling the resources (i.e., scaling out of 20 additional resources) 4545 customers could be served (an 8% increase). However, the maximum achievable capacity would be bounded to less than 5000 customers per period, no matter how many additional resources are thrown in. Reducing contention would be a much more effective lever: decreasing the contention rate of 5% would increase capacity by 25% (to 5195 customers per period).

Software Application Customers

Customers are current or potential adopters of a software application sold in the market. The decision to adopt an application is made on the basis of the obtained surplus. The surplus for the i-th customer of type θ when adopting an application j is:

$$S_{ij} = \theta_i Q_j - TCO_j(T) + \propto X_j \tag{2}$$

The first term in equation (2) is the willingness to pay of a customer with marginal valuation of quality θ for an application j of quality Q_j. θ is an input parameter set randomly for each consumer at simulation start (drawn from a uniform distribution with support between 0 and 1). The second term of the equation is the present value of the total cost of ownership of the application (detailed below). The third addend is the network externality derived from all consumers that already adopted an application with the same delivery model. The relevant network X_j is the total number of SaaS customers if j is a SaaS application, or the total number of on-premise customers if j is the incumbent's on-premise application.

The total cost of ownership over a horizon of T years $TCO_j(T)$ is computed for both on-premise and SaaS applications employing the formula for the present value of an annuity:

$$TCO_j(T) = \varphi_{t_0} + \varphi_t + \frac{\varphi_t}{r}(1 - (1 + r)^{-T+1}) \tag{3}$$

where $\varphi_{t_0}$is initial charge (activation of the SaaS subscription or on-premise license charge), φ_t is the anticipated periodical charge (the subscription fee or the maintenance fee respectively), and r is the annual interest rate.

When taking a purchase decision, a consumer first calculates (2) for every available application, then adopts the one with highest non-negative surplus among those with available capacity offered in the market. After having adopted an application, a consumer considers the initial charge a sunk cost and drop $\varphi_{t_0}$from equation (3) when comparing the surplus of the current choice with other alternatives in the market. Therefore, the initial charge accounts for switching costs as well.

Each offering in the market has a certain initial market share in terms of pre-assigned customers and the incumbent's on-premise application gets the largest market share. The overall addressable market includes preassigned customers and potential customers who will take their first buying decision during the simulation.

7.5.4. Experiments

We performed experiments consisting of 10 replications, where each replication was 21 periods of length. We chose a temporal scale of one simulation period = one calendar year we chose so that each replication was the equivalent of three 7-years software application life cycles. Each replication differed in terms of initial model configuration. A model configuration was given by the contention rate of the incumbent's SaaS infrastructure, specified in a 0%-50% interval with 5% steps. Each experiment was conducted in different growth and competitive scenarios as detailed in the two following sub-sections.

Experiments in a Monopolistic Market

Our first series of experiments dealt with a monopoly in two scenarios: high growth and low growth of the SaaS segment. In the high growth scenario, the SaaS segment has a total size (in terms of potential customers) 10 times the on-premise segment. In the low growth scenario, it merely matches the on-premise segment's size.

In a monopolistic situation the decisions of the incumbent is linked to the trade-off between sales cannibalization and market expansion. If the potential market tapped into with SaaS is large enough to offset the effect of cannibalizing the high-margin on-premise sales, then the vendor should pursue a high-capacity strategy and, therefore, invest in a scalable infrastructure. Otherwise, cannibalization could be averted by limiting the capacity offered in the market with a more conservative strategy. Conversely, a company that has not yet reached the needed level of scalability would unprofitably pursue growth in the SaaS segment and should refrain from it.

Examining the results of these first experiments, it can be seen that, in case of high-growth in the SaaS segment, the monopolist may indeed offset (in terms of sales volume) revenue cannibalization with market expansion by pursuing a high-scalability strategy (Figure 7.12). On the contrary, a low-scalability strategy allows the vendor to minimize cannibalization in a low-growth scenario, where no significant market expansion would be possible anyway (Figure 7.13). Please note that throughout the remainder of this section we calculate total cannibalization in terms of the projected on-premise revenues lost when the customers switch to SaaS (i.e., the discounted stream of maintenance fees, as expressed by eq. 3).

The specific contribution margins of the two software products will dictate the overall effect on the monopolist's profit. Given the higher margins enjoyed in delivering on-premise applications, a multi-product monopolist in a low-growth scenario would be better off slowing the rate of SaaS adoption among its own customers by limiting the offered capacity (Figure 7.14). On the contrary, being able to scale to expand into the SaaS segment would be, in case of high growth, the more profitable strategy.

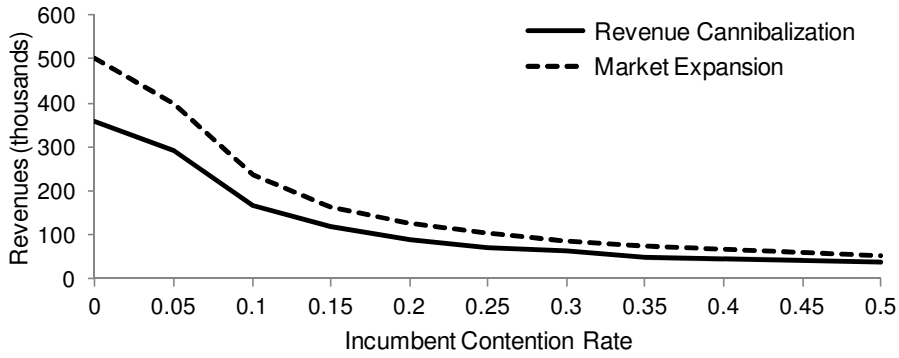


Figure 7.12 Total cannibalized on-premise revenues and total SaaS market expansion in a scenario of high growth (average for 10 replications)

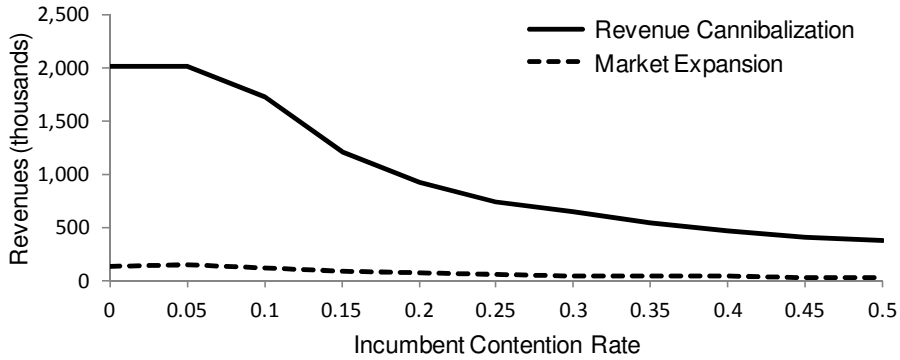


Figure 7.13 Total cannibalized on-premise revenues and total SaaS market expansion in a scenario of low growth (average for 10 replications)

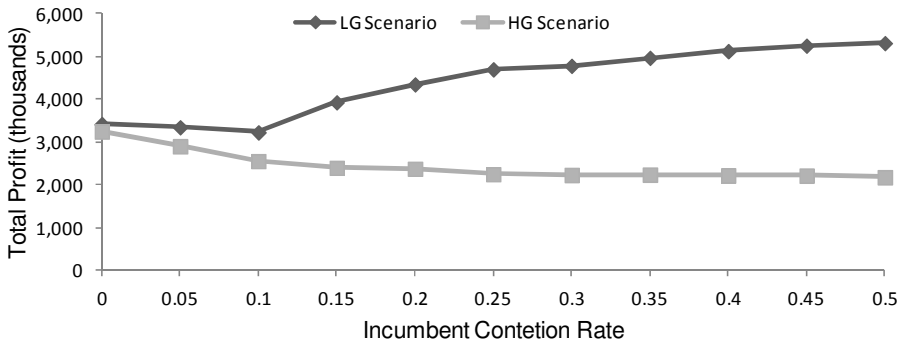


Figure 7.14 Incumbent's total profit in the two monopolistic scenarios (*HG* = high growth, *LG* = low growth; average for 10 replications)

