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The dollar and the German stock market: determination of exposure to and pricing of exchange rate risk using APT-modelling

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The dollar and the German stock market: determination of exposure to and pricing of exchange rate risk using APT-modelling

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Summary: We estimate the impact of dollar changes on the value of German DAX corporations, using APT-modelling for the period 1977 - 1995. Several macroeconomic risk factors, including the dollar and a residual market factor representing the general market risk, are specified. The general notion is that the export-oriented German companies should benefit from increasing dollar values. We find time-varying dollar exposure presumably depending on the prevailing trade regime. Dollar sensitivity is positive as expected in periods with a positive trade balance, whereas it turns negative in periods with a negative trade balance (e.g., in the first half of the 1980s). APT-modelling simultaneously considers exchange rate exposure and risk-premia of macroeconomic risk factors, the latter also being unstable over time.

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1. Introduction

It is generally assumed that there is a negative correlation between the German stock market and the euro/$ exchange rate, as is revealed by financial press headlines.[1] According to conventional wisdom, the German economy is strongly export oriented and therefore usually benefits from a strong dollar as dollar-denominated export revenues rise. Therefore, there should be a measurable currency exposure of the German stock market.

Currently there is only limited evidence on the currency exposure of German companies. Entorf and Kabbalakes (1998), analysing DAFOX sector stock indices, detected significant positive exposure for certain industries such as chemicals, motor cars and machinery, steel production and holdings, suggesting that exposure is mainly driven by exporting activities. Bartram (2002) identifies linear as well as non-linear components of exchange rate exposure. Entorf and Jamin (2003), using rolling-regression techniques, find time-varying exchange rate exposure which depends positively on the ratio exports/GDP and negatively on the ratio imports/GDP, thus supporting the assumed impact of foreign trade on currency exposure, and the deviation of the exchange rate from its long-run median level.

This paper complements the aforementioned papers by addressing the issue of exchange rate exposure of German companies using APT modeling. APT, pioneered by Ross (1976), allows for answering two questions: First, what is the exposure of a company to changes of the exchange rate? Exchange rate exposure is usually defined as the change of the value of the firm in response to exchange rate fluctuations (see Adler and Dumas, 1984) and therefore corresponds to the factor sensitivity estimated in APT models. Second, is the exchange rate risk significantly priced in the market, i.e., do investors demand a higher expected rate of return on stocks with a high exchange rate exposure? We examine 28 large German companies comprising the DAX, the leading stock index of the Frankfurt stock exchange over a period from 1977 - 1995. This time period excludes the turbulences in the aftermath of the breakup of the Bretton Woods system as well as potential rebalancing of currency holdings by investors in expectation of the advent of the euro, the common European currency, in 1999.

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[1] See e.g., Süddeutsche Zeitung 6th of October, 2003: "Duisenberg fears too quick depreciation of dollar" ("Duisenberg fürchtet zu schnelle Dollar-Abwertung").

The novelty of our approach is to simultaneously consider exchange rate exposure and risk-premia of macroeconomic risk factors. We find time-varying dollar exposure presumably depending on the prevailing trade regime. Dollar sensitivity is positive as expected in periods with a positive trade balance, whereas it turns negative in periods with a negative trade balance (e.g., in the first half of the 1980s). In addition, we also find that risk premia are unstable over time.

This paper is organised as follows. In Section 2, we present our estimation methodology. Section 3 describes our data, whereas Section 4 presents the results. Section 5 offers a brief conclusion.

2. Methodology

The well-known Arbitrage Pricing Theory (APT) developed by Ross (1976) allows for simultaneously examining the impact of several different macroeconomic variables on stock prices. One can therefore disentangle the partial impact stemming from exchange rate fluctuations and of other macroeconomic risk factors in addition to the general market risk.[2] According to the APT, the variation of stock returns is explained by a K-factor model of the form

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

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

(2) $$\mu = \lambda_0 + B \lambda_K \ ,$$

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

[2] The importance of using several macroeconomic risk factors instead of only the dollar and the market risk in order to avoid an omitted variable bias is explained in more detail in Entorf and Jamin (2003).

