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Dance with the Dollar: Exchange Rate Exposure on the German Stock Market

Horst Entorf, TU-Darmstadt, FG Empirische Wirtschaftsforschung
Gösta Jamin, McKinsey & Company (Munich)

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Dance with the Dollar: Exchange Rate Exposure on the German Stock Market

Horst Entorf, Gösta Jamin

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Summary: We estimate the Dollar exposure of German DAX corporations. Our results are based on a new time-variant, APT-based and panel econometric extension of the exchange-rate exposure model in the tradition of Adler and Dumas (1984) and Jorion (1990). Our stock market data consist of 28 performance indices of German DAX corporations. We include macroeconomic risk factors, and data on export and import involvement. Dollar exposures turn out to differ between exporters and importers and they are rather unstable over time. In contrast to most previous studies in the literature that find little evidence of exposure, we confirm recent results of Dominguez and Tesar (2001) who report that higher foreign involvement corresponds to higher exposure at least in Germany. Moreover, our findings suggest that exposure also depends on the prevailing level of the Dollar exchange rate.

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Authors:

Horst Entorf
Professor of Applied Econometrics
Darmstadt University of Technology
Department of Economics
Marktplatz 15 (Schloss)
D-64283 Darmstadt

Tel. (+49) 6151/ 16-2436
entorf@mail.tu-darmstadt.de
http://www.tu-darmstadt.de/fb/fb1/vwl2/

Gösta Jamin
McKinsey & Company
Prinzregentenstr. 22
D-80538 München

Tel. 089/ 55948817
Goesta_jamin@mckinsey.com

1. Introduction

The great majority of analysts seem to assume a negative correlation between the German stock market and the Euro/$ exchange rate, respectively they assumed a positive correlation between the German stock market performance and the former DEM/$ rate. Comments in the business press are based on Germany's economy dominated by exporting industries to which any appreciation of the German/European currency would mean "bad news" for the profitability of German companies, because of the worsened competitiveness relative to Non-German companies.

The framework business analysts might have in mind when discussing the conjunction between the value of the US-Dollar and the German stock market is known as the "exposure to exchange rate risk" in the literature on international finance. It is defined as the change of the value of the firm in response to exchange rate fluctuations (Adler and Dumas, 1984). Dominguez and Tesar (2001a,b,c) give a detailed survey on the relevant literature and of existing channels of interaction between currency risks and firm values. Following along the lines of basic arguments, export-oriented firms would suffer from an appreciation of the domestic (German) currency as its products become less affordable to foreign consumers. Even non-exporting firms could be negatively affected, because foreign competitors can sell their products more easily on the domestic market. However, it is obvious that there are also industries and firms who benefit from an appreciation of the domestic currency (and would suffer from a depreciation) because a considerable amount of them have much higher import shares than export shares. Even when focusing on aggregate numbers, the persistence of Germany's overall trade surplus is not given per se.[1] Thus, any appreciation might imply "good news" as well because of decreasing costs of production such that the conjectured correlation between DEM/$ changes and German stock market returns would be negative, in particular if companies of import-intensive and oil-importing industries (e.g. of the German power industry) are concerned. Moreover, if we think of the exchange rate exposure of the German economy in terms of the share value of

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[1] During the year 2000, for instance, high oil prices have let to a share of imported goods and services in GDP that was almost of the same size as the corresponding share of exported goods and services in GDP. Germany's exported goods and services amounted to DEM 1326 billion, while the German economy spent DEM 1311 billion for imported goods and services. At the same time, the German GDP was DEM 3976 billion (Statistisches Bundesamt, 2001). The trade surplus was even negative in aftermath of the first oil price shock in 1981/82.

the 30 biggest German corporations comprising the most important German stock market index, the XETRA-DAX, which is under investigation in this study, it is to be expected that these large firms engage in hedging activities.[2] However, if German companies fully hedge their currency risk by using derivative products and other exchange rate hedging instruments as, for instance, locating production in the United States[3], then their stock price changes should not be correlated with any movement of the Dollar at all.

Thus, an important question is whether exchange rate exposure is influenced through the channel of international trade. Previous research in this area was pioneered by Jorion (1990), who showed using a sample of US multinationals that a firm's exchange rate exposure is positively related to the ratio of foreign sales to total sales. This result was extended and confirmed by Allayannis and Ofek (2001). He and Ng (1988) shows that Japanese multinationals with higher exposure levels are related to higher export shares. However, looking at international evidence from eight countries, Dominguez and Tesar (2001b,c) conclude that they do not find a strong connection between trade and exposure, although there seems to be some evidence that a higher level of foreign sales corresponds to higher exposure for Germany (Dominguez and Tesar, 2001c, Table 10).

This study takes a fresh look at the topic using German data. The econometric approach extends the existing literature by incorporating available information in a more complete and efficient way than it was done in previous research. The usual way of first testing and then explaining exchange rate exposure consists in performing a two-stage procedure. All firm or industry returns in the sample are regressed on the market portfolio and the return of the relevant exchange rate, which in most applications is measured as the dollar exchange rate (see, for instance, Dominguez and Tesar, 2001b). The coefficient on the exchange rate represents the resulting estimate of the exchange rate exposure. The presence of the market portfolio leads to a CAPM interpretation of this first stage regression. However, the reason of choosing a CAPM specification is not to test the CAPM but to isolate the variation coming from the exchange rate risk. Following this intention more thoroughly than in previous research, we extend the framework by applying APT instead of CAPM in the first step, i.e. by controlling for other potential macroeconomic risks such as inflation and interest rate fluctuations. The main reason for this extension can be seen in

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[2] Nance, Smith and Smithson (1993) report that larger firms are more likely to use hedging instruments than are smaller companies.

[3] See, for instance, Dominguez (1998) for a discussion of hedging instruments.

the nature of macroeconomic factors that have asymmetric influences on both stock returns and exchange rates. Prominent candidates are divergent monetary and fiscal policies, as well as asynchronous output movements that might drive stock returns and exchange rates in different ways such that any prediction of the prevailing direction of correlation between both financial market prices is difficult and regime-dependent (see Gavin, 1989). From a more technical point of view, we isolate exchange rate movements and other macroeconomic variables with respect to the market factor by following an orthogonalization procedure suggested by McElroy and Burmeister (1988).

Going beyond most studies applying the two-step procedure, we do not assume that magnitude and direction of exposure is stable over time, an assumption that is refuted by evidence obtained in Santis and Gerard, 1997, 1998, Tai, 2000, and Allayannis and Ihrig, 2000). In order to take account of time-varying risks, we use a moving-window regression approach for all firms in our sample. Moreover, in order to receive results of the overall German exchange rate exposure, we extend the moving-window approach by applying rolling-panel estimation techniques.

The usual second step of the procedure consists of relating the exchange rate exposure to potential covariates, where the trade hypothesis plays a prominent role. The standard way is to run cross-sectional regressions with the individual exchange rate betas used as left-hand side variables. This strategy was followed, for instance, by Dominguez and Tesar (2001bc) and Allayannis and Ofek (2001), who test whether exchange rate exposure is affected by the presence of foreign currency derivatives. However, given the time-varying nature of the exposure data at the firm level that we obtain in the first step, we are able go beyond the traditional approach: We propose to exploit available first-step information in a more efficient way by implementing panel data estimation and SUR (seemingly unrelated regression) techniques. Furthermore, the construction of aggregate currency exposure time series enables us to test for cointegration between exchange rate exposure and national export and import data which in turn allows us to focus on general macroeconomic conclusions for the German economy.

We base our analysis on performance indices from the German DAX corporations of the time 1977-1995. We find a rather unstable association between stock returns and DEM/Dollar changes. Estimated Dollar exposures are significantly negative at the beginning of the 80's, but they change their sign in the late 80's and early 90's. Cointegration tests reveal that the association strongly depends on the import-export structure and the existing DEM/$ level.

This paper is organised as follows. In Section 2, we measure the stability of German exchange rate exposures within the APT framework. Section 3 presents our econometric approach that exploits the nature of financial panel data. Section 4 informs about estimated exchange rate exposures, and in Section 5 results are briefly summarized.

2. Measuring exchange rate exposure: Tests of stability within the APT framework

2.1. Exchange Rate Exposure, its measurement, and explanatory factors

The expected reaction of stock markets to dollar changes can be captured in the simple stochastic equation

(1) $$r_{it} = \alpha_i + \beta_{it} d_t + \varepsilon_{it} \,,$$

where r_{it} is the stock market return of company i at time t, and d_t is the return of the DEM/$ exchange rate at time t. Most comments in business newspapers, for instance, are based on a strong positive foreign involvement of German firms, and they expect the slope parameter β_{it} to have a positive sign, because they see rising dollars (i.e. a rising DEM/$, respectively a depreciation of the Euro) as driving force of good stock market prospects. This approach looks rather ad hoc, but in fact, Adler and Dumas (1980, 1984) have shown analytically that exposure to currency risk can be measured within a simple linear regression framework, in which the stock market return is regressed on a constant and the exchange rate (in practical applications, proxies of market portfolios are included as second explanatory variable). The exchange rate exposure boils down to the partial derivation with respect to the exchange rate, i.e. to the slope parameter of the bivariate regression which requires the assumption of a stable $\beta_{it} = \beta_i$ for all t.

This line of research was followed in an influential paper by Jorion (1990), who analysed the exposure to exchange rates of U.S. multinationals. Most applications are for U.S. financial markets, with important exceptions. Bodnar and Gentry (1993) provided evidence for Canada, Japan and the U.S., Bailey and Chung (1995) studied the effects of exposure to currency and political risks on equity returns in Mexico, and He and Ng (1998) as well as Dominguez (1998) investigated the exchange rate exposure of Japanese corporations.