Experiments in a Duopolistic Market

In the presence of a SaaS challenger, a customer of the incumbent's on-premise application can switch to either the incumbent's SaaS offering or the competitor's one. Thus, the risk of competitive draw enters in the strategic considerations of the incumbent. This risk can be more or less pronounced depending on the scalability of the challenger's SaaS infrastructure. We therefore define four basic scenarios, shown in the following table:

		Challenger's Scalability	
		Low (CnR = 0.3)	**High (CnR = 0.05)**
Growth in the SaaS Segment	**Low (1X)**	Scenario *LG1*	Scenario *LG2*
	High (10X)	Scenario *HG1*	Scenario *HG2*

In confronting a high-scalable SaaS challenger it always pays for the incumbent to be able to match the competitor's scale, because this allows at least retaining through cannibalization customers that would otherwise be lost (Scenario *LG2*, Figure 7.15) if not even offsetting any competitive draw or cannibalization effect by riding growth (Scenario *HG2*, Figure 7.16). As shown in Figure 7.17, the incumbent's total profit is generally higher in case of high-growth and negatively correlated with contention, except for the particular case of low growth and presence of a non-scalable challenger (Scenario *LG1*), where the option to limit capacity as a lever to control cannibalization could still be viable. This is due to the lower risk of losing relevant market shares to a poorly scalable competitor.

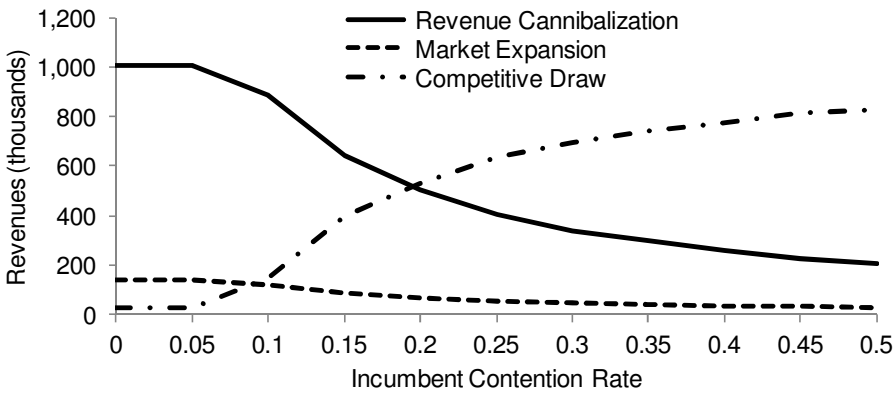


Figure 7.15 Total cannibalized on-premise revenues, total SaaS market expansion, and total competitive draw of on-premise revenues by the SaaS challenger in scenario *LG2* (average for 10 replications)

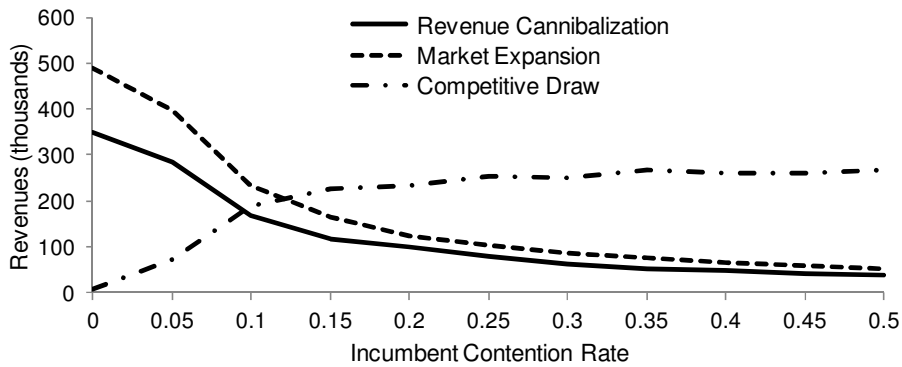


Figure 7.16 Total cannibalized on-premise revenues, total SaaS market expansion, and total competitive draw of on-premise revenues by the SaaS challenger in scenario *HG2* (average for

10 replications)

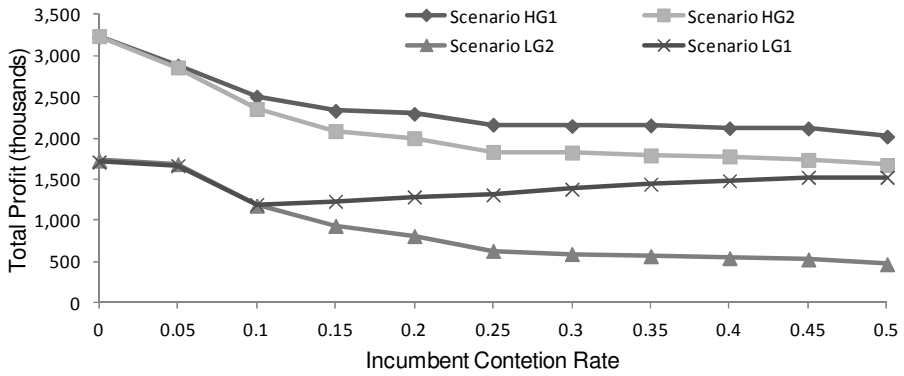


Figure 7.17 Incumbent's total profit in the identified market scenarios (average for 10 replications)

7.5.5. Discussion of Results

This illustrative application of Agent-Based Modeling and Simulation to a cannibalization case focused on the multi-faceted interdependence of cannibalization and scalability. This interdependence determines the success of a SaaS strategy pursued by an on-premise vendor, both in a monopolistic position and in an oligopolistic one in which an incumbent is challenged by a SaaS competitor.

Given the lower margins of a SaaS offering, the monopolist prefers to avoid cannibalization by limiting scale, unless the achievable market expansion proves substantial. In the presence of a SaaS challenger, instead, sales cannibalization may be for the incumbent a necessary evil whereby customers are retained against the threat of competitive draw. Scalability then represents a key requirement for the incumbent to ride the curve of SaaS adoption, cannibalize, and expand the market.

These findings were obtained by going after specific strategic interdependences in simplified market scenarios. The modeled market landscape and competitive dynamics could be extended to get a more realistic and comprehensive picture of the trends affecting the software industry. Moreover, a thorough validation of the experimental outcomes, based on empirical market data, ought to be conducted.

8. Summary and Conclusion

8.1. Recapitulation of Case Studies

In this section, we summarize the case studies conducted in the course of this research project. Table 8.1 gathers the distinctive characteristics of each case in terms of the cannibalization instance (rows I-V), the detection and measurement problem (rows V-VII), and the methodological decisions taken by the researchers accordingly (rows VIII-XIV).

Case I

We chose an exemplary occurrence of product cannibalization as our first empirical application: potential sales diversions within the portfolio of portable computing platform manufactured by Apple. In particular, we verified sales diversion both within the iPod product line (among different models in the product category of portable digital music players), and between this product line and the iPhone/iPad ones (instances of the smartphone and tablet product categories respectively), which feature an equivalent music playing capability.

The sales volume expansion experienced by the iPod product line lasted until about 2008, when the trend reverted. The low-frequency behavior of the iPod sales series is seemingly the opposite in the periods prior to the iPhone market launch (upward trend) than in the periods posterior to it (downward trend). The goal of this econometric application was to assess whether the introduction into the market of entry-level iPods, and the iPhone and iPad product lines may be accounted responsible for the behavior of the iPod sales-generating process, or at least part of it.

The analysis in this case study featured time series econometric models with exogenous break. The events to be considered in the detection and measurement of cannibalization, and their respective breakdates, were selected by the researchers based on their own judgment and then statistically tested for significance. Specifically, we elaborated an iterative procedure to pretest the breakdates for significance before entering the phase of model selection and estimation. Once the breakdates were screened for significance, further tests were applied (for instance, the Perron test for the detection of unit roots in the presence of structural breaks) and the effects of the structural changes estimated.

