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Horst Entorf, Jochen Moebert, Katja Sonderhof

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The Foreign Exchange Rate Exposure of Nations*

Horst Entorf[†], Jochen Moebert[⊞], and Katja Sonderhof[‡]

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Abstract

Following the well-known approach by Adler and Dumas (1984), we evaluate the foreign exchange rate exposure of nations. Results based on data from 27 countries show that national foreign exchange rate exposures are significantly related to the current trade balance variables of corresponding economies.

JEL Classification: G15, F31

Keywords: Exchange rate exposure, international trade, current trade balance

Contact details of the authors:

[†]entorf@vwl.tu-darmstadt.de [⊞]moebert@vwl.tu-darmstadt.de [‡]sonderhof@vwl.tu-darmstadt.de

Darmstadt University of Technology, Department of Economics, Marktplatz 15, Residenzschloss, D-64283 Darmstadt, Germany

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1 Introduction

Are stock values of nations vulnerable to exchange rate movements? Standard papers targeting the foreign exchange rate exposure à la Adler and Dumas (1984) are concerned with single firms or industries. We take a new perspective and investigate the foreign exchange rate exposure of nations. This new view contributes to the understanding of currency markets and the dependence of foreign exchange rate exposures on macroeconomic variables.

Adequate tests of exchange rate exposure require international data sets from heterogeneous economic situations. However, evidence from a large cross-section of nations is rare because of the rather limited availability of company-specific data (for notable exceptions, see, for instance, Dominguez and Tesar, 2001, 2006, Rees and Unni, 2005). In particular, the aim of relating individual exposure to foreign trade is difficult as information on company-specific foreign involvement is difficult to obtain. While collecting information on individual sales going to exports might be possible in a sufficient way for many countries, it is almost impossible to find data on firm-specific costs arising from imported goods. However, both exports and imports are driving supply and demand on the currency markets, such that some omitted variable bias might explain some poor results of the relevant literature on exchange rate exposure.

We argue that using aggregate data on a national level for a large set of countries allows us to test exchange rate exposure in a more complete way. While access to firm data is often difficult, expensive, and subject to country and even company-specific peculiarities, macroeconomic times series such as the IFS data base used in this paper are available for a large group of industrialized countries and a long period of time in a standardized way, and the data set has the advantage of including country-specific time series on both exports and imports such that needed cross-sectional and longitudinal heterogeneity of trade regimes has empirical support in the data.

Results based on monthly data from 27 countries mostly ranging from January 1991 to July 2004 confirm the hypothesis according to which exchange rate exposure depends positively on the share of national exports and negatively on the share of imports relative to GDP.

This paper is organised as follows. We first summarize results of previous research. Subsequently, in Section 3 we explain the theoretical foundations on which our approach is based. In the same Section we provide a description of our data set. Research findings are reported in Section 4 and we conclude and offer some additional consideration for further research in the last Section.

2 Previous Research

Most studies have been of limited success in identifying foreign currency exposure. Jorion (1990) analysed the exposure to exchange rates of 287 U.S. multinationals and found that only 15 of them are significantly affected by exchange rates. Bodnar and Gentry (1993), who provided evidence based on industry data for Canada, Japan and the U.S. reported that between 20 and 35 percent of industries have statistically significant exchange rate exposures. He and Ng (1998) investigated the exchange rate exposure of Japanese corporations and found that for the period 1979 to December 1993, only 25 percent of the 171 Japanese multinationals have significant exposure. Dominguez and Tesar (2001) examine the extent of firm and industry-level exposure in a sample of industrialized and developing countries for the period 1980-1999. In the pooled eight-country sample, they found that 23 percent of firms and 40 percent of industries are exposed to at least one of their indicators of exchange rate exposure (US dollar, trade-weighted exchange rate, currency of the country's major trading partner). Koutmos and Martin (2003) analysed exchange rate exposure in nine aggregate sectors of major economies (Germany, Japan, the United Kingdom, and the United States), and confirmed the existence of exposure in approximately 40 percent of the country-sector models. In a recent paper, Rees and Unni (2005) investigate the pre-Euro exposure to exchange rate changes of large firms in the UK, France, and Germany and find that in all three countries exchange rate sensitivity is considerably stronger then previously thought.