Publications with a special focus on the relationship between exchange rates and stock market returns in Germany are rare.[4]

Still only little empirical research can be found on determinants of currency exposure. Jorion (1990) finds that exposure varies systematically across the companies under consideration, depending on firm characteristics such as the percentage of foreign operations. Bodnar and Gentry (1993) compare industry-level exchange rate exposures for Canada, Japan and the USA. They find that between 20 and 35 per cent of industries have statistically significant exchange rate exposures that are larger for Canada and Japan than for the USA. He and Ng (1998) examine a sample of 171 Japanese multinational companies and find that higher exposure levels are related to higher export shares. However, looking at international evidence from eight countries, Dominguez and Tesar (2001b,c) conclude that they do not find a strong connection between trade and exposure, although for Germany there seems to be some evidence that a higher level of foreign sales corresponds to higher exposure (Dominguez and Tesar, 2001c, Table 10).

2.2. Estimation of time-variant exchange rate exposure within the APT framework using German Data

A problem with the usual way of testing and measuring exchange rate exposure is that it overlooks that in Adler and Dumas (1984), stock prices and exchange-rate movements are both endogenous variables and that third influences might drive both exchange rates and stock markets simultaneously. Gavin (1989) provides a macroeconomic framework that shows how both financial variables interact, and how both markets react to changes in interest rates, output, and, in particular, to anticipated and unanticipated changes of monetary and fiscal policy. Table 1 illustrates channels of influence. Employing the European/German case, we see that monetary expansions (contractions) of the central bank would lead to both positive (negative) stock returns on the one hand, and positive (negative) DEM/$ movements on the other hand, because the Euro depreciates (appreciates). Thus, the correlation between both market returns would be positive. In case of a fiscal expansion, however, the correlation would be negative, when we start from the reasonable

[4] Recent exceptions are provided by Glaum et al. (1998), and in some German written studies by Müller (1998), Entorf and Kabbalakes (1998), Entorf (2000), Jamin (1999), and Schieszl (2000).

assumption that, in general, fiscal expansion is considered as „good news“ for short-run output fluctuations.

Table 1: Monetary and fiscal policy changes, and their impact on the correlation between stock market returns and exchange-rate movements

	Stock prices	Exchange rates
Monetary Expansion	Falling interest rates → lowering user costs of capital → rising stock prices	(i) falling interest rates → increasing capital exports → depreciation (ii) increasing prices on the goods market → depreciation
Fiscal Expansion	(i) Increasing output → rising profits → rising stock prices („good news“) *) (ii) Increasing interest rates → higher user costs of capital → decreasing stock prices („bad news“)	Rise of interest rates → increasing capital imports → appreciation

*) In general, fiscal expansion is considered as „good news“ for short-run output fluctuations.

Thus, to disentangle the partial impact stemming from exchange-rate fluctuations, it is necessary to control for other disturbing macroeconomic influences. A well known strategy to achieve this aim is the use of “Arbitrage Pricing Theory” (APT), pioneered by Ross (1976). According to the APT, the variation of stock returns is explained by a K-factor model of the form

(2) $$r = \mu + B f_K + \varepsilon$$

where r is the vector of returns of N stock prices, μ is the vector of expected returns of the N securities, f_K is a vector of realisations of K factors, including exchange-rate fluctuations, B a NxK matrix of factor sensitivities of the N securities to the K factors, and ε is the vector of error terms of the N securities. The vector of expected returns can be decomposed into

(3) $$\mu = \lambda_0 + B \lambda_K \; ,$$

where λ_0 is the risk-free rate, and λ_K is the vector of risk premia for the K factors. Thus, estimating APT-models allows for the joint determination of factor sensitivities, with special interest in the coefficients representing exchange rate exposures, i.e. in the reaction of single assets to exchange rate movements, and of risk premia, which reveal whether investors have to be compensated by a higher expected return because the exchange rate risk or other risks are not diversifiable.

Substituting equation (3) into equation (2), rearranging terms and observing variables as times series results in

(4) $$r_t = \lambda_0 + B(\lambda_K + f_{Kt}) + \varepsilon_t .$$

The APT model, presented in equation (4), is a system of seemingly unrelated non-linear regressions with (N-1)K cross-equations restrictions (imposing that the $\lambda's$ are the same for each of the N securities). In our study, it is estimated using the ITNLSUR (Iterated Non-linear Seemingly Unrelated Regressions) technique developed by Burmeister and McElroy (1988).

Our sample of stocks includes 28 leading German corporations comprising the DAX (the leading index of the Frankfurt stock exchange) on the 31st of March 1995.[5] They represent about 70 % of total turnover in German stocks during the sample period.[6] Monthly returns for the period from April 1977 through March 1995 are adjusted for dividends and capital increases and splits according to adjustment factors obtained from KKMDB, i.e the German Karlsruhe data base for financial time series ("Karlsruher Kapitalmarktdatenbank") in order to obtain total returns of the assets.[7]

Before estimating the model, macroeconomic risk factors have to be selected. According to the "Discounted Cash Flow Model", which assumes that prices of assets are determined through their expected discounted dividend payments, factors have to be selected that are potentially responsible for the determination of these payments. For our investigations, we use a survey indicator of the German business climate, the inflation rate, the term struc-

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[5] VIAG and Henkel had to be excluded as their returns are not available for the whole estimation period.

[6] See Sauer, A. (1994), p. 102.

[7] KKMDB was supported by the German National Science Foundation (DFG, Deutsche Forschungsgemeinschaft) to provide a scientific use file of German stock prices and performance indices. For further information see http://finance.wiwi.uni-karlsruhe.de/Forschung/kkmdb.html.

ture, a (residual) market factor, and, in particular, the U.S.-Dollar. These factors are similar to those proposed by Chen et al. (1986), who pioneered the macroeconomic variables approach of estimating the APT. Since only unexpected components of macroeconomic time series can influence asset returns in efficient capital markets, we calculate unexpected variation applying ARMA- and ARIMA-filtering techniques. To isolate the effect of exchange-rate returns from the general market factor, we follow the procedure suggested by McElroy and Burmeister (1988). They draw attention to the fact that the market return has to be orthogonalized with respect to the explanatory macroeconomic variables in order to capture the (residual) market risk that is not explained by other systematic risk factors. Therefore we include the residual market factor that is represented by the residuals of an OLS-regression of the market return on the unexpected components of macroeconomic variables.

In detail, macroeconomic risks are based on the following variables:

- Business climate: Monthly change rate of the “ifo business climate” (“ifo-Geschaeftsklimaindex”), an acknowledged leading indicator of the German business cycle published by ifo institute (Munich).
- Inflation: Monthly change rate of the German consumer price index (“Lebenshaltungskostenindex”) calculated by the German Statistical Office (Statistisches Bundesamt, Wiesbaden).
- Term structure: Difference between the 10-year rate on German government bonds and the 1-month money market rate, both calculated by the Deutsche Bundesbank (Frankfurt).
- Residual market factor: This variable is estimated on the basis of the DAFOX (“Deutscher Aktien-Forschungs-Index”), a broad German stock market index generated for scientific research purposes, obtained from the KKMDB data base. DAFOX is a Laspeyres performance index including all stocks traded at Frankfurt stock exchange. It is a generally acknowledged substitute for the overall German stock market portfolio.
- US-dollar: Growth rate of the closing price of the US-dollar at the Frankfurt foreign exchange market.

After separating the total estimation period into four subperiods, 04/77 – 12/79, 01/80 – 12/85, 1/86 – 12/90 and 01/91 – 03/95, estimation results reveal that the exposure to exchange-rate risk is not constant over time. The sensitivity of DAX stock returns with respect to Dollar returns is documented in Table 2. During the first period 04/77 – 12/79, the relationship is mostly positive, but only four of all t-values are above 1.96. The sign of the Dollar exposure turns negative during the second period 01/80 – 12/85, where 22 of all 28 factor sensitivities are significant at the 5 % level. The period coincided with the second oil shock and a sharply rising dollar, which led to increasing input costs of the German economy. The prospect of high prices for foreign inputs seemed to have a negative impact on German stock prices.

Again the sign reverses to a positive association during the third and fourth period from 01/86 – 12/90 and 01/91 – 03/95, respectively. Out of 28 factor sensitivities, 26 are positive and 10 are significant during the third period, whereas in the fourth period even all 28 coefficients are positive, out of which 12 are significant. The rising German trade surplus from the mid-eighties on (see Figure 3 in Section 4) might have let exporters more strongly profit from a rising dollar.

The estimates of the remaining factor sensitivities and of risk premia are displayed in the Appendix. Table A1 displays estimated factor sensitivities for the business climate variable. They, too, turn out to be unstable depending on the time period under consideration. During the first period from 04/77 – 12/79, the relationship turns out to be negative, which is counterintuitive since an improved business climate should result in improved expectations of firm profits. The sign is positive throughout the remaining estimation periods. Results for the inflation variable are shown in Table A2. During the first three periods, signs of factor sensitivities are negative. This might imply, contrary to the Fisher hypothesis, that investors expect a negative impact of increasing money depreciation on firm profits. The relationship becomes positive in the fourth period from 01/91 – 03/95, when 26 of the 28 estimated factor sensitivities are significant on the 5 % level.