The cheaper iPod Mini/Nano and Shuffle introduced between 2004 and 2006 allowed Apple to penetrate the market for portable digital music player and increase its total revenues significantly by selling way more units (positive volume effect) albeit at a lower average price (negative monetization effect). Apple tried to balance the iPod line the with the iPod Touch – an upward extension, whose positive effect on average revenues we could ascertain (positive monetization effect). Moreover, both the introductions of the iPhone and of the iPad Mini correspond to statistically significant structural breaks which negatively affect iPod volume sales.

Case II

A fascinating aspect of contemporary IT markets is the occurrence of platform wars, which shape the involved ecosystems through platform substitution and platform cannibalization. Platform competition may engender substitution and cannibalization processes whereby customers and complementors drift from one platform to another. A platform cannibalization process may manifest itself in the competitive race between a general-purpose computing platform and a single-purpose rival, whereby an incumbent provider of a single-purpose platform becomes a complementor in the ecosystem of an innovative general-purpose platform, thus in potential competition with its own proprietary one. A case in point in such “general-purpose vs. single-purpose” platform wars is how sales of personal navigation devices have allegedly been sapped by GPS-enabled smartphones with comparable turn-by-turn navigation functionalities.

By means of an econometric analysis, we obtained evidence of the impact of smartphones in the quarterly volume sales of two leading PND manufacturers – Garmin and TomTom. Our econometric analysis reveals a significant shift in the level of the underlying stochastic processes and dates it the third quarter of 2008, when the iOS and Android ecosystems were launched. This substantiates a causal relationship between the PND sales slowdown and the rise of the most recent generation of GPS-enabled smartphones. However, later launches of their own navigation apps did not significantly affect these manufacturers' sales further. We thus ascribe the drop in sales to the competition by other mobile navigation software providers rather than an intra-organizational diversion between app and device. In other words, the phenomenon of competitive draw seems to be the major driver in the negative shift in PND sales, with sales cannibalization taking on a minor (and for our methodology statistically insignificant) role.

Methodologically, we built on the econometric approach of the Case I but relaxed the exogeneity assumption. In other words, the breakdates were selected subjectively by the researchers and then tested for significance in Case I, while this time they were estimated within the econometric methodology itself. This required employing a different unit-root test. While in Case I we relied on the Perron test – a unit-root test conditional on the presence of a structural break at a known date – in this case we used the Zivot-Andrews test, which endogenously estimates the most plausible breakdate in a series.

Case III

Lured by the success of online sales channels in the consumer software market, enterprise software vendors have launched proprietary online channels *alongside* their traditional offline ones. Online sales could thus cannibalize offline sales. However, it is disputable whether the online purchase of a software application is as compelling for an organizational buyer as it is for an individual consumer.

We qualitatively investigated the channel adoption decision by organizational software buyers when they purchase business software applications. We identified and categorized drivers and barriers influencing channel selection and provided a qualitative adoption model which takes factor interdependences and buying process phases into account. Our findings suggest that, in the enterprise software market, offline channels will not be cannibalized by online ones unless some peculiar characteristics of enterprise software applications change. That said, an online channel has the potential to enhance how enterprise software is being evaluated, purchased, and ultimately consumed, to the benefit of customers and vendors alike. Therefore, we also derived recommendations for the design of multichannel sales systems according to the main classes of enterprise software products and services.

We deemed a qualitative research strategy the most suitable for this endeavor. An online channel for enterprise software represents an innovation in the socio-technological context of business software acquisition and it is unclear which channel designs and technologies might establish themselves in the enterprise software market. Therefore, we opted for an open-ended, nomothetic, and inductive approach by combining a qualitative research strategy with a cross-sectional research design to capture the phenomenon's uncertain traits in this rather "fluid" stage of development. Qualitative content analysis based on coding and the subsequent use of comparison tables and counting was the main analytical tool for the case.

Case IV

Verdicts on the advisability for software vendors to adopt on-demand delivery models are widespread in the business and technology press. Incumbent software vendors, in particular, are prompted to transition to on-demand and cannibalize their on-premise customer-base, in order to supposedly enjoy market expansion, economies of scale and revenue predictability. Yet, academic research addressing

this strategic move and its repercussions in terms of organizational and technological transformation is scarce.

Few on-premise vendors were able to showcase the transition to a hybrid or purely SaaS model so far. Concur Technologies paired its on-premise offerings with the Application Service Provider model (the predecessor of SaaS) in the late 90s already, and then transitioned to become a purely SaaS player just as this delivery model emerged (Warfield 2007). Analogously, Ariba started the transition in 2006 and gradually ported all its applications to a SaaS model.

From a methodological point of view, we built on the quantitative and qualitative research methodologies employed in the previous three case studies. We employed a mixed-method research approach to study the transition of these two software companies – among the very few which already turned into pure on-demand players from on-premise. Specifically, based on a qualitative analysis of reports and transcripts documenting the transition, we sketched the main phases composing such a transition and elicited the most salient organizational issues they raise. Relying on an econometric analysis of their quarterly performances, we then assessed the financial impact statistically ascribable to these milestones.

Table 8.1 Recapitulation of the performed case studies

	Case (Chapter)	**I (3)**	**II (4)**	**III (5)**	**IV (6)**
I	**IT market segment**	Consumer electronics	Personal navigation devices	Business application software	Business application software
II	**Product type**	Consumer durable	Consumer durable	Enterprise durable	Enterprise durable
III	**Victim offering**	Apple iPod	Personal navigation device	Software and services sold through the offline channel	On-Premise business application
V	**Cannibal offering**	Apple entry-level iPod models; iPhone; iPad	Own navigation app	Software and services sold through the online channel	On-Demand business application
VI	**Cannibalization problem**	Ex post	Ex post	Ex ante	Ex post
VI	**Innovation type**	Product innovation	Product innovation	Service and process innovation	Product and process innovation
VII	**Uncertainty linked with the innovation dynamics**	Product performances and customers' preferences change over time	Product performances and customers' preferences change over time	No dominant design; performance criteria and preferences are forming	Product performances and customers' preferences change over time
VIII	**Research Strategy**	Quantitative	Quantitative	Qualitative	Mixed-method
IX	**Research design(s)**	Quasi-experimental	Longitudinal + Quasi-experimental	Cross-sectional	Longitudinal + Quasi-experimental
X	**Research methods: data collection**	Secondary data collection	Secondary data collection	Primary: qualitative interviewing	Secondary data collection
XI	**Data**	Time series: aggregated unit sales 2001-2014	Time series: aggregated unit sales 2000-2012	16 semi-structured interviews	Time series: revenues and profits 1998-2012; Documents: 247; SEC filings, 141 transcripts of interviews and earnings calls
XII	**Research methods: data analysis**	Time series econometric analysis	Time series econometric analysis	Content analysis	Content analysis; Time series econometrics analysis
XIII	**Level of analysis**	Macro	Macro	Micro	Macro
XIV	**Unit of analysis**	Vendor customer base	Vendor customer base	Individual customer	Vendor customer base

8.2. Contributions to Research Objectives

The overall goal of this research project was to find and apply methodologies for the detection and measurement of sales cannibalization in IT markets when technological innovation acts as a confounding factor. We contributed both newly defined constructs to allow researchers to conceptualize the phenomenon rigorously (as the answer to the Preliminary Research Question in Section 1.3) and novel methodological approaches to address the detection and measurement problems (answers to the Research Questions 1 and 2 in Section 1.3).

8.2.1. Conceptual Contributions

Based on a qualitative explorative study and an in-depth analysis of the literature, we have formulated a novel *nominal* definition of sales cannibalization (Section 2.3.1). While being generic enough to reflect all cannibalization occurrences encountered in the praxis, this definition is precise and rigorous. We also distinguished between volume and monetization effects of cannibalization and defined them.