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 (2) into equation (1), rearranging terms and observing variables as times series results in

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

The APT model, presented in equation (3), 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).

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 structure, a (residual) market factor, and, in particular, the US 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.

A problem with including the market risk in the estimations of equation (3) is that overall market exposure r_m which in empirical studies is represented by broad market indices such as the DAX or the DAFOX, includes several driving factors of which exchange rate risk might be a significant one. Therefore, if stock returns are regressed on macroeconomic variables and on the return of a proxy for the market such as the DAX and the DAFOX results for the macroeconomic variables might be insignificant simply due to the fact that part of the influence is not direct but absorbed by the market proxy. To circumvent this problem, we apply a strategy well known from testing APT. McElroy and Burmeister (1988) introduced the use of the so called "residual market factor" which implies orthogonalization

of overall market risk vis-à-vis the other risk factors to disentangle "pure" market risk besides the other macroeconomic risk factors employed in the estimation. Thus, we estimate an auxiliary OLS regression to capture that particular fraction of aggregate market risk which was induced by exchange rate fluctuations:[3]

(4) $$r_{mt} = a + \beta_m d_t + \varepsilon_{mt}\,.$$

In equation (4), r_{mt} is the return of the DAFOX index as a proxy for the market return, a the regression constant, β_m the sensitivity of the market to changes of the dollar, and d_t the return of the dollar. The residual of the regression ε_{mt} thus represents the residual market factor, i.e. that part of the market return that is not induced by changes of the dollar. r_{mt} is replaced by ε_{mt} in model (3).

3. Data

Our sample of stocks includes 28 leading German corporations comprising the DAX (the leading index of the Frankfurt stock exchange) on 31st March 1995.[4] They represent about 70 % of total turnover in German stocks during the sample period.[5] 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.[6]

- 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).

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[3] This procedure is also used by Entorf and Jamin (2003).

[4] VIAG and Henkel were excluded as their returns are not available for the whole estimation period.

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

[6] 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.

- 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 the 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.

4. Results

First, the total estimation period is divided into four subperiods, 04/77 – 12/79, 01/80 – 12/85, 1/86 – 12/90 and 01/91 – 03/95. This division is motivated by the intended separation of different macroeconomic environments of the German economy. The situation of the first period 1977 - 1979 is characterized by an appreciation of the Deutsche Mark which can be seen in figure 1 in the appendix. The next period 1980 - 1985 is predominated by the second oil price shock and the recession in 1981/82 and a significant depreciation of the Deutsche Mark. After the so-called Plaza Agreement reached in September 1985 by the G-5 countries (France, Japan, West Germany, UK and USA) on a need to adjust the dollar exchange rate, the time span 1986 - 1990 was characterized by a strongly depreciating dollar. The final period, 1991 - 1995, contains the period following German unification with a relatively stable but low DM/dollar rate.[7]

[7] The periods coincide with those chosen by Entorf and Jamin (2003).

Table 1: 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 (1) to (3). t-statistics in parentheses.

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 1. 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, of which 12 are significant. Also, the absolute value of the coefficient is higher in the fourth period in comparison to the third. The rising German trade surplus from the mid-eighties on (see Figure A1 in the appendix) might have let exporters more strongly profit from a rising dollar. These results confirm those of Entorf and Jamin (2003) who, using rolling-window estimation techniques, find time-varying dollar exposure which is negative in the first half of the eighties.

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 at the 5 % level.

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. Apparently, risk premiums are unstable over time, and therefore one might question the validity of APT modeling in detecting the impact of macroeconomic risk factors on stock prices. However, as was 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 as well as to compare the results to studies using different methodologies such as e.g. Entorf and Jamin (2003). The obvious result is that the exposure to dollar movements are statistically significant and time-variant which confirms the findings of the other studies referred to in the introduction.

5. Conclusion

According to many financial market analysts, there should have been a negative correlation between German stock market returns and the former DM/$ rate. After the introduction of the common European currency, the euro, the same should apply to the euro/$ rate. This supposition is based on Germany's export strength, such that any depreciation of the German/European currency would mean good news to German companies.