Table 2: Company-specific Dollar exchange rate exposures based on APT-modelling

	04/77-12/79	01/80-12/85	01/86-12/90	01/91-03/95
Allianz	-0.004606 (-0.072073)	-0.118845 (-2.942663)	0.058385 (0.664388)	0.164780 (1.734495)
BASF	0.102862 (1.392689)	-0.107094 (-3.800522)	0.048737 (0.590938)	0.280191 (3.094935)
Bayer	0.096361 (1.408947)	-0.097310 (-4.259209)	0.027313 (0.346880)	0.142051 (1.640058)
BMW	0.027181 (0.257188)	-0.060796 (-1.580642)	0.188607 (1.661649)	0.334268 (2.759314)
Bayer. Vereinsbank	0.257188 (0.271493)	-0.079241 (-2.750427)	0.158728 (2.005301)	0.158847 (1.767028)
Commerzbank	0.110512 (1.593226)	-0.205454 (-5.073234)	0.250561 (2.932397)	0.031369 (0.400595)
Continental	-0.278017 (-1.721159)	-0.109992 (-2.186452)	0.373449 (2.358318)	0.285933 (1.860148)
Daimler-Benz	0.001972 (0.029095)	-0.117528 (-3.271778)	0.310095 (3.261456)	0.515357 (5.566667)
Degussa	0.195366 (2.651987)	-0.094757 (-2.705430)	0.420750 (3.488749)	0.386453 (3.412070)
Deutsche Bank	0.064943 (1.061435)	-0.144234 (-4.775309)	0.277771 (2.954908)	0.124914 (1.806802)
Dresdner Bank	0.145019 (2.437319)	-0.195016 (-4.933935)	0.129032 (1.617576)	0.012332 (0.164029)
Deutsche Babcock	0.039512 (0.409046)	-0.131928 (-2.375848)	0.332366 (2.390498)	0.249980 (1.773243)
Hoechst	0.123310 (1.497804)	-0.110131 (-4.744283)	-0.043001 (-0.471778)	0.268596 (2.855792)
Hypobank	0.032789 (0.426645)	-0.072864 (-1.682275)	0.292017 (3.511323)	0.055338 (0.682146)
Karstadt	0.178303 (1.412288)	-0.056928 (-1.149292)	0.253886 (1.757769)	0.377474 (3.214940)
Kaufhof	0.258629 (2.069859)	-0.065819 (-1.531888)	0.418875 (3.094912)	0.214490 (1.681324)
Linde	0.014598 (0.164061)	-0.101333 (-3.547084)	0.146101 (1.808238)	0.367441 (4.378376)
Lufthansa	0.173477 (1.007329)	0.054114 (0.865635)	0.014847 (0.113544)	0.267151 (1.391007)
MAN	0.093140 (-1.081803)	-0.179159 (-4.410100)	0.014636 (0.106041)	0.660426 (5.583742)
Mannesmann	0.022406 (0.212827)	-0.120999 (-3.443393)	0.056997 (0.416643)	0.432408 (3.618515)
Metallgesellschaft	-0.008916 (-0.072916)	-0.106816 (-2.477040)	-0.025510 (-0.179936)	0.228537 (0.971785)
Preussag	-0.035825 (-0.242432)	-0.070974 (-1.375417)	0.286024 (1.857735)	0.555758 (4.091376)
RWE	0.121377 (1.369300)	-0.059607 (-2.030123)	0.145243 (1.178403)	0.110953 (1.359883)
Schering	0.282589 (0.0129)	-0.112220 (-3.127653)	0.044985 (0.402639)	0.184105 (1.536119)
Siemens	0.155162 (2.985798)	-0.080959 (-3.212608)	0.214002 (2.297772)	0.277545 (3.965073)
Thyssen	0.213323 (1.903968)	-0.111529 (-2.541879)	0.024964 (0.219229)	0.465127 (3.752378)
VEBA	0.089848 (0.816545)	-0.074557 (-2.496618)	0.129873 (1.462866)	0.124495 (1.507106)
VW	0.067549 (7.113015)	-0.171268 (-3.474283)	0.138990 (1.272088)	0.189876 (1.361675)

Notes: Estimation of APT factor sensitivities based on model (2) to (4). t-statistics in parentheses.

Table A3 shows the results for the term structure variable. Throughout all estimation periods the relationship between changes in the term structure and stock returns is negative. The sensitivity becomes even stronger over time: the number of companies with significant factor sensitivities increases from 7 in 04/77 – 12/79 to 24 in 01/91 – 03/95. This result is in accordance with the rational expectations hypothesis of the term structure, as an increase in the term structure implies the expectation of increasing future interest rates, and therefore a heavier discounting of future profits. Table A4, finally, displays parameter estimates for the residual market factor. All estimated coefficients are positive and highly significant. As expected, the market return covers the most important influence of individual asset returns.During the first period from 04/77 – 12/79, the risk premia for the business climate, inflation, the term structure and the Dollar are significant at the 95 % level (see Table A5) which implies that these risks are not diversifiable, and therefore investors have to be compensated with a higher expected return for bearing these risks. During the second period from 01/80 – 12/85, only the dollar and the residual market risk are significant. The third period from 01/86 – 12/90 shows inflation to be significant, whereas in the fourth period none remains significant. This might reflect the increasing efficiency of markets, where due to the global integration of financial markets and sophisticated derivative instruments more and more risks can be hedged, such that the exchange rate risk is not priced.

However, as already stressed in the introduction to this study, the main purpose of estimating an APT model is not to see whether macroeconomic risks are priced, but to isolate exchange rate exposure and to test its stability. The obvious result is that the exposure to Dollar movements are statistically significant and time-variant.

3. Analysing factors of time-varying exchange rate exposure: A new econometric rolling-panel approach

Most applications of exchange rate exposure models are based on two-step procedures, pioneered by the work of Jorion, 1990. In the first step, by running N time series regressions, the stock returns of a sample of N companies are regressed on the exchange rate (the Dollar). Step 2 consists of regressing the exchange rate (Dollar) exposure (i.e., the slope parameter of the first step) on indicators of foreign involvement. Jorion (1990), for instance, employs the ratio of foreign to total sales:

(5) $$r_{it} = \alpha_i + \beta_i \; d_t + \varepsilon_{it} \;, \quad i = 1,\ldots,N, \; t = 1,\ldots,T$$
$$\beta_i = \gamma_0 + \gamma_1 X_i + \upsilon_i \;, \; i = 1,\ldots,N.$$

Econometric problems arise, because estimated exposures are based on common samples, such that they are not i.i.d and υ_i ´s are correlated. In our estimations (see below), that makes use of pooled cross-sectional information, we propose to tackle this problem by applying the method of "seeming unrelated regressions" (SUR), which takes the correlation between different υ_i´s into account. Jorion (1990) has proposed a second alternative procedure that was also applied by Bodnar, Gentry (1993) in a similar fashion. Jorion suggests to insert the dollar exposure in the first equation :

(6) $$r_{it} = \alpha_i + \gamma_{0i} \, d_t + \gamma_{1i} X_i \, d_t + \varepsilon_{it}$$

Expected signs look as follows:

(7) $$\frac{\partial r}{\partial d} = \gamma_0 + \gamma_1 X \begin{cases} > 0, \; if \; X > 0 \Rightarrow \gamma_0 > 0, & \gamma_1 > 0 \\ < 0, \; if \; X < 0 \Rightarrow \gamma_0 < 0, & \gamma_1 < 0 \end{cases}$$

The advantage of the one-step procedure is its higher efficiency because time series and cross-sectional information can be used in a GLS framework, for instance. The disadvantage, however, lies in the fact that cross terms might suffer from the problem of both multicollinearity of both explanatory variables and from difficult interpretation. Now the dollar exposure is no longer just the regression coefficient, but it depends on the level of foreign activities, and more than one estimated parameter is involved to calculate it, as can be seen from equation (7). This leads to potential ambiguities and misinterpretations which make this alternative less appealing. These disadvantages have let us to stick with the traditional two-step procedure, though in a modified and more efficient way.

Some should be taken into account that would allow some improvement compared to the conventional approach.

- First, it should be possible to include the panel information X_{it} instead of the cross-sectional information X_i (as is the case in equation (5)).
- Second, currency exposure is not stable over time but depends on current knowledge of market participants. Beliefs and expectations, however, do not depend on the whole history of financial markets, but rather depend on limited information sets, as can be seen from our time-variant exposure estimates in Section 2 and other examples of unstable coefficient estimates on CAPM and APT modelling in the literature (see, for in-

stance, De Santis and Gérard, 1998, for time varying currency risks in an international asset pricing model). Thus, estimations should be time-variant, and they should give much more weight on recent observations.

- Third, financial time series are available as high frequency data, whereas covariates from non-financial markets such as indicators of foreign involvement X_{it} are not. Nevertheless, high frequency data should be used in a more disaggregate, non-averaged way , in order to avoid loss of information.
- Fourth, simultaneity matters. This might not be the case when single companies are considered, since for them it can be argued that any movement of the Dollar is exogenous. However, when exchange rate exposures are estimated for the whole economy, as we intend to do in our paper, then macroeconomic theory has taught us that third factors might influence the correlation between exchange rates and equity returns. Thus, as a matter of fact, the direction of causation is unclear, such that it might be preferable to consider a correlated instead of a causal relationship, as was already suggested by Adler and Dumas (1984).