Many recent empirical studies focus their research on factors that determine the extent of exposure. An evident 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 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 recent work of He and Ng (1978), Dominguez and Tesar (2001), and Allayannis and Ofek (2001), inter alia. He and Ng (1998) showed that Japanese multinationals with higher exposure levels are related to higher export shares. However, looking at firm-specific international evidence over the years 1994 to 1999, Dominguez and Tesar (2006) concluded that they did 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 companies in Germany, Japan, and UK (Dominguez and Tesar, 2006, Table 5). Entorf and Jamin (2006), using data from German DAX companies, confirm that DEM/USD rates are positively affected by the ratio of exports to GDP and negatively affected by imports to GDP. They further hint at the fact that firms' values and exposures might depend on exchange rate adjustment costs.

3 Country Model and used Data Sets

The estimated country model is the standard regression model introduced by Adler and Dumas (1984). In addition to this model, we use the yield of the world equity index which is orthogonalized relative to the foreign exchange yield for each country.[1] Hence, we estimate for each country i the following equation

$$r_i = \alpha_i + \beta_i sdr_i + \gamma R_W^\circ + \epsilon_i \tag{1}$$

where α is the constant term, β measures the total foreign exchange rate exposure, r is the yield of the equity index, sdr corresponds to the yield of the national currency per special drawing right (SDR), R_W° is the orthogonalized yield of an equity world index, γ is the corresponding coefficient and ϵ is the error term. We assume that foreign exchange rate exposure depends on the importance of international trade for each national economy. Importance of international trade is measured by the export and import quota defined by exports and imports relative to the GDP for each country. The relationship of both variables indicates whether a more export-oriented or more import-oriented country is observed. If the national currency unit (NCU) is depreciated, firms in export-oriented countries earn higher profits since goods sold abroad at a constant price in the national currency are less expensive. This implies a higher demand for exported products such that profits and stock prices rise. Therefore, we expect to measure a foreign exchange rate exposure β greater than zero which positively depends on the size of export quota. For import-oriented countries, the line of reasoning is the same except that the sign is reversed. A

[1] Commonly, the yield of the world index depends on the price of the special drawing right. To capture the aggregate risk of the yield of the world index not induced by exchange rate fluctuations we orthogonalized the yield of the world index. This so-called residual market factor R_W° (McElroy and Burmeister, 1988) is represented by the residual of an auxiliary regression model in which the original R_W is regressed on the price of the special drawing right. Thus, R_W° and sdr_i are stochastically independent.

depreciation leads to higher procurement costs of commodities and reduced profits. Stock returns and the foreign exchange rate exposure are negative. Hence, the higher the imports, the smaller our expected exposure coefficient is. We summarize these considerations in the following hypothesis:

Hypothesis 1 (Exposure) *The Foreign Exchange Exposure measured by* β *depends positively on the share of exports and negatively on the share of imports relative to GDP.*

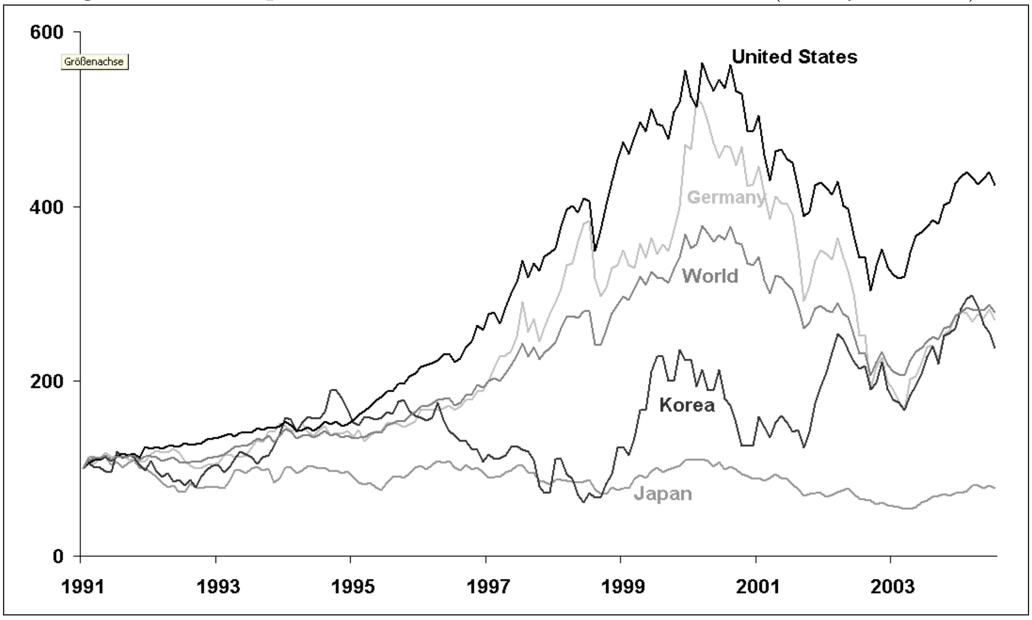
In Section 4 we analyze the foreign exchange exposure of the following 27 countries: Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, Korea, Mexico, the Netherlands, New Zealand, Norway, Poland, Portugal, Singapore, Spain, Sweden, Switzerland, the United Kingdom, and the United States. The chosen countries are considered as the most relevant countries with respect to their economic importance.[2] For the computation of country exposures we used broad stock indices provided by Morgan Stanley Capital International Inc. We used nominal monthly data from 27 national indices as well as the world index. Figure 1 shows the time series performance of various stock indices during the observation period. Most countries experienced sharply rising performance indices, while Japan, for example, performed badly due to its burst stock bubble and other Japan-specific economic difficulties. In general, stock indices developed in a rather heterogeneous way. An investment in Singapore increased the value by a factor of two while in the United States the investment quadruples in nominal values.