Cannibalization is a phenomenon identified by three elements. It manifests itself as a demand interdependence between (at least) two offerings – a *cannibal* and a *victim* – where each offering is a set of IT artifacts and/or activities sold to customers through a given sales and distribution channel. The second element, which allows distinguishing cannibalization from competitive draw, is the existence of an *organizational realm* benefiting from the cumulative sales of both cannibal and victim. The third element is the *relationship between the sales-generating processes* of cannibal and victim offerings. The cannibal offering captures potential customers of the victim with a precise behavioral profile: those who would purchase the victim if the cannibal were not in the market, all other things equal.

Putting it all together, we define cannibalization as follows: the intra-organizational phenomenon of sales diversion by means of which sales of a product or service (the cannibal) are generated by diverting potential sales that a substitute product or service (the victim) would have obtained in absence of the former, *ceteris paribus*, within a common organizational realm collecting the revenues of both.

8.2.2. Methodological Contributions

We extended the range of available methods for the detection and measurement of cannibalization with new approaches suitable when, due to the innovation dynamics at work in IT markets, traditional methodologies from the Marketing Science and Management Science disciplines could not be appropriate. We derived several *operational definitions* from our nominal definition and implemented them through appropriate research designs and methods of data collection and analysis. Table 8.3 summarizes the methodological approaches presented throughout this work.

The simplest operationalization we conceived was to conduct a thought experiment with the customer to elicit his purchase intention in the presence and in the absence of the cannibal. This operationalization was implemented in the course of Case III (Chapter 5) with a qualitative research strategy and a cross-sectional research design. A semi-structured interview was designed to guide the customers through the thought experiment. The interviewer introduced and discussed alternative scenarios, and prompted participants to state explicitly their hypothetical purchase decision in each of them.

The two "break testing" operational approaches assume that cannibalization will manifest itself as a structural modification – a "break" – in the victim's sales-generating process (SGP). Cannibalization is the estimated difference between the observed behavior of the victim's SGP and the hypothetical behavior estimated by removing the effects of the cannibal on the victim's SGP. Depending on whether the breaks affecting the SGP are given (*exogenous*), or discovered as part of the operationalization (*endogenous*), the operational definition will comprise one or two steps respectively. Both types of

break tests were implemented in the course of this research. A brief comparative recapitulation can be found in Table 8.2.

In an exogenous-break test, the operational definition is implemented in one single step as a quasi-experimental design where the date of the natural experiment is selected by the researcher based on his own judgment and then statistically tested for significance. In Case I (Chapter 3), new-product launches within the victim's product line and in adjacent product categories were considered as the given natural experiments and pretested with an iterative application of the Chow test. Once the dates were screened, further tests were applied (the Perron test for the detection of unit roots in the presence of structural breaks) and, finally, the effects of the structural changes were estimated by fitting time series econometric models to the sales data.

When the candidate breaks are determined endogenously, the first step is a longitudinal research design to select the tentative breakdates. The second step is the quasi-experimental analysis conducted in the same way as for an exogenous-break test. This two-step operationalization was implemented in Cases II and IV (Chapter 4 and 6 respectively). Case II is, to our knowledge, the first microeconomic application of the unit-root testing procedure proposed by Zivot and Andrews, which endogenously determines an unknown breakdate (Zivot & Andrews 1992). Interpreting the estimated date in light of the milestones in the history of the cannibal, and validating against alternative explanations, it is possible to demonstrate the cannibalistic origin of the break in the victim's SGP. In Case IV, we combined quantitative and qualitative methods. The candidate breakdates were identified through qualitative content analysis of a set of documents spanning the interval of potential occurrence of cannibalization. The econometric part of the study was a structural break analysis analogous to those performed in Cases I and II.

Table 8.2 Comparison of the implemented instances of the "break testing" operationalizations

Case (Ch.)	Structural break	Identification methodology	Statistical tests
I (3)	Exogenous	Subjective selection	Chow test; Perron test
II (4)	Endogenous	Econometric test	Zivot – Andrews test
IV (6)	Endogenous	Qualitative Content Analysis	None (qualitative strategy)

We based another operationalization on modeling the customer's adoption decision and then verifying under which circumstances cannibalization may be occurring. An adoption model includes the factors determining the chances of adoption of each entity – drivers and barriers of adoption. The researcher can feed the adoption model with given buying scenarios to assess the customer's adoption decision in that specific context. If the addition of the cannibal alters the outcome of a buying situation where the adoption of the victim would be expected, this provides evidence of a cannibalistic relationship between the entities.

We implemented this operational definition in Case III, and built the adoption model empirically, on the basis of a qualitative content analysis of semi-structured interviews with current adopters of the victim. This represents, to our knowledge, the first application of qualitative research to sales cannibalization. Semi-structured interviews offered the flexibility required to build a shared understanding of the innovative ("fluid") socio-technological context, independently of the preexistent knowledge and expectations of the participants and ensuring high consistency among the interviews. The interview guide provided, for instance, a common terminology and a schematic description of an enterprise product portfolio. Subsequently, coding allowed the researchers to bring structure to the yet not fully articulated customers' attitudes and to build the adoption model.

In the Computational Lab (Chapter 7), we also implemented this operational definition but with two important differences: we derived the adoption model from microeconomic consumer theory and we deployed it through numerical experiments. In each numerical experiment, customer adoption is

recorded and compared in two alternative states of nature: one with the cannibal in the market together with the victim and one without the cannibal, all other things held equal. The victim's total cannibalized sales are the difference between the sales levels in the scenario without cannibal and those in the scenario with it. A positive difference represents cannibalization.

We conceived a second operational definition which relies on a decision-making model. This time, however, the model goal was reconstructing the customer's preference structure over a set of given offerings. To detect cannibalization with such a preference-formation model, the preference rank orders over all offerings in the market for the customers of the cannibal are recorded during a numerical experiment. Then those whose product ranking has the cannibal as the top item and the victim as the second best choice are counted as cannibalized. We showed in Chapter 7 how to take advantage of this operational definition in the Computational Lab by using a particular simulation methodology – Agent Based Simulation and Modeling. This methodology allows the researcher to model and simulate a buying agent's decision-making and record its outcomes during the simulation.

Table 8.3 Summary of the methodological approaches presented in this research project

Operational Definition	Research Design	Research Strategy	Research Methods	Ch.
Thought experiment	Cross-sectional / Experimental	Qualitative	Semi-structured Interviews	5
Exogenous-break test	Quasi-experimental	Quantitative	Econometric time series analysis	3
Endogenous-break test (quantitative discovery)	Longitudinal + Quasi-experimental	Quantitative	Econometric time series analysis	4
Endogenous-break test (qualitative discovery)	Longitudinal + Quasi-experimental	Mixed-method	Qualitative Content Analysis; Econometric time series analysis	6
Adoption model (empirically derived)	Cross-sectional	Qualitative	Semi-structured Interviews; Qualitative Content Analysis	5
Adoption model (derived from theory)	Numerical experiment	Quantitative	Agent-Based Modeling & Simulation	7
Preference formation model	Numerical experiment	Quantitative	Agent-Based Modeling & Simulation	7

8.3. Evaluation of Methodological Contributions

8.3.1. Validity, Reliability, and Generalizability

The specific merits and limitations for the individual methodologies implemented in the case studies are discussed at the end of each chapter (cf. Sections 3.7.2, 4.7.2, 5.7.3, and 6.7.2). In this section, we evaluate our contributions from a wider perspective. Since the aim of this project was designing detection and measurement strategies to assess the phenomenon of cannibalization, we must evaluate our proposed methodologies from the point of view of measurement validity, reliability, and generalizability.