We proceed by performing the following modified two-step procedure. In step I, $\beta_{it}, i = 1, ..., N$, i.e. firm-specific and time-variant exchange rate exposures are estimated. We do so by running rolling regressions:

STEP I:

(8) $$r_{ij} = \alpha_{it} + \beta_{it} d_j + \varepsilon_{ij}, \quad i = 1, ..., N$$
$$j = t - \tau + 1, \; t - \tau + 2, \; ... \; , t - 1, \; t$$
$$t = \tau + 1, \; \tau + 2, ... \; , T,$$

where τ represents the size of the rolling window, and T is the number of total time series observations. Based on the APT multi-factor model, the extended multivariate estimation of the exchange rate exposure looks as follows, where the exchange rate is measured by the unanticipated residual from ARIMA-modelling (see Section 2.2), and where f includes all (unanticipated) factors (incl. the residual market factor) except the exchange rate factor, which is represented by d_j^u:

(8') $$r_{ij} = \alpha_i + \beta_{it} d_j^u + b'_{it} f_t + \varepsilon_{ij}$$

In order to achieve overall (macro) estimates of the currency exposure, β_{it} can be restricted to be identical to β_t for all $i = 1, ..., N$ by using rolling-GLS (SUR) or rolling-panel estimation techniques:

(9) $$r_{ij} = \alpha_i + \beta_t d_j + \varepsilon_{ij}$$

A restricted rolling multi-factor version needs to be changed accordingly:

(9') $$r_{ij} = \alpha_i + \beta_t d_j^u + b'_t f_t + \varepsilon_{ij} .$$

In step 2, we analyse the relationship between exchange rate exposures and foreign involvement. Exposure and its determinants can be identified using both firm-specific and time-specific information. Moreover, cross-correlated residuals can be accounted for by estimation of seemingly unrelated regressions (SUR):

STEP II:

(10) $$\beta_{it} = \gamma_{0i} + \gamma_{1i} X_{it} + \upsilon_{it} , \quad i = 1,..., N , \quad t = 1,..., T$$

$$\text{var}(\upsilon) = (\sigma_{ij}) \otimes I_T$$

SUR is (asymptotically) efficient under the assumption of given exchange rate exposures that are known up to random measurement errors, and these residuals are allowed to have a non-zero contemporaneous covariance, for instance due to unanticipated shocks that hit all corporations simultaneously (in form of general crashes, for instance).

Overall macroeconomic estimates can be achieved by restricted SUR or panel estimation:

(11) $$\beta_{it} = \gamma_{i0} + \gamma_1 X_{it} + \varepsilon_{it}$$

Applied estimation has to take account of data restrictions, because only limited information is available at the firm level, particularly when high frequency data would be needed. Nevertheless, we are still able to identify the impact from different regimes of foreign involvement by relating exchange rate exposures to aggregated trade activities, available from macroeconomic foreign trade statistics:

(12) $$\beta_{it} = \gamma_{0i} + \gamma_{1i} X_t + \upsilon_{it} , \quad \text{or} \quad \beta_{it} = \gamma_{0i} + \gamma_1 X_t + \upsilon_{it} .$$

Does the modified two-step procedure meet the requirements described above? First, the approach has the potential to go beyond the conventional cross-sectional approach by incorporating panel information, though information on both firm and time in X_{it} is not available in the present paper. Second, unstable relationships and limited information sets are taken into account by the proposed moving window procedure. Third, the potential of high frequency data can be saved because exchange rate exposures are estimated in the step by exclusively focusing on financial data. According to the fourth requirement, macroeconomic influences are now considered in STEP I, see equation (8') and (9'). As regards correlation versus causation, we provide additional empirical evidence based on t-values on estimated Dollar exposures of the bivariate regressions (8) and (9). Here, t-statistics, i.e. $\hat{\beta} / (\hat{\sigma}_{\beta})$, which can be interpreted as exposure estimates weighted by their importance in terms of estimated standard errors, have the wanted effect of not depending on the choice of the left-hand side variable, i.e., the same t-value would arise if we take the Dollar as dependent variable and the stock return as explanatory variable, as can be shown easily. Calculation of the rolling t-value from equation (8) gives:

$$t_t = \sqrt{\frac{R_t^2 \, (\tau - 2)}{(1 - R_t^2)}} \; , \; R_t^2 = \frac{S_{rdt}^2}{S_{rrt} \, S_{ddt}}$$

where

$$S_{rdt} = \sum_{j = t-\tau+1}^{t} (r_j - \bar{r}_t)\,(d_j - \bar{d}_t), \qquad \bar{d}_t = \frac{1}{\tau} \sum_{j = t-\tau+1}^{t} d_j \, , \; \bar{r}_t = \frac{1}{\tau} \sum_{j = t-\tau+1}^{t} r_j$$

$$S_{rrt} = \sum_{j = t-\tau+1}^{t} (r_j - \bar{r}_t)^2, \qquad S_{ddt} = \sum_{j = t-\tau+1}^{t} (d_j - \bar{d}_t)^2$$

The proof follows directly from the symmetry of involved variances and covariances.

4. Results from rolling panel regressions

4.1. Results, STEP I

The (unconditional) Adler-Dumas Dollar exposure is not constant over time, as can be seen from Table 3, which provides GLS (panel) estimates of equation (9) for different time periods. The estimate is significantly negative until 1985, and turns out to be significantly positive thereafter. For the total period, the Dollar exposure is positive and significant, but the estimate is only about 0.097, which is much lower than the estimated absolute values from the sub-samples.

Table 3: Estimation of Dollar exposure using fixed-company effects

	Dependent variable: r_{it}, measured in:				
	1974-1995	1974-1979	1980-1985	1986-1989	1991-1995
d_t	0.097 (4.0)	-0.269 (6.2)	-0.257 (7.4)	0.484 (8.1)	0.358 (9.1)
$\overline{R}^2$	0.0001	0.0092	0.0197	0.0250	0.0330
BFN-DW	1.92	1.97	2.09	1.84	2.12

Notes: Sample: Monthly observations from 28 DAX corporations of the period 1974:02 – 1995:03 (7112 observations). Estimates include company-specific constants and consider company-specific heteroskedasticity under the assumption that residuals are contemporaneously uncorrelated. Estimates are based on FGLS with variances estimated from a first-stage pooled OLS regression. In parentheses: t-values based on White's (1980) heteroskedasticity consistent covariance matrix. BFN-DW: Panel-DW statistic (Bhargava, Franzini and Narendranathan, 1982).

According to the procedure described in equation (8), the complete picture emerges from Figure 1, which shows the Dollar exposure of all 28 companies over time. The window size, τ , is chosen at 48 months. The estimated coefficient of each rolling regression period is displayed at the time of the midterm period, more precisely at $t - \tau / 2$, where t is the final observation of the moving window estimation. Two preliminary observations are in order: a) Dollar exposures are rather unstable over time, b) the majority of firm-specific exposures is rather low in the 80s and quite high in the 90s. Going deeper into details, we observe that for energy oriented corporations like VEBA and RWE rather strong negative exposures are estimated for the beginning of the eighties, i.e. at the time of the second oil crisis, when high invoices for imported oil had to be paid, whereas in case of the more export oriented car-producers exposures are quite high at the time of a low Dollar and high export shares, i.e. at the end of the 80s and the beginning of the 90s (see DAIMLER, for instance).

In Figure 2, these observations are confirmed by inspecting the results from rolling regressions, in which the Dollar exposure is restricted to be the same across all companies (B_BIV, see equation (9)). The time series from these estimates is depicted in Figure 2. Figure 2 also displays results according to equation (9'), i.e. the (conditional) coefficient on the DM/$ returns in a multivariate framework (B_APT). As before, estimated β_{it} are displayed at time $t - \tau / 2.$ Movements are less pronounced than in the bivariate (unconditional) case, but general tendencies keep the same. In the aftermath of both oil price shocks 1975/76 and 1981/82, estimates of the Dollar exposure are negative, suggesting that a further increase of the DM/$ was "bad news" to expected profits of German companies because of suspected rising input costs, in particular due to more expensive oil imports. These concerns were reinforced by the prevailing Dollar price level, which was quite high in the beginning of the 80's and still rising until 1985 (and quickly falling thereafter as a consequence of the Plaza agreement , see Figure 3).

These situations contrast sharply with the end of the 80's and the beginning of the 90's, when Germany's trade structure has become strongly export oriented, backed by a weak Dollar (see Figure 3). In situations like this, a rise of the DM/$ is good news to the German economy, because the car industry and other export-oriented industries driving the German economy are expected to benefit from the more favourable terms of trade. In fact, the estimate of the Dollar exposure turns out to be positive since 1987.