To capture dividend effects the data analysis is based on performance indices called "Gross Index (MSCI Local)".[3] For most stock indices observations are

[2] Turkey was not considered due to data problems.

[3] MSCI offers two kind of performance indices: the Gross Index and the Net Index. While the latter "approximates the minimum possible dividend reinvestment" with respect to tax regulations,

Figure 1: Development of stock indices of five countries (base year 1991)



Data Source: Morgan Stanley Capital Indices (MSCI).

available from January 1991 to July 2004. These are 163 monthly observations and we calculated 162 returns for each time series. The series from Poland have been available since December 1992, while the series from the Czech Republic and Hungary commenced in December 1994.

The special drawing rights (SDR) and balance of payment information were taken from the International Financial Statistics (IFS). The SDR is an artificial currency basket constructed by the International Monetary Fund. The SDR basket is especially suited for our purposes since it includes the currencies of the five member countries of the International Monetary Fund with the largest exports of services and goods during the five-year period preceding the revision. The weights of SDR

the former "approximates the maximum possible dividend reinvestment". For exact definitions see MSCI Index Calculation Methodology (July 2005).

Table 1: Weights in % of SDR currency basket

Currency	Jan 2001	Jan 1996	Jan 1991
USD	45	39	40
EUR	29		
DEM		21	21
FRF		11	11
YEN	15	18	17
GBP	11	11	11

Source: International Monetary Fund (2005). The special drawing right (SDR) is a currency basket which consists of the most important global currencies. Its basket is reviewed quinquennially.

are shown in table 1.[4] Currently, these major currencies cover more than 80% of the total foreign exchange turnover worldwide.[5] The next adjustment of the currency weights of the special drawing right took place in January 2006. In 1999, the German mark and the French franc were replaced by the Euro. The IFS data are again available on a monthly basis. The SDR were balanced for 26 of 27 countries. Due to the division of Czechoslovakia the series from the Czech Republic starts in February 1993. Our data set includes 11 of 12 countries which adopted the Euro.[6] After the fixing of the Euro at the beginning of 1999 the foreign exchange yields of the participating countries were zero. The yields of the Greek drachma were fixed in January 2001. Thus, these time series vary relative to other Euro-economies for a longer time span than countries which adopted the Euro at the official settlement day.

If we look upon the correlation between stock returns and foreign exchange returns, the countries in our sample seem to belong to different clusters. Singapore's time series reveals the minimal correlation of -0.478, while Switzerland's correlation