Measurement validity is a primary criterion to judge the quality of our research results. It indicates whether a measure devised for a concept does reflect the concept that it is supposed to be denoting. The whole point of this research project was indeed to devise valid measures for the conceptual construct of cannibalization. We have designed our research process to maximize the degree of correspondence between that construct and the proposed measures. First of all, we laid a solid foundation by preliminary formulating a clear and accurate nominal definition of sales cannibalization. We reviewed definitions from the literature, decomposed them to find the building blocks of the construct, and rearranged these components in a novel definition. Our conceptual definition is precise but still generic. It namely allowed us to derive several alternative but coherent operational definitions. The operational definitions then served as the intermediate step between the generic cannibalization concept and the specific instances found in each case, with their own requirements and constraints of data availability and uncertainty.

As already mentioned in Section 2.3.2 (cf. first subsection), direct sales measurements can be taken at different stages along the distribution channel and this may affect the measurement validity of a quantitative cannibalization study. A sale from the manufacturer to a retailer or distributor is called "sell-in" or shipment. A sale which has already reached the end-customer is called "sell-through". The latter are more conservative estimates of sales since they exclude units which have not yet been purchased by end-customers (i.e., those units which merely make up the inventory volume in the distribution system and may never be actually sold). However, sell-in figures are what is usually published in financial statements. Some degree of measurement error must thus be reckoned whenever they represent the input to the analysis. We namely try to assess customer behavior from sales measures taken upstream. That said, a rather strong correlation between the behavior of intermediaries (more closely reflected by sell-in figures) and customers (more closely reflected by sell-through figures) may be assumed, given it is in the financial interest of the former to ensure that. Since channel agents downstream monitor customer behavior and then react to it with some delay, we may hypothesize the use of sell-in figures to affect mostly the temporal precision of a cannibalization measurement.

Another element of measurement validity to take into account when different measures of the same concept exist is *convergent validity*. It indicates whether results from a measurement methodology correlate with measures of the same concept developed through other methods. A limitation of our project is that we implemented ad-hoc procedures for each case study and did not tackle a situation where, for instance, *both* a qualitative cross-sectional study and an econometric estimation are applied to the same occurrence of cannibalization in parallel. We detail this issue further when discussing possible areas of interest for future research (in Section 8.5 below).

Measurement reliability is the issue of guaranteeing measure consistency. Factors of reliability are stability, internal reliability, and inter-observer consistency. Stability of the measurement over time is not an applicable criterion in our case. As a matter of fact, our methodologies were conceived to detect and measure instability. Internal reliability designates whether all the indicators of a multiple-indicator measure relate to the same thing and are not instead indicative of something else. This might be an issue when evaluating volume and monetization effects of cannibalization – two possibly contradictory indicators of cannibalization. Inter-observer consistency is the degree of consistency among the decisions taken by the involved researchers. We confronted this issue in the subjective selection of candidate breakdates (in the exogenous-break operationalization in Case I), by means of a rigorous pretesting procedure to screen the subjectively chosen dates, and in qualitative coding (in Case III and IV), by means of a highly formalized use of codes (which entailed, for instance, creating and updating a common codebook).

From the point of view of generalizability, we must prove that our methodologies are generalizable beyond our specific research context (external validity) and that they are practically applicable outside of the research environment in which they were conceived (ecological validity). First of all, we may highlight that the four case studies dealt with four very different occurrences of cannibalization, and that we showed the use of quantitative techniques in three of them, and qualitative techniques in two. Therefore, by means of our multicase design, we proved that our proposed solutions can be applied to a range of cannibalization cases: from classical product cannibalization to the conceptually more complex cases of platform, channel, and business model cannibalization. Taking into account that the ultimate goal of our research was to find ways of measuring cannibalization in the specific context of innovative IT markets, generalizability beyond this context was never a concern. Nevertheless, we may argue that our approaches could be tried in other settings with similar requirements as well. We cannot see any reason why, for instance, a qualitative cross-sectional study, such as the one in Case III, might not be employed to investigate the adoption of other types of industrial durables or capital goods, where a buying center is responsible for the purchase decision. At the same time, the techniques presented in Cases I to III to identify, pretest and test structural changes could be employed whenever there is uncertainty around the identification of the cannibalization-relevant market events and/or their timing.

The whole array of methodologies that we proposed and implemented should be judged ecologically valid. The qualitative methodologies proposed are ecologically valid by birth, since the case study in which they were developed was commissioned by a nonacademic institution driven by other interests than scientific research. Moreover, qualitative methods tend to be ecologically valid by definition, since the qualitative material to be analyzed is collected from a "natural" social setting (the customer base of the vendor) and by interacting directly with it (sampled through convenience and snowball sampling). In the case of the econometric applications, we considered only actual cannibalization occurrences of topical interest in the trade press. The ecological validity of the agent-based Computational Lab is proved, we believe, by the fact that it was actually implemented as a prototype within the scope of the research and development activities of a renowned enterprise software application vendor and judged of commercial interest by its management.

8.3.2. Explanatory Value

When we introduced our research questions, we noted that they were methodological in nature. They namely stated the necessity to provide valid methods to answer the *positive* question of whether cannibalization be occurring. This could be read as a purely *descriptive* issue ("*what is going on between these two offerings*?"). As a matter of fact, all the methodologies that we developed and employed in the course of this work possess a crucial explanatory element as well ("*why is it going that way*?"). This explanatory element is required to be able to answer the descriptive question in the first place.

In the time series econometric analysis in Case I, II, and IV, structural break testing could prove the occurrence of structural changes in the sales-generating process of the victim at certain periods in the series. However, the analysis could not be confined to that. It had to provide some evidence for the causal link between the identified/dated breaks and the cannibal entity. In the qualitative cross-sectional study (Case III), interview participants were not merely asked what their channel adoption decision would be, but a more thorough analysis of the factors influencing this decision took place in order to shed light on the cannibalization phenomenon.

This is coherent with the intrinsically unobservable nature of cannibalization, which cannot be examined by itself, abstractly, but only in conjunction with something else existing or happening in the market at some point. Therefore, although the question seems posed and destined to be answered in strictly descriptive terms ("*is the phenomenon taking place?*", i.e., "*is cannibalization occurring*?"), the answer can actually be found only through the evaluation and explanation of the cannibalistic repercussions of some entity or process. This can be, for instance, an IT artifact (a new product), a socio-technological composite (a sales channel), a marketing decision (the introduction of a new product variant), or a strategic move (diversification in an adjacent market). Cannibalization can only be detected and measured by somehow better understanding this entity or process.

8.4. Evaluation of Empirical Findings

We believe that the empirical findings from the case studies not only deepen the understanding of some particular instances of a phenomenon and supplement the related streams of research (described in the "related work" section of each chapter, cf. Sections 3.3, 4.3, 5.3, and 6.3). They can also be read together and jointly shed light on the generic nature of some relevant IT phenomena. On the one hand, the set of analyses conducted throughout this research project provide *original* views on already widely researched topics in the field of IS, such as platform and ecosystem strategies. On the other hand, they allow us to gain an *informed* perspective on more recent trends witnessed in the IT industry in the last decade, such as convergence of portable computing platforms, the adoption of online sales channels, and "appification".

The platform is such a fundamental element in the success and demise of IT vendors that all four cases could be actually read with the lenses of a platform strategist. Taken in its merely technological meaning, the platform becomes a common denominator for all cases. In Cases I and II, we provided evidence for a phenomenon of sales diversion from specialized platform (digital music players and

personal navigation devices) to generic ones (smartphones and tablets). Case II and IV revealed the struggles of undertaking a platform overhaul. In Case II, manufacturers of specialized navigation platforms had to suffer the inroad of a generic highly innovative platform such as the touchscreen smartphone, which can offer through the installation of a proper application, the same exact navigation functionalities. This not only lowered the relevance of their proprietary platform technology, but also forced them to change role altogether and to face a very different competitive landscape. From platform owner in a very concentrated market to – at least in the personal navigation segment – complementors in a highly competitive software market. In Case IV, software vendors proactively followed the course of a radical platform overhaul with the adoption of an on-demand multitenant architecture.