Figure 1: Dollar exposure of DAX corporations

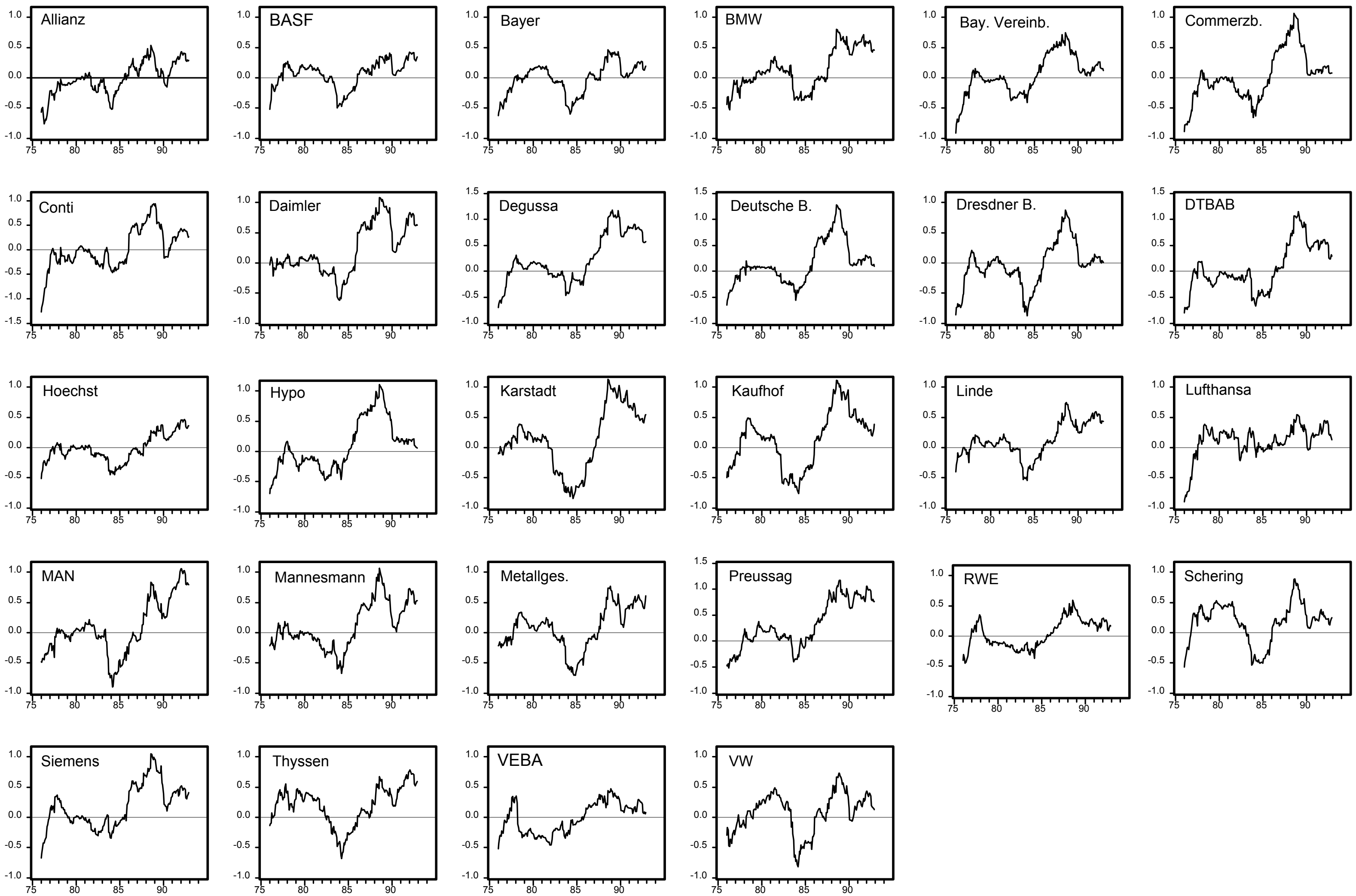
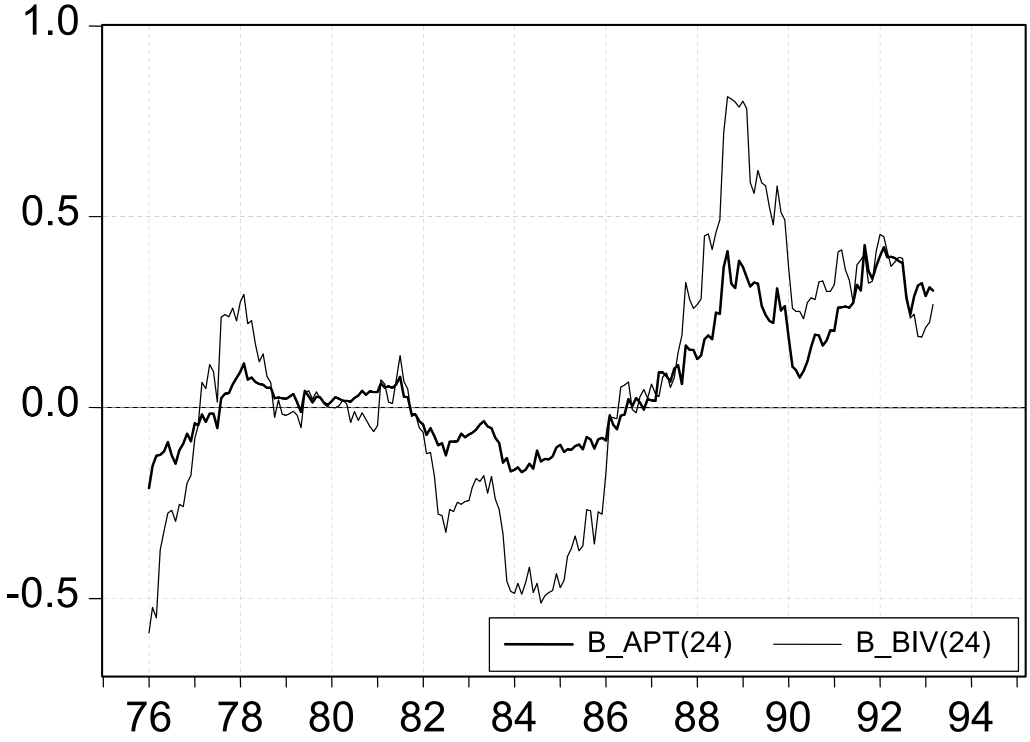
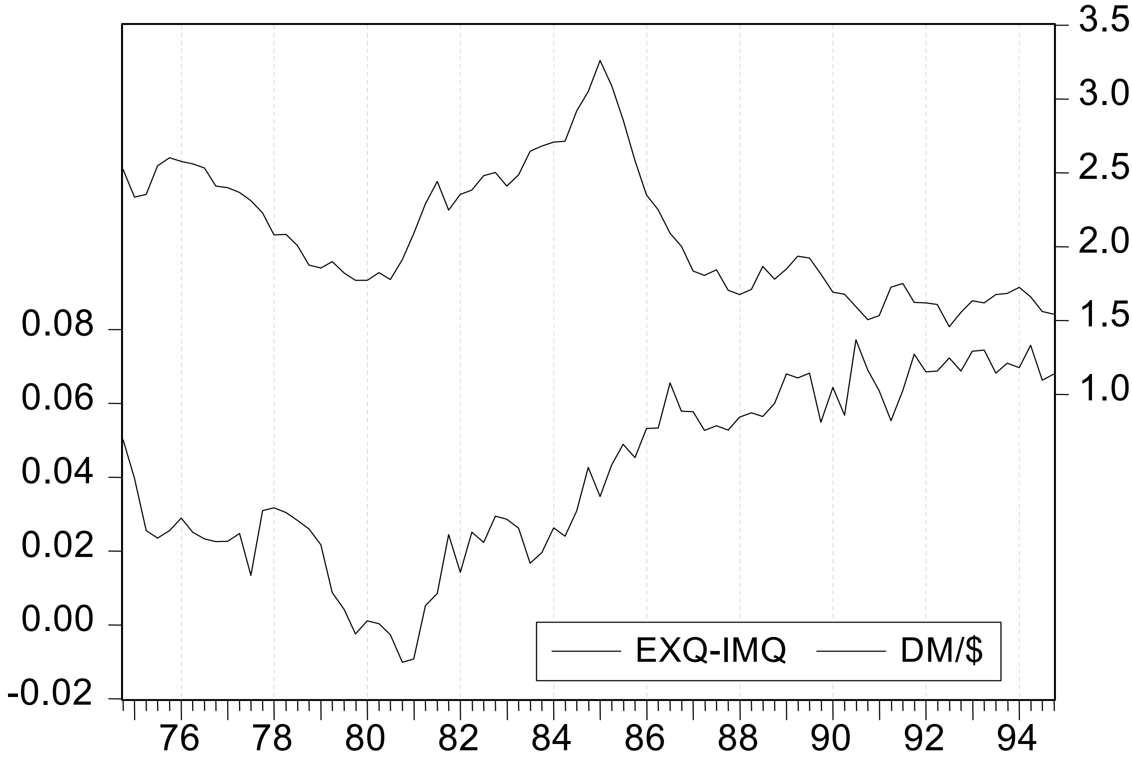


Figure 2: Conditional and unconditional Dollar exposure



Note: See the text for further details

Figure 3: The Dollar and the German net export ratio



Note: left scale: export share - import share, right scale: DM/$

4.2. Results, STEP II

Our observations based on Figures 1 and 2 suggest to assess the influence of trade as well as of the level of the Dollar rate on the exchange rate exposure. Table 4, showing unrestricted results in the sense of equation (12), confirms previous suppositions: 1) the higher is the DM/$ level, the lower is the Dollar exposure; 2) the higher is the export ratio, the higher is the Dollar exposure (24 out of 28 companies reveal a positive sign); 3) the higher is the import share, the lower is the Dollar exposure (21 out of 28 companies show a negative sign).

Restricted results (assuming identical parameters for all firms) are presented in Table 5. They confirm in a more compact way what has already been found in Table 4. As further checks of robustness, we have measured the Dollar exposure as a t-value (i.e. the t-value on the Dollar return) and we used the difference between the export share and import share as explanatory variable, in order to dispel potential concerns about multicollinearity. All results confirm previous findings.

Table 6, finally, makes use of β_t (instead of β_{it}) according to equation (9'). Since β_t as well as explanatory variables could not unambiguously distinguished from nonstationary time series by consulting standard unit root tests, a test of cointegration has been performed. We use a test based on the ECM framework. Banerjee et al. (1998) have published critical values and have shown the good statistical power of this test. Since trade variables have been available only at a quarterly basis, monthly data had to be transformed to a quarterly frequency. Table 6 presents results for "merging the last observation" and for "merging by averaging". Long-run parameters, which are the relevant parameters here, turn out to be robust, and confirm our results found in Table 4 and Table 5. The ECM parameter γ is negative, and rejects the null of non-cointegration in 3 out of 4 cases.