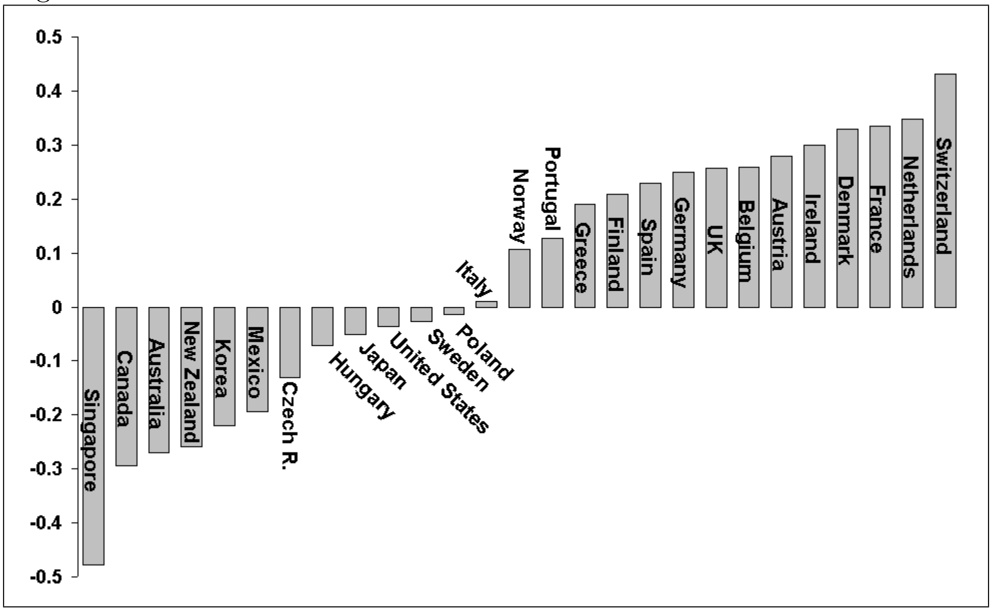
[4] See www.imf.org for further details.

[5] See Triennial Central Bank Survey (2005).

[6] Except Luxembourg which is not part of our data set.

coefficient is maximal and 0.432. The average correlation is 0.063. All values ranked by the size of the correlation coefficient are shown in Figure 2. Obviously stock indices of European countries are more sensitive to foreign exchange changes than other countries in the sample. In Figure 3 we show the development of the national

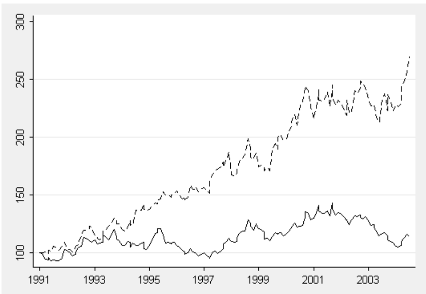
Figure 2: Correlation coefficients of stock and FX returns from 1991 to 2004



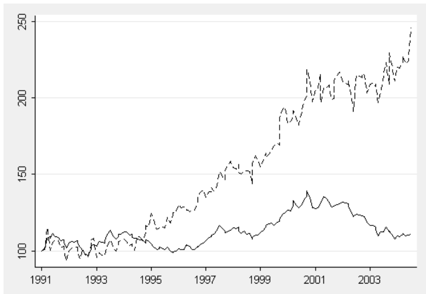
Own Calculations: Countries are shown in ascending order.

currency units relative to the special drawing rights (SDR) and the development of the current trade balance surplus of Australia, Austria, Canada, and Japan from 1991 to mid 2004. Although the scales of the ordinates are different, it seems that in strongly export-oriented countries (in absolute terms) such as Japan both time series are more interrelated than in countries like Australia or Austria which are less involved in international trade. In countries such as Canada, characterized by small exports relative to GDP, both time series seem to be less dependent on each other. These conjectures derived from visual inspection are confirmed by estimated correlations in Figure 3.

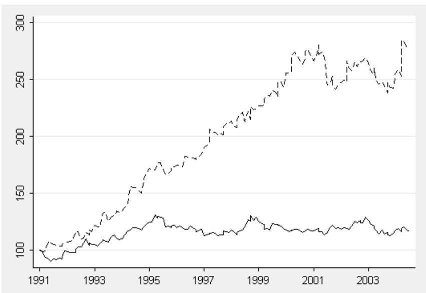
Figure 3: Special Drawing Right and Current Trade Balance (base year 1991)



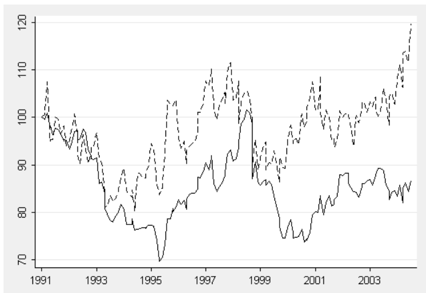
(a) Australia $\rho = 0.591$



(b) Austria $\rho = 0.587$



(c) Canada $\rho = 0.316$



(d) Japan $\rho = 0.669$

—— NCU/SDR - - - - Current Trade Balance Surplus

Own Calculations: ρ = correlation of stock returns and foreign exchange returns.