This article tries to shed some light on the dollar exposure of German DAX companies by using APT modeling. We have estimated an APT specification using five different macroeconomic risk factors including the return of the dollar and a residual market factor representing the general market risk not covered by the other risk factors. Separating the period from 1977 - 1995 into four sub-periods, we find a time-varying dollar exposure. While currency exposures are significantly negative at the beginning of the 80s, they change their sign in the late 80s and early 90s. Therefore, we confirm similar results of Entorf and Jamin (2003), who also find time-varying dollar exposure with negative sign in the first half of the 80s using rolling-window estimation techniques.

The novelty of our approach is to simultaneously consider exchange rate exposure and risk-premia of macroeconomic risk factors. We find that also risk premia are unstable over time.

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Appendix

Figure 1: The Dollar and the German net export ratio

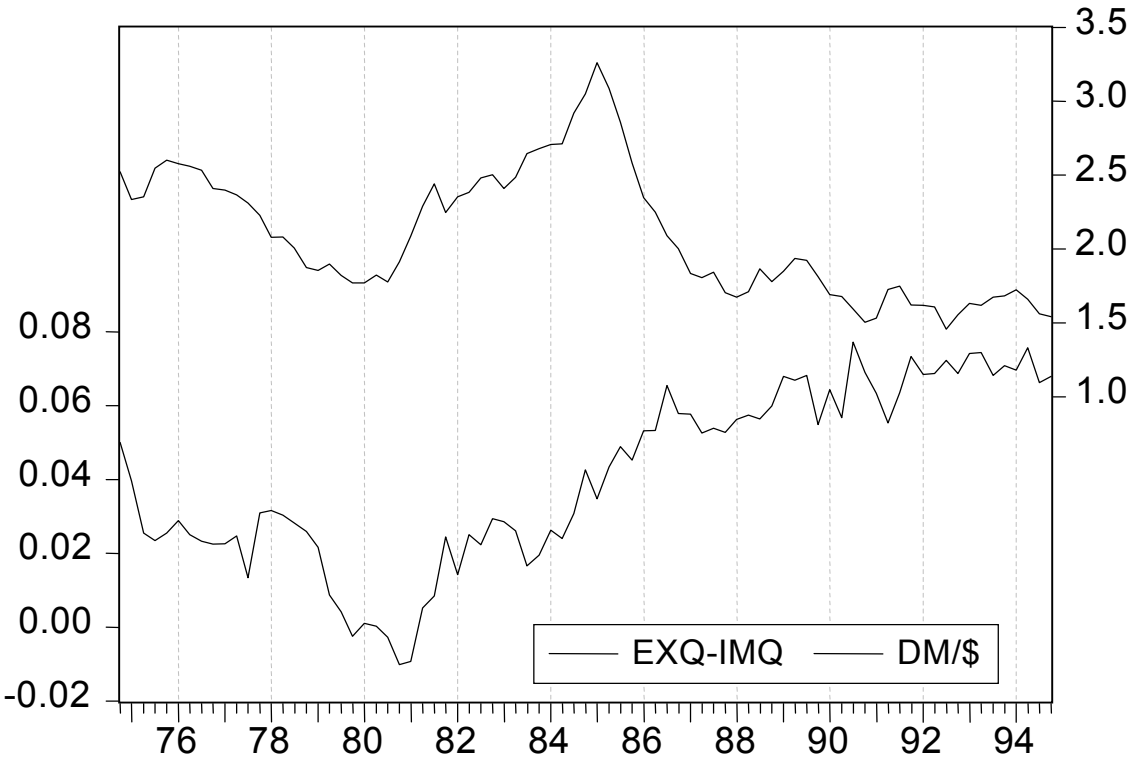

Table A1: APT-modelling: Sensitivity to "business climate"

	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. (1) – (3). 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. (1) – (3). 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. (1) – (3). 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. (1) – (3). t-statistics in parentheses.

Table A5: APT-modelling: APT risk premiums

	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. (1) – (3). t-statistics in parentheses.