Table 4: Dollar exposure of 28 DAX corporations as a linear function of export ratio EXQ, import ratio IMQ, and DM/$ exchange rate

Dependent Variable: β_{it} (Dollar Exposure)

Variable	Coefficient	St. Error	t-Statistic	Prob.
DM / $				
ALLIANZ	-0.307	0.052	-5.849	0.0000
BASF	-0.395	0.038	-10.341	0.0000
BAYER	-0.461	0.046	-10.105	0.0000
BMW	-0.554	0.047	-11.892	0.0000
BV	-0.242	0.070	-3.451	0.0006
COBA	-0.398	0.088	-4.497	0.0000
CONTI	-0.417	0.083	-5.019	0.0000
DAIMLER	-0.472	0.068	-6.943	0.0000
DEGUSSA	-0.667	0.062	-10.796	0.0000
DEUTSCHE	-0.348	0.089	-3.929	0.0001
DREBA	-0.456	0.081	-5.633	0.0000
DTBAB	-0.584	0.079	-7.424	0.0000
HOECHST	-0.395	0.033	-12.045	0.0000
HYPO	-0.178	0.086	-2.070	0.0386
KARSTADT	-0.889	0.080	-11.050	0.0000
KAUFHOF	-0.722	0.079	-9.168	0.0000
LINDE	-0.452	0.042	-10.808	0.0000
LUFT	-0.305	0.061	-5.021	0.0000
MAN	-0.771	0.058	-13.230	0.0000
MANNES	-0.392	0.063	-6.248	0.0000
METALLGES	-0.653	0.057	-11.542	0.0000
PREUSSAG	-0.620	0.053	-11.790	0.0000
RWE	-0.194	0.041	-4.702	0.0000
SCHERING	-0.601	0.064	-9.431	0.0000
SIEMENS	-0.273	0.065	-4.200	0.0000
THYSSEN	-0.603	0.059	-10.260	0.0000
VEBA	-0.047	0.044	-1.073	0.2833
VW	-0.593	0.070	-8.450	0.0000

Table 4 (continued), dependent Variable: β_{it} (Dollar Exposure)

Variable	Coefficient	St. Error	t-Statistic	Prob.
EXQ				
ALLIANZ	4.098	0.960	4.267	0.0000
BASF	0.448	0.700	0.640	0.5222
BAYER	-0.041	0.836	-0.050	0.9605
BMW	3.347	0.853	3.924	0.0001
BV	6.541	1.286	5.085	0.0000
COBA	7.046	1.621	4.348	0.0000
CONTI	6.842	1.521	4.498	0.0000
DAIMLER	9.203	1.246	7.384	0.0000
DEGUSSA	8.285	1.132	7.322	0.0000
DEUTSCHE	7.260	1.623	4.474	0.0000
DREBA	3.534	1.483	2.383	0.0173
DTBAB	7.738	1.441	5.370	0.0000
HOECHST	2.150	0.601	3.578	0.0004
HYPO	10.754	1.573	6.835	0.0000
KARSTADT	3.721	1.474	2.524	0.0117
KAUFHOF	4.625	1.443	3.204	0.0014
LINDE	3.794	0.766	4.955	0.0000
LUFT	0.359	1.111	0.323	0.7468
MAN	4.957	1.067	4.644	0.0000
MANNES	8.760	1.150	7.615	0.0000
METALLGES	1.394	1.036	1.346	0.1785
PREUSSAG	8.860	0.963	9.197	0.0000
RWE	5.798	0.756	7.668	0.0000
SCHERING	-3.250	1.167	-2.784	0.0054
SIEMENS	8.594	1.191	7.213	0.0000
THYSSEN	-0.314	1.076	-0.292	0.7705
VEBA	8.312	0.808	10.293	0.0000
VW	-1.495	1.285	-1.630	0.2450

Table 4 (continued), dependent Variable: β_{it} (Dollar Exposure)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
IMQ				
ALLIANZ	-1.528	1.355	-1.127	0.2598
BASF	-0.049	0.987	-0.050	0.9602
BAYER	1.785	1.180	1.513	0.1305
BMW	1.248	1.204	1.037	0.2999
BV	-7.472	1.815	-4.116	0.0000
COBA	-8.700	2.287	-3.804	0.0001
CONTI	-5.821	2.147	-2.712	0.0068
DAIMLER	-10.350	1.759	-5.885	0.0000
DEGUSSA	-5.491	1.597	-3.439	0.0006
DEUTSCHE	-9.995	2.290	-4.364	0.0000
DREBA	-5.106	2.093	-2.439	0.0148
DTBAB	-6.414	2.034	-3.154	0.0016
HOECHST	0.016	0.848	0.019	0.9848
HYPO	-13.784	2.220	-6.208	0.0000
KARSTADT	-5.138	2.080	-2.470	0.0136
KAUFHOF	-7.515	2.037	-3.689	0.0002
LINDE	-2.687	1.080	-2.487	0.0130
LUFT	2.487	1.568	1.586	0.1128
MAN	-0.296	1.506	-0.196	0.8445
MANNES	-10.603	1.623	-6.532	0.0000
METALLGES	-0.482	1.462	-0.330	0.7415
PREUSSAG	-4.279	1.359	-3.147	0.0017
RWE	-7.788	1.067	-7.299	0.0000
SCHERING	1.939	1.647	1.177	0.2394
SIEMENS	-11.031	1.681	-6.561	0.0000
THYSSEN	0.612	1.518	0.403	0.6869
VEBA	-10.888	1.140	-9.554	0.0000
VW	3.795	1.813	2.093	0.0365

Variable	Coefficient		
Fixed Effects			
ALLIANZ	-0.246		
BASF	0.777		
BAYER	0.478		
BMW	-0.121		
BV	0.584		
COBA	1.080		
CONTI	0.368		
DAIMLER	1.192		
DEGUSSA	0.561		
DEUTSCHE	1.399		
DREBA	1.248		
DTBAB	0.653		
HOECHST	0.132		
HYPO	0.929		
KARSTADT	2.281		
KAUFHOF	2.317		
LINDE	0.621		
LUFT	-0.064		
MAN	0.204		
MANNES	1.145		
METALLGES	1.154		
PREUSSAG	-0.000		
RWE	0.795		
SCHERING	1.951		
SIEMENS	1.138		
THYSSEN	1.407		
VEBA	0.509		
VW	0.742		
R-squared	0.672	Mean dependent var	0.104
Adjusted R-squared	0.652	S.D. dependent var	0.368
S.E. of regression	0.217	Sum squared resid	84.621
Log likelihood	2621.246	F-statistic	51.07627
		Prob(F-statistic)	0.000000

Notes: Sample: Quarterly observations from 28 DAX corporations of the period 1976:i – 1992.iv (1904 observations). Monthly observations are transformed to quarterly observations by merging last observations. Endogenous dollar exposures have been shifted to the centre of their moving window (four years), i.e. they enter the estimation as (t+8). Results are based on restricted SUR-estimation.

Table 5: Dollar exposure of 28 DAX corporations as a linear function of export ratio EXQ, import ratio IMQ, and DM/$ exchange rate; restricted parameters

	Indicator of Dollar exposure					
	β_{it}	t_{it}	β_{it}	β_{it}	β_{it}^*	t_{it}^*
Constant or FE	FE	FE	0.54 (4.7)	FE	FE	FE
EXQ	4.7 (11.1)	13.2 (9.3)	4.7 (11.1)	-	4.5 (12.1)	12.0 (9.7)
IMQ	-3.7 (6.1)	-10.1 (5.0)	-3.7 (6.1)	-	-3.4 (6.6)	-9.2 (5.2)
EXQ-IMQ	-	-	-	4.8 (11.2)	-	-
DM / $	-0.43 (18.2)	-1.48 (19.0)	-0.43 (18.2)	-0.42 (17.7)	-0.45 (22.3)	-1.55 (23.0)
$\overline{R}^2$	0.553	0.560	0.506	0.556	0.559	0.562
Restriction re-jected?	-	-	yes	Yes	-	-

Notes: SUR estimation based on quarterly observations from 28 DAX corporations of the period 1976:i – 1992.iv (1904 observations). Monthly observations are transformed to quarterly observations by merging last observations; in case of β_{it}^* and t_{it}^*: frequency conversion by averaging monthly observations. Endogenous dollar exposures have been shifted to the centre of their moving window (four years), i.e. they enter the estimation as (t+8). FE="fixed effects".

Table 6: Aggregate Dollar exposure as a linear function of export ratio EXQ, import ratio IMQ, and DM/$ exchange rate; ECM-t-Ratio test of cointegration

	$\Delta\beta_t = c - \gamma(\beta_{t-1} - \alpha' x_{t-1}) + \delta \Delta x_{t-1}$			
	moving window size: 4 years			
	„merge last observation“		„merge by averaging“	
constant	0.18 (2.3)	0.16 (3.1)	0.11 (2.7)	0.12 (2.7)
γ	0.31 (3.9)	0.33 (4.1)	0.24 (3.4)	0.23 (3.7)
	long-run parameters (α)			
EXQ	3.7 (4.0)	-	3.1 (3.3)	-
IMQ	-4.1 (2.9)	-	-3.0 (2.0)	-
EXQ-IMQ	-	3.5 (4.2)	-	3.2 (2.9)
Dollar	-0.25 (5.2)	-0.25 (5.7)	-0.25 (4.8)	-0.25 (4.8)
	short-run parameters (δ)			
Δ Dollar $_{-1}$	0.10 (2.0)	-	-	-
$\Delta\beta_{-1}$	0.10 (2.1)	0.11 (0.9)	0.21 (1.8)	0.21 (1.8)
$\bar{R}^2$	0.162	0.167	0.140	0.154
DW	1.81	1.99	2.10	2.10
Restriction rejected?	-	no	-	no
Crit. Val. 5%	3.82	3.57	3.82	3.57
Crit. Val. 1%	4.59	4.29	4.59	4.29
ECM-t-Ratio	3.9*	4.1*	3.4	3.7*

Notes: ECM cointegration test (Banerjee et al., 1998); sample period: quarterly observations of the period 1976:i – 1992.iv (68 observations. Endogenous dollar exposures have been shifted to the centre of their moving window (four years), i.e. they enter the estimation as (t+8). *) Significant at the 5%-level.

6. Conclusions

According to many financial market analysts, there should be a negative correlation between German stock market returns and returns of the Euro/$ exchange rate, respectively there should have been a positive correlation between German stock market returns and corresponding values of the former DM/$ rate. The supposition is based on Germany's export strength, such that any depreciation of the German/European currency would mean good news to German companies.