Case IV shares in this sense a common element with Case III as well. Turning to an on-demand software delivery models meant much more than just the adoption of a different technology. As a matter of fact, organizational and technological factors were both relevant and interdependent in the path to a successful business model transition. Case III confirmed this interdependence of technological and organizational factors. Online channels for software purchases in the enterprise market will only replicate the success stories of the consumer market (the "app stores") if both organizational innovations (such as contractual frame agreements) and technological ones (such as instant deployment) are implemented.

From an historical point of view, one must bow to the predominant role played by Apple in the disruption, reconfiguration, and expansion of IT market segments and their underlying technologies in the last decade. Apple is namely either one of the protagonists or the motivating factor of three case studies out of four. In Case I, we dealt with Apple handheld devices which have changed the way people use computing platforms and relate to them. In Case II and III, we saw how these devices and the ecosystem around them disrupted or inspired change in adjacent markets by means of the revolutionary ways in which they allowed software to be consumed. In Case II, the birth of the smartphone software ecosystems – area in which Apple is both the pioneer and the charismatic trend-setter – swallowed the market for computer-aided navigation and reduced it to a niche for specialized users (Garmin and TomTom had to turn to sportsmen to keep selling their devices). In Case III, we showed the arduous way before today's leading enterprise software vendors if they aim at replicating a parallel development in the consumption of enterprise software. And they will probably have to, to the extent that the Apple-driven changing habits in the consumer software markets may influence the attitudes of professional buyers as well.

8.5. Future Research

In the course of this research project, we illustrated the simultaneous use of multiple operational definitions for the analysis of one occurrence of cannibalization. In Case III, the detection of channel cannibalization was operationalized both as a thought experiment and by means of an adoption model. In Case IV, cannibalization among alternative software delivery models was operationalized as an endogenous break test. Then the same scenario was employed in numerical experiments with operationalizations through models of adoption and preference formation. At the same time, we employed both qualitative and quantitative methods. Cases I and II, and the Computational Lab experiment were based on a quantitative strategy. Case III relied on a qualitative strategy. Case IV was an example of mixed-method research with both strategies arranged in sequence.

It should be clear, that we believe in the merits of a triangulative approach, where different methodologies are employed concurrently on the same research topic and their outcomes confronted to see if they contradict or corroborate each other. There are several ways to mix and match methodologies for the detection and measurement of sales cannibalization, and future research can be expected to expand the restricted set of solutions we proposed here both in triangulative and non-triangulative arrangements.

Theoretically, a researcher has two decisions to take: the selection of an operational definition/research design combination and the selection of the specific qualitative/quantitative research methods for the collection and analysis of data. By picking more than one option for one or both of these decisions and then comparing the outcomes, he exploits triangulation. While it would be difficult to consider exhaustively all the possible triangulation settings when mixing research methods and operationalizations/designs, we can provide some guidance for future research if we limit ourselves to the higher-level decision concerning the research strategy. In this simplified conceptual scenario (summarized in Table 8.4), the researcher picks first the operationalization/design pair and the research strategy, in order to define his methodological framework for investigating cannibalization.

Possible triangulation approaches could prescribe one or more operational definitions and one or more strategies. Moreover, when mixing qualitative and quantitative strategies, we could either arrange them sequentially (as we did in Case IV) or in parallel. We find that the one exciting area of research for scholars interested on building on our results might be to explore the triangulative implementation of the same operationalization with two different strategies, i.e., deploying the operational definition through mixed-method research where qualitative and quantitative methods are used in parallel. Another area of interest could be mixing operationalizations implemented with different strategies.

Table 8.4 Areas of interest for future research building on the outcomes of this research project

		Operational Definitions	
		One	**More than one**
Research Strategy	**Qualitative**		(Case III)
	Quantitative	(Case I & II)	(Computational Lab)
	Mixed-Methods in sequence	(Case IV)	
	Mixed-Methods in parallel	Areas of interest for future research	

8.6. Conclusion

Every IT multi-product company – that is, practically, every IT company – is competing with itself to some extent. Strange as it may sound, knowing that a product "is selling" is not enough to judge its value for the seller. The fortunes of an offering may actually be the ruin of another in the same portfolio. Knowing where the sales of that product are coming from is then a step in the direction of ensuring that, through an informed evaluation of the whole product portfolio and the interdependences therein, both fortunes and misfortunes within a common organizational realm are the building blocks of current and future market success.

Yet, this apparently very simple piece of information is inherently challenging to obtain, and even more so in the presence of technological innovation. The detection and measurement approaches conceived and implemented in the course of our research can discover and quantify sales diversion even in uncertain technological environments. They thus allow any stakeholder of an IT enterprise to conduct the above-mentioned informed assessment – the foundation of any trustworthy analysis of the success and durability of a growth strategy.

Appendix

Glossary of Applied Time Series Econometrics

For the reader unfamiliar with econometric time series analysis we provide here a glossary of the main concepts needed to understand the research methodology in Cases I, II, and IV (for the quantitative steps). These definitions are not meant to be comprehensive nor formal but merely an aid to understanding our applications of this quantitative approach. For a thorough treatment of each argument please refer to a manual on time series analysis, such as Enders (2010), and to the specific bibliographical references given in the text.

Akaike Information Criterion (AIC): A numerical model selection criterion which takes into account that each additional model parameter entails both a benefit (fit improvement) and a cost (increase in parameter uncertainty) and aims at optimizing this trade-off.

Augmented Dickey-Fuller test (ADF): An extension of the Dickey-Fuller test which to encompass serial correlation of the response variable as well.

Autocorrelation and **partial autocorrelation**: Measures of correlation between a variable and its value at some point in the past. The autocorrelation of kth order means the correlation between a variable and its value k periods before. The *partial* autocorrelation of order k eliminates the effects of indirect correlations by the intervening values at lag –1 through $t - k + 1$.

Autocorrelation Function (ACF) and **Partial Autocorrelation Function (PACF)**: The plot of the (theoretical or sample) autocorrelations and partial autocorrelations against their order k.

Autoregressive (AR) term: A model component of a regression equation representing the effect on the current response of a lagged response value (for example, for an effect at i lags, given the current response y_t and a coefficient a_i: $a_i y_{t-i}$).

Bayes Information Criterion (BIC, also called **Schwartz Bayesian Criterion)**: A numerical model selection criterion analogous to the Akaike Information Criterion but attributing a higher marginal cost to the estimated parameters.

Box-Cox transformation: A preliminary transformation of the time series data points employed to improve the quality of the estimated model.

Box-Jenkins methodology: An approach for the construction of time series models whereby the three phases of model identification (choice of the model specification), parameter estimation (calculation of the values for each parameter in the model specification), and diagnostics (assessment of the quality of the estimates) are iteratively repeated until a satisfactory model is obtained.

Breusch-Pagan test: A statistical procedure for testing if a series is heteroskedastic.

Chow test: A statistical procedure for testing the presence of a structural change at a *known* date in a time series.

Confirmatory data analysis: The analytical phase which follows the exploratory data analysis and, by means of estimation and selection of the most appropriate econometric model formulations, rigorously verifies the clues identified in the exploratory steps and provides statistically significant evidence thereon.

Constrained model: A model of orders p, q where the AR terms for some lags < p and/or the MA terms for some lags < q are actually not considered. For instance, a constrained second-order AR model would include only the second lag of the response variable in the right-hand side of the regression.

Deterministic trend: A model component consisting of a function of time.

Diagnostic checks (or **diagnostics**): The statistical tests performed on the residuals from a calibrated model, to verify whether they are independent, normal, and homoscedastic – in other words, to assess if all the relevant information is extracted from the data by the chosen model specification.

Difference-stationary (as opposed to trend-stationary): Containing a stochastic trend (it becomes stationary by differencing).

Dickey-Fuller test: The most commonly used unit-root test.

Durbin-Watson test: A statistical procedure for testing whether a time series presents 1st order serial autocorrelation.

Endogenous variable: A variable whose value is determined within the model.

Exogenous variable: A variable whose value is not determined within the model but instead given as an input.

Exploratory data analysis: "Detective" work to reveal the main statistical characteristics of a time series and to identify candidate models for later estimation. It encompasses the use and peruse of graphical and nonparametric instruments, such as time-plots, smoothers, autocorrelation and partial autocorrelation functions.

Heteroskedasticity (as opposed to **homoskedasticity**): The presence of a change in the variance of a stochastic process.

Intervention: A natural or man-caused event taking place at a discrete point in time and producing a change in the mean of a process. The change can be permanent (following a step function), temporary (pulse function), or gradual (deterministic trend function).

Intervention analysis: Construction of intervention models for the analysis of the interventions impacting the mean of a process.

Jarque-Bera test: A statistical procedure for testing if a series is normally distributed.

Kolmogorov-Smirnov test: A statistical procedure for testing if a series is normally distributed.

Lag operator (L, also called **backward-shift operator**): An operator used to represent lagged variables within mathematical expressions. A lag of order k of the response variable (i.e., y_{t-k}) can be expressed as $L^k y_t$.

Ljung-Box test: A statistical procedure for testing whether a time series is autocorrelated.

Maximum Likelihood (ML): An estimation technique calculating the parameter values of a model to maximize the probability of obtaining the observed data under the assumption that the model does indeed represent the actual data-generating process.

Moving-average (MA) term: A component of a regression equation representing the effect on the current response of a past disturbance (for example, for an effect at i lags, given the current disturbance ε_t and a coefficient b_i: $b_i \varepsilon_{t-i}$).

Multivariate model: A model specification with multiple response variables.

Nonstationarity: The presence of a permanent change in the mean or variance of a series. Nonstationary model components are those capable of altering the long-run mean or variance of the process, for instance: deterministic or stochastic trends, structural changes, deterministic or stochastic exogenous variables.

Noise (also called **disturbance**, **error**, **random term, random shock**): The unexplained or truly random dynamic in a process.

Orders (of a time series model): The maximum lags considered for the AR or MA components of a model, usually represented by the letters p and q respectively, for the seasonal components, and the number of times the data were differenced, represented by d. A second-order autoregressive model

(AR2) is, for instance, a model where only the first two lags of the response variable appears in the right-hand side of the regression and no differencing takes place (p=2, q=0, d=0).

Ordinary Least Squares (OLS): An estimation technique calculating the parameter values of a model to maximize its goodness of fit.

Perron test: A statistical procedure for testing the presence of a unit root in a time series where a structural break at a known time also occur.

Parameter instability: The changing over time of some parameters in the model. Structural changes and interventions are common forms of parameter instability.

Residuals: The difference between the values of the observed time series and the predictions obtained from an estimated model.

Sample autocorrelation and **sample partial autocorrelation of kth order**: measures of the degree of correlation between two observations k periods apart.

Seasonality: serial correlation among the values of a time series at a certain "season" across the years. Specifically, in the case of the financial data in this work, it is the serial correlation between the same fiscal quarter across succeeding fiscal years.

Shapiro-Wilk test: A statistical procedure for testing if a series is normally distributed.

Smoother: A filter which maps a series into a smoothed curve.

Stationarity: If stationarity can be assumed, changes in the mean and variance of the series are only temporary and dissipated in the short-run. Stationary model components are constants (the "intercept"), invertible autoregressive terms, and moving-average terms.

Stochastic process: A mathematical expression describing the probability structure of a time series.

Stochastic trend: A series is said to have a stochastic trend if the random shocks in each period have nondecaying effects, that is, if they permanently affect the mean of the series. A series with a stochastic trend has at least a unit root in the autoregressive polynomial.

Structural break (or **structural change**): A change in the parameters of a data-generating process.

Structural break test: A statistical procedure for testing the presence and/or the timing of a structural break.

Time series: A set of observations arranged chronologically.

Trend: The nondecaying component of a series.

Trend-stationary (as opposed to difference-stationary): Not containing a stochastic trend (but possibly a deterministic one, it becomes stationary by detrending).

Unit-root process: In general, any series that contains at least one characteristic root which equals unity. In the context of our research applications, we are usually concerned with the characteristic roots of the autoregressive polynomial. If at least one equals unity, the series has a stochastic trend.

Unit-root test: A statistical procedure for testing the presence of a unit root / stochastic trend in the time series.

Univariate model: A model specification with just one response variable.

Zivot-Andrews test: A statistical procedure for testing the presence of a unit root in a time series where a structural break at an unknown date may also occur.

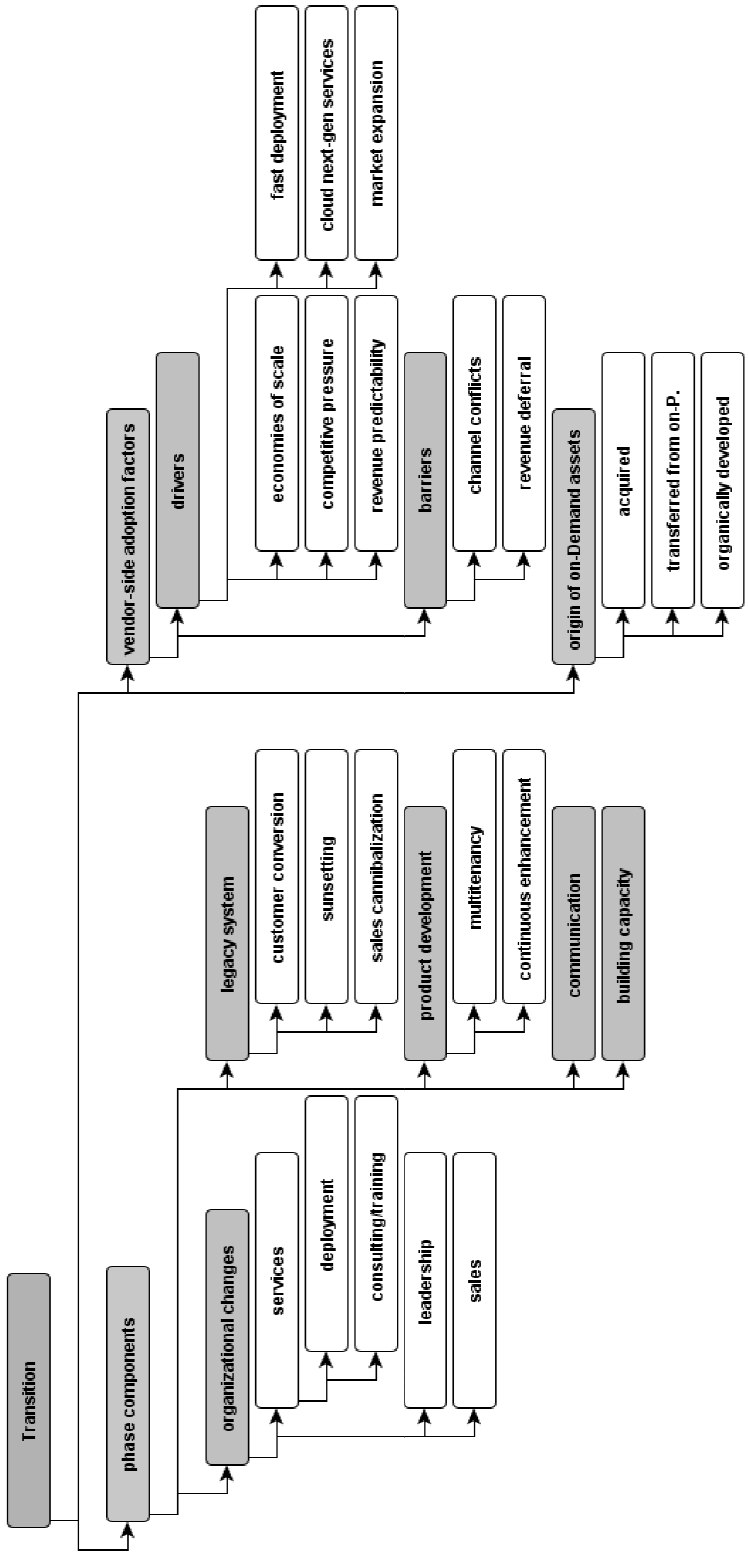
Chronology of Apple New-product Events (Case I)