In this paper, we have tried to shed some light on the Dollar exposure of German DAX corporations. We have estimated several econometric specifications grounded on a time-variant, APT-based extension of the exchange-rate exposure model in the tradition of Adler and Dumas (1980, 1984) and Jorion (1990). Our stock market data consist of 28 performance indices of German DAX corporations. We include macroeconomic risk factors, and data on export and import involvement, and we perform econometric panel, GLS, SUR and cointegration techniques. Dollar exposures turn out to differ between exporters and importers and they are rather unstable over time. While currency exposures are significantly negative at the beginning of the 80's, they change their sign in the late 80's and early 90's. The negative correlation seems to be a result of the second oil shock and a sharply rising dollar, which have induced increasing import costs. The prospect of increasing prices for foreign inputs apparently had a negative impact on stock prices. The positive association reflects the rising German trade surplus from the mid-eighties on which has let exporters more strongly profit from a rising dollar.

Thus, in contrast to most previous studies in the literature that find little evidence of exposure, we confirm results of Dominguez and Tesar (2001) who report that higher foreign involvement corresponds to higher exposure at least in Germany. Our additional finding suggests that exposure also depends on the prevailing level of the Dollar exchange rate.

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Appendix

Table A1: APT-modelling: Sensitivity to "business climate"

	04/77-12/79	01/80-12/85	01/86-12/90	01/91-03/95
Allianz	-0.037808 (-6.056247)	0.000218 (0.045478)	0.021181 (4.084276)	-0.006400 (-1.444770)
BASF	-0.005132 (-0.711987)	0.002656 (0.805184)	0.004328 (0.889396)	-0.001976 (-0.468190)
Bayer	-0.004052 (-0.605755)	0.002304 (0.849288)	0.006864 (1.476547)	0.009234 (2.286698)
BMW	-0.014307 (-1.386800)	0.001587 (0.345780)	0.004833 (0.720741)	0.008975 (1.589014)
Bayer. Vereinsbank	-0.025602 (-2.934911)	0.003283 (0.960529)	0.016096 (3.447230)	0.001252 (0.298751)
Commerzbank	-0.015109 (-2.226771)	0.006609 (1.474257)	0.012667 (2.513174)	0.002861 (0.783602)
Continental	-0.007681 (-0.484700)	0.008637 (1.444075)	0.006474 (0.693160)	0.005449 (0.760279)
Daimler-Benz	-0.009903 (-1.495731)	0.006638 (1.801508)	0.014661 (2.612782)	0.012636 (2.927361)
Degussa	-0.006621 (-0.921201)	-0.000336 (-0.081165)	0.007978 (1.119602)	-0.004601 (-0.871308)
Deutsche Bank	-0.019420 (-3.257705)	0.005730 (1.634590)	0.016151 (2.910664)	-0.001223 (-0.379376)
Dresdner Bank	-0.011780 (-2.032117)	0.006789 (1.622943)	0.016005 (3.398943)	-0.001254 (-0.357835)
Deutsche Babcock	-0.030232 (-3.200422)	0.004803 (0.828826)	0.002618 (0.319059)	-0.001999 (-0.304095)
Hoechst	-0.005126 (-0.636510)	0.004315 (1.608288)	0.010924 (2.030225)	0.000769 (0.175424)
Hypobank	-0.016391 (-2.187269)	0.009554 (1.978922)	0.016238 (3.309445)	0.001263 (0.334045)
Karstadt	0.001428 (0.115808)	0.007744 (-1.370526)	-0.005823 (-0.682933)	-0.006999 (-1.278536)
Kaufhof	-0.006487 (-0.532033)	0.003558 (0.702268)	-0.008106 (-1.013207)	-0.000389 (-0.065383)
Linde	-0.041523 (-4.760518)	-0.000727 (-0.223464)	0.014549 (3.053431)	-0.003222 (-0.823440)
Lufthansa	-0.004446 (-0.264911)	0.008045 (1.408628)	0.011969 (1.551473)	0.003101 (0.346309)
MAN	-0.028979 (-3.433244)	0.004086 (0.004086)	0.019093 (2.345312)	0.009400 (1.704461)
Mannesmann	-0.004473 (-0.433193)	0.007888 (1.874838)	0.021195 (2.625758)	0.011987 (2.151401)
Metallgesellschaft	-0.037678 (-3.158826)	0.006883 (1.357734)	0.023443 (2.801088)	0.012182 (1.110943)
Preussag	-0.030627 (-2.127880)	0.009652 (-1.677105)	0.030164 (3.313558)	0.004824 (0.761658)
RWE	-0.017358 (-2.003099)	0.003106 (0.900312)	0.002794 (0.383519)	-0.008914 (-2.343336)
Schering	0.011166 (1.007141)	-0.007572 (-2.106714)	0.011055 (1.676620)	0.004586 (0.820756)
Siemens	-0.019537 (-3.840200)	0.003608 (1.316164)	0.021165 (3.852693)	-0.000591 (-0.181074)
Thyssen	0.005684 (0.517758)	0.006568 (1.230938)	0.009752 (1.451967)	0.019680 (3.405292)
VEBA	-0.041710 (-3.862136)	0.008074 (2.300695)	0.010177 (1.943665)	-0.001006 (-0.261166)
VW	-0.021309 (-1.885862)	0.011574 (2.089541)	0.016514 (2.559311)	0.016235 (2.497194)

Notes: APT factor sensitivities estimated using the procedure described in chapter 2, eqn. (2) – (4). t-statistics in parentheses.

Table A2: APT-modelling: Sensitivity to inflation

	04/77-12/79	01/80-12/85	01/86-12/90	01/91-03/95
Allianz	-2.562619 (-1.139575)	-4.207588 (-1.628070)	-1.704562 (-0.569462)	8.391110 (5.945107)
BASF	-4.912299 (-1.892373)	-0.112472 (-0.063093)	-1.950335 (-0.697900)	5.096868 (4.629656)
Bayer	-7.863918 (-3.262143)	-2.760371 (-1.883117)	-4.986297 (-1.834363)	2.698319 (2.367297)
BMW	-5.972126 (-1.607506)	-3.622408 (-1.461138)	-2.215328 (-0.556279)	4.025023 (2.679085)
Bayer. Vereinsbank	-3.952464 (-1.258992)	-3.698605 (-2.002566)	-4.127887 (-1.549807)	5.346297 (4.480344)
Commerzbank	-1.168826 (-0.478019)	-2.636571 (-1.087116)	-3.399644 (-1.185620)	4.667351 (4.302154)
Continental	-1.284306 (-0.224682)	-4.559430 (-1.410883)	-3.180366 (-0.599250)	3.995226 (2.059594)
Daimler-Benz	-7.732466 (-3.242119)	1.470096 (0.736288)	-9.678805 (-2.984303)	4.403909 (3.201607)
Degussa	-4.043052 (-1.562409)	-1.070851 (-0.478368)	-1.168919 (-0.274179)	5.490750 (3.836988)
Deutsche Bank	-2.907208 (-1.355014)	-2.816861 (-1.486504)	-5.645212 (-1.748574)	5.844345 (5.968609)
Dresdner Bank	-6.179998 (-2.961972)	-4.888743 (-2.158048)	-0.371073 (-0.135466)	5.499666 (5.138584)
Deutsche Babcock	2.979087 (0.875206)	5.863190 (-1.867910)	-3.235105 (-0.682355)	9.020569 (4.986530)
Hoechst	-6.159668 (-2.122340)	-2.162964 (-1.491359)	-3.976949 (-1.269849)	5.178930 (4.645982)
Hypobank	-2.372182 (-0.879327)	-5.932031 (-2.271468)	-6.104263 (-2.173483)	5.891808 (5.086090)
Karstadt	-13.45788 (-3.031070)	-4.446943 (-1.455499)	1.774349 (0.356633)	3.443173 (1.986493)
Kaufhof	-14.48828 (-3.299988)	-4.705350 (-1.718676)	2.777547 (0.573227)	6.288466 (3.199158)
Linde	1.585603 (0.504115)	-0.577846 (-0.328579)	-0.100556 (-0.037343)	5.663656 (4.695808)
Lufthansa	-5.768072 (-0.954945)	-11.44680 (-3.687992)	-2.027017 (-0.458797)	4.662036 (2.051522)
MAN	3.096887 (1.017408)	-1.514339 (-0.630077)	-1.208915 (-0.261523)	3.865769 (2.181367)
Mannesmann	-8.400767 (-2.255851)	-1.813177 (-0.797682)	-2.183424 (-0.471031)	4.327588 (2.890596)
Metallgesellschaft	-0.985271 (-0.229420)	-0.045272 (-0.016525)	6.744132 (1.382826)	8.474352 (2.156620)
Preussag	-9.504113 (-1.834855)	-1.352553 (-0.434453)	7.917035 (1.429599)	2.889504 (1.574442)
RWE	2.696646 (0.863697)	-3.051313 (-1.636452)	4.649981 (1.062894)	5.776350 (5.279105)
Schering	-7.622816 (-1.908382)	-2.357077 (-1.209594)	1.483030 (0.389091)	3.102239 (2.232727)
Siemens	-1.576070 (-0.859439)	-5.425008 (-3.656648)	-3.597979 (-1.150874)	4.906491 (5.570770)
Thyssen	-7.038219 (-1.778059)	-2.709193 (-0.939999)	-0.645119 (-0.169050)	2.931726 (1.777640)
VEBA	-7.491346 (-1.922802)	-0.745175 (-0.392919)	0.109741 (0.037038)	3.978945 (3.548902)
VW	-7.979597 (-1.959804)	-2.865680 (-0.956542)	-8.711869 (-2.291628)	5.047158 (2.733066)

Notes: APT factor sensitivities estimated using the procedure described in chapter 2, eqn. (2) – (4). t-statistics in parentheses.

Table A3: APT-modelling: Sensitivity to the term structure

	04/77-12/79	01/80-12/85	01/86-12/90	01/91-03/95
Allianz	-1.310459 (-1.496661)	-1.865668 (-1.929210)	-5.194704 (-4.186206)	-11.21016 (-5.682718)
BASF	-2.493986 (-2.465395)	-1.382845 (-2.073604)	-2.687058 (-0.697900)	-5.716532 (-3.047428)
Bayer	-1.720128 (-1.834820)	-1.425935 (-2.599502)	-3.579248 (-3.213612)	-3.871451 (-2.155605)
BMW	-0.035953 (-0.024837)	-0.781879 (-0.842697)	-2.077894 (-1.291402)	-6.203242 (-2.470894)
Bayer. Vereinsbank	0.000175 (0.000143)	-1.078173 (-1.560005)	-5.054664 (-4.529271)	-9.380692 (-5.032006)
Commerzbank	-1.243738 (-1.308050)	-2.015278 (-2.224031)	-4.855552 (-4.031853)	-6.141989 (-3.780611)
Continental	-0.113345 (-0.051133)	-1.965694 (-1.625420)	-2.765700 (-1.239373)	-9.265576 (-2.908140)
Daimler-Benz	1.604563 (1.728175)	-0.112589 (-0.151227)	-5.540447 (-4.125930)	-7.973133 (-4.147560)
Degussa	-2.238007 (-2.218434)	-0.328849 (-0.392597)	-0.890473 (-0.520332)	-5.619599 (-2.393759)
Deutsche Bank	-1.389460 (-1.659128)	-2.460347 (-3.471291)	-6.412475 (-4.825724)	-7.961788 (-5.549343)
Dresdner Bank	-1.661779 (-2.040478)	-2.866052 (-3.390079)	-5.353727 (-4.748004)	-6.362636 (-4.077856)
Deutsche Babcock	-1.332694 (-1.006578)	0.851955 (0.727553)	-2.215563 (-1.128327)	-9.517714 (-3.256764)
Hoechst	-3.564580 (-3.158524)	-1.907696 (-3.517035)	-1.747473 (-1.356203)	-5.578516 (-2.863149)
Hypobank	0.266294 (0.253076)	-0.742870 (-0.761225)	-5.386441 (-4.591753)	-8.030865 (-4.769906)
Karstadt	-2.710569 (-1.567269)	0.062974 (0.055129)	-4.231178 (-2.071556)	0.210493 (0.086345)
Kaufhof	-1.501035 (-0.877160)	-1.142507 (-1.115338)	-5.259155 (-2.733600)	2.398557 (0.905022)
Linde	0.100381 (0.082232)	-0.654978 (-0.996179)	-3.079640 (-2.706637)	-4.707531 (-2.702560)
Lufthansa	-3.284558 (-1.393325)	-0.485598 (-0.421118)	-1.727243 (-0.936413)	-11.35674 (-2.854502)
MAN	0.088553 (0.074969)	-1.822918 (-2.030669)	-4.536211 (-2.332409)	-9.506939 (-3.870534)
Mannesmann	-2.265588 (-1.568356)	-0.879254 (-1.033497)	-5.869965 (-3.040740)	-6.841233 (-2.762225)
Metallgesellschaft	-0.755498 (-0.451207)	0.115980 (0.113152)	-0.576691 (-0.287698)	1.473586 (0.301249)
Preussag	0.512858 (0.253587)	-1.175943 (-1.010799)	0.361665 (0.165143)	-4.946992 (-1.755849)
RWE	-2.417548 (-1.990042)	-1.010799 (-0.487107)	-5.434959 (-3.105762)	-4.622722 (-2.731842)
Schering	-2.732853 (-1.758058)	-2.516609 (-3.465858)	-4.760925 (-3.017140)	-5.537031 (-2.230555)
Siemens	-2.571130 (-3.608229)	-0.487401 (-0.879681)	-3.753835 (-2.859607)	-5.235493 (-3.608663)
Thyssen	-4.257975 (-2.770621)	-1.050679 (-0.973698)	-2.546323 (-1.586835)	-7.144126 (-2.779178)
VEBA	-0.212407 (-0.140644)	-0.170052 (-0.239664)	-1.944063 (-1.554711)	-4.757537 (-2.776617)
VW	2.111389 (1.333219)	-3.391726 (-3.029085)	-3.424896 (-2.213706)	-5.757580 (-1.991120)

Notes: APT factor sensitivities estimated using the procedure described in chapter 2, eqn. (2) – (4). t-statistics in parentheses.

Table A4: APT-modelling: Sensitivity to the residual market factor

	04/77-12/79	01/80-12/85	01/86-12/90	01/91-03/95
Allianz	0.871771 (5.492081)	1.452645 (9.854710)	1.277198 (14.69842)	1.279106 (9.497071)
BASF	0.712715 (3.883372)	0.910422 (8.950020)	0.843724 (10.34569)	1.130005 (8.836085)
Bayer	1.113212 (6.557257)	1.003411 (12.00269)	0.876608 (11.26068)	0.909046 (7.420565)
BMW	1.761988 (6.709928)	1.034157 (7.315605)	1.308202 (11.65904)	1.286657 (7.516651)
Bayer. Vereinsbank	0.979477 (4.397832)	0.894315 (8.490150)	1.103114 (14.09278)	0.966817 (7.602904)
Commerzbank	1.120024 (6.505246)	1.523373 (10.98139)	0.980945 (11.60897)	0.932421 (8.411159)
Continental	1.771611 (4.424896)	1.199462 (6.508466)	0.753869 (4.813959)	0.732019 (3.369332)
Daimler-Benz	0.994767 (5.910958)	1.323645 (11.54794)	1.300288 (13.83105)	1.307453 (9.961587)
Degussa	0.874055 (4.773869)	0.961320 (7.528789)	0.859478 (7.209689)	1.229109 (7.677863)
Deutsche Bank	0.848008 (5.573159)	1.360653 (12.57888)	1.064982 (11.45839)	0.981337 (10.02222)
Dresdner Bank	0.713554 (4.822291)	1.513640 (11.65724)	1.137031 (14.41664)	0.884119 (8.302374)
Deutsche Babcock	1.055325 (4.400920)	1.164041 (6.465452)	1.020927 (7.426159)	1.557132 (7.812853)
Hoechst	0.823543 (4.030127)	1.010502 (12.20360)	0.777655 (8.629285)	1.185061 (8.922982)
Hypobank	0.972797 (5.091741)	1.033099 (6.918197)	1.113213 (13.53643)	1.023140 (8.903657)
Karstadt	0.989688 (3.155409)	0.707287 (4.052545)	0.977536 (6.845279)	0.891425 (5.356067)
Kaufhof	1.438526 (4.632716)	0.775753 (4.967023)	0.880914 (6.585420)	1.536207 (8.486964)
Linde	1.309768 (5.936082)	0.978386 (9.738289)	0.977718 (12.23581)	1.169388 (9.835662)
Lufthansa	1.146274 (2.676625)	0.637749 (3.555675)	1.081031 (8.360482)	0.974309 (3.592708)
MAN	1.535757 (7.194000)	1.163776 (8.460785)	1.118500 (8.194385)	1.162344 (6.930601)
Mannesmann	1.528651 (5.857201)	1.100323 (8.490648)	1.154220 (8.532539)	1.330889 (7.880702)
Metallgesellschaft	1.755691 (5.777079)	0.819809 (5.244904)	1.287927 (9.188124)	1.665545 (4.981233)
Preussag	1.180039 (3.210572)	0.942932 (5.296979)	1.150227 (7.559103)	1.133981 (5.899637)
RWE	0.670998 (3.048751)	0.625544 (5.880106)	0.825636 (6.777041)	1.005281 (8.708476)
Schering	1.223797 (4.344750)	1.103938 (9.856036)	0.958472 (8.676193)	0.822194 (4.859684)
Siemens	0.899957 (6.979635)	1.212563 (14.27769)	1.194540 (12.96975)	1.046331 (10.57656)
Thyssen	1.389852 (5.001628)	1.075179 (6.547216)	1.025764 (9.109022)	1.263599 (7.206072)
VEBA	0.332112 (1.217957)	0.802119 (7.413012)	0.813405 (9.264314)	0.915546 (7.831997)
VW	2.040186 (7.113015)	1.279086 (7.469244)	1.312754 (12.15317)	1.296567 (6.573379)

Notes: APT factor sensitivities estimated using the procedure described in chapter 2, eqn. (2) – (4). t-statistics in parentheses.

Table A5: APT-modelling: estimated risk premia

	04/77-12/79	01/80-12/85	01/86-12/90	01/91-03/95	04/77-3/95
Business climate	-0.213603 (-3.424870)	0.108629 (0.224226)	-0.003178 (-0.015727)	-0.977582 (-0.855645)	-0.006482 (-0.775972)
Inflation	0.001246 (6.022274)	0.001719 (1.230012)	0.001387 (3.298397)	-0.009511 (-1.128937)	-0.000182 (-0.293946)
Interest rate term structure	0.001694 (2.660712)	-0.003828 (-1.490610)	-0.001016 (-0.861853)	-0.001968 (-0.999591)	-0.002098 (-1.823590)
Dollar	0.033745 (3.262461)	0.235939 (2.306820)	-0.002807 (-0.250563)	-0.042578 (-0.907591)	0.038019 (2.327922)
Residual market factor	0.001876 (1.137838)	0.038074 (3.538150)	-0.000541 (-0.108985)	0.049311 (1.217405)	0.002529 (1.105950)

Notes: APT risk premia estimated using the procedure described in chapter 2, eqn. (2) – (4). t-statistics in parentheses.