Product			Event	Price points[c] and Memory allotment						Date[d]
Line	Model[a]	G[b]		(USD)	(GB)	(USD)	(GB)	(USD)	(GB)	
iPod		1	Product line introduction	399	5					21/10/01
iPod		1	Variant	399	5	499	10			21/03/02
iPod		2	Generational renewal	299	5	399	10	499	20	17/07/02
iPod		3	Generational renewal	299	10	399	15	499	30	28/04/03
iPod		2	Variant	299	10	399	20	499	40	08/09/03
iPod	Mini	1	Downward extension	249	4					06/01/04
iPod		4	Generational renewal	299	20	399	40			19/07/04
iPod		4	Variant	299	10	349	20	499	40	26/10/04
iPod	Photo	1	Upward extension	499	40	599	60			26/10/04
iPod	Shuffle	1	Downward extension	99	0.5	149	1			11/01/05
iPod	Mini	2	Generational renewal	199	4	249	6			23/02/05
iPod	Photo	1	Minor renewal	349	30	449	60			23/02/05
iPod	Photo	1	Discontinuation							28/06/05
iPod	Shuffle	1	Price change	99	0.5	129	1			28/06/05
iPod		4	Product replacement	299	20	329	20	399	60	28/06/05
iPod	Nano	1	Product replacement	199	2	249	4			07/09/05
iPod	Mini	2	Discontinuation							07/09/05
iPod		5	Generational renewal	299	30	399	60			12/10/05
iPod	Nano	1	Variant	149	1	199	2	249	4	07/02/06
iPod	Shuffle	1	Price change	69	0.5	99	1	99		07/02/06
iPod		5	Variant	299	30	329	30	399	60	06/06/06
iPod	Nano	2	Generational renewal	149	2	199	4	249	8	12/09/06
iPod	Shuffle	2	Generational renewal	79	1					12/09/06
iPod		6	Generational renewal	249	30	349	80			12/09/06
iPod	Nano	2	Variant	149	2	199	4	249	8	13/10/06
iPod	Nano	2	Variant	149	2	199	4	249	8	03/11/06
iPhone		1	Product line introduction	599						09/01/07
iPod	Shuffle	2	Variant	79	1					30/01/07
iPod	Touch	1	Upward extension	299	8	399	16			05/09/07
iPod	Classic	6	Minor renewal	249	80	349	160			05/09/07
iPod	Nano	3	Generational renewal	149	4	199	8			05/09/07
iPod	Touch	2	Variant	299	8	399	16	499	32	05/02/08
iPhone			Variant	399						05/02/08
iPod	Shuffle	2	Variant	49	1	69	2			19/02/08
iPhone	3G	3	Minor renewal	199						09/06/08
iPod	Nano	4	Generational renewal	149	8	199	16			09/09/08
iPod	Touch	2	Generational renewal	229	8	299	16	399	32	09/09/08
iPod	Classic	6	Minor renewal	249	120					09/09/08
iPod	Shuffle	3	Generational renewal	79	4					11/03/09
iPhone	3GS	3	Minor renewal	199						08/06/09
iPod	Nano	5	Generational renewal	149	8	179	16			09/09/09
iPod	Touch	3	Generational renewal	199	8	299	32	399	64	09/09/09
iPod	Shuffle	3	Variant	59	2	79	4			09/09/09
iPod	Classic	6	Minor renewal	249	160					09/09/09
iPad		1	Product line introduction	499						27/01/10
iPhone		4	Generational renewal	199						07/06/10
iPod	Touch	4	Generational renewal	229	8	299	32	399	64	01/09/10
iPod	Nano	6	Generational renewal	149	8	179	16			01/09/10
iPod	Shuffle	4	Generational renewal	49	2					01/09/10
iPad		2	Generational renewal	499						02/03/11
iPhone	4S	4	Minor renewal	199						04/10/11

iPad		3	Generational renewal	499						07/03/12
iPhone		5	Generational renewal	199						12/09/12
iPod	Touch	5	Generational renewal	299	32	399	64			12/09/12
iPod	Touch	4	Price change	199	16	249	32			12/09/12
iPod	Nano	7	Generational renewal	149	16					12/09/12
iPad	Mini	1	Downward extension	329						23/10/12
iPad		4	Variant	799						29/01/13
iPhone	5s	5	Minor renewal	199						10/09/13
iPhone	5c	5	Downward extension	99						10/09/13
iPad	Air	1	Product replacement	499						22/10/13
iPad	Mini	2	Variant	399						12/11/13
iPad			Variant	399						18/03/14
iPod	Touch	5	Variant	199	16	249	32	299	63	26/06/14

Notes:
a) Blank cells refer to parent model.
b) Generation.
c) Suggested retail price. All available price points are listed for the iPod product line, for iPhone and iPad only the lowest price point is indicated.
d) Announcement date, i.e., publishing date of the press release.
Source: Apple press releases 2001-2014 (https://www.apple.com/pr/library/)

Codes Hierarchy (Case IV)



Abbreviations

10K	SEC form for annual reports
10Q	SEC form for quarterly reports
3G	3rd Generation mobile telecommunications technology
ABMS	Agent-based Modeling & Simulation
ACF	Autocorrelation Function
ADF	Augmented Dickey-Fuller test
AIC	Akaike Information Criterion
App	Software Application for portable computing platforms
AR	Autoregressive
ARIMA	Autoregressive Integrated Moving Average
ARMA	Autoregressive Moving Average
ARPU	Average Revenue per Unit
ASP	Application Service Provider
CAQDAS	Computer-aided Qualitative Data Analysis Software
CFO	Chief Financial Officer
CIO	Chief Information Officer
CnR	Contention Rate
CRM	Customer Relationship Management
CSV	Comma-separated Values
CUSUM	Cumulative Sum
DF	Dickey-Fuller test
DGP	Data Generating Process
DMP	Digital Music Player
DOI	Diffusion of Innovation
DSS	Decision Support System
DW	Durbin-Watson test
ERP	Enterprise Resource Planning
ESV	Enterprise Software Vendor
FMC	Fundamental Modeling Concepts
FMCG	Fast Moving Consumer Goods
FY	Fiscal Year
GB	Gigabyte
GPS	Global Positioning System
GUI	Graphical User Interface
H0	Null Hypothesis
H1	Alternative Hypothesis
IaaS	Infrastructure-as-a-Service
ICT	Information and Communications Technology
IIA	Independence of Irrelevant Alternatives
IS	Information Systems
ISR	Information Systems Research
IT	Information Technology
JB	Jarque-Bera test
LE	Large Enterprises
LoB	Line of Business
LS	Least Squares
MA	Moving Average
ML	Maximum Likelihood
MLE	Maximum Likelihood Estimator
MP3	MPEG Audio Layer III
NAICS	North American Industry Classification System
OLS	Ordinary Least Squares
OS	Operating System
PaaS	Platform-as-a-Service
PACF	Partial Autocorrelation Function
PC	Personal Computer
PDSS	Pricing Decision Support System
PLC	Product Life Cycle theory
PND	Personal Navigation Device
POJO	Plain Old Java Object
PPI	Producer Price Index
Q1, Q2…	First, Second… Quarter
RDBMS	Relational Database Management System
R&D	Research and Development
RNG	Random Number Generator
SaaS	Software-as-a-Service
SARIMA	Seasonal ARIMA
SDK	Software Development Kit
SE	Standard Error
SEC	U.S. Securities and Exchange Commission
SGP	Sales-Generating Process
SIIA	Software & Information Industry Association
SME	Small & Medium Enterprises
SSR	Sum of Squared Residuals
SW	Shapiro-Wilk test
TAM	Technology Adoption Model
TC	Total Costs
TOE	Technology-Organization-Environment framework
TR	Total Revenues
UML	Unified Modeling Language
VAR	Vector Autoregression
VoD	Video on Demand
XML	Extensible Markup Language

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