4 Country-Specific Exchange Rate Exposures

We used Zellner's seemingly unrelated regression (SUR) to calculate foreign exchange exposures.[7] SUR-Estimation results from equation 1 are listed in Table 2. Column (1) shows the foreign exchange rate exposure of all 27 countries included. Column (3) presents the coefficient on the orthogonalized world index[8] while columns (2) and (4) inform about corresponding t-values. It can be seen from Durbin-Watson statistic (DW) that serial correlation causes no estimation problems. Single-equation Breusch-Godfrey autocorrelation tests with 12 lagged residuals performed on all countries show that for Australia and Finland serial correlation statistics were below the 10% but not below the 5% significance level. Test statistics from other countries clearly rejected the presence of autocorrelation. Table 2 shows that for most countries the coefficients of the extended Adler-Dumas model are highly significant. The last column indicates whether the country had a cumulated trade surplus measured in USD during the period from 1991 to 2004. Export-oriented countries such as France, Germany, and Japan had a positive current account, while relatively large and closed economies like Canada and the United States are more import-oriented and have a negative sign. If we compare the signs in column (1) and column (5), only 16 out of 27 observations have the expected sign in both columns, while the other nations have a positive trade balance and a negative exposure or vice versa.

It is important to mention that Singapore is very special since it is the only

[7] Ordinary least squares estimators differ only slightly from system estimators. The sign of the estimator changed only for Hungary and Italy. However, both coefficients are far from being significant in both estimation procedures.

[8] Notice in the SUR the value of the coefficient changes if the orthogonalized world index is excluded, while in the OLS regression both covariates are made independent and therefore the exposure coefficient is the same.

country in the sample where exports exceed GDP. The ratio of exports to GDP was on average 1.488 in Singapore.[9] Also, the import quotient had a similar value which indicates that Singapore is also a reloading point for goods from neighboring countries such as Malaysia or Indonesia. Hence, the results of Singapore might be flawed and we exclude it from the further analysis. Among the nations which have a positive exposure but a negative current account are countries such as Greece, Portugal, and Spain. These nations may be more import-oriented because many high-tech products are manufactured in fully industrialized economies and must be imported. Although the current trade balance is negative for these countries, the positive foreign exchange rate exposures might indicate economies being on the verge of competing with more fully industrialized countries. Current trade balances represent a nation's relative importance in international trade today whereas stock indices anticipate future developments. Thus, any depreciation or appreciation might reflect the reaction of efficient financial markets to tomorrow's possibly export-oriented economies and might therefore be positively related to stock returns.

In the next step we use a simple regression model to explain the national foreign exchange rate exposures documented in column (1) of Table 2 by economic factors. We exclude Singapore from our sample due to its exceptional position described above. Therefore, we are left with 26 observations. The set of possible covariates for these economies is taken from the current balance of the IFS. The current balance can be divided into trade balance, service balance, income balance and transfer balance. For each of these balance sheets export and import data are available. However, the additional information provided by the series is negligible since all series are highly correlated. In particular, export and import values of each subaccount have high correlation coefficients of about 0.9. Hence, from an econometric perspective the

[9] This figure is confirmed by the CIA worldfactbook which reports a ratio of 1.45 for 2004.

Table 2: SUR Estimation - Foreign Exchange Exposure for 27 countries

	(1)	(2)	(3)	(4)	(5)
Country	β	σ_β	R^o_{Welt}	σ_R	CurAcc
Australia	-0.330**	(0.067)	0.634**	(0.057)	-
Austria	0.770**	(0.181)	0.590**	(0.096)	-
Belgium	0.657**	(0.125)	0.814**	(0.071)	+
Canada	-0.604**	(0.095)	0.892**	(0.058)	-
Czech Republic	-0.332^+	(0.193)	0.557**	(0.162)	-
Denmark	0.879**	(0.155)	0.877**	(0.080)	+
Finland	1.020**	(0.232)	1.700**	(0.161)	+
France	0.919**	(0.109)	1.112**	(0.063)	+
Germany	0.742**	(0.140)	1.259**	(0.078)	+
Greece	0.738*	(0.295)	0.949**	(0.168)	-
Hungary	0.094	(0.308)	1.297**	(0.198)	-
Ireland	0.808**	(0.131)	0.970**	(0.075)	+
Italy	-0.052	(0.159)	1.049**	(0.108)	+
Japan	0.054	(0.116)	0.867**	(0.087)	+
Korea	-0.570**	(0.141)	1.031**	(0.189)	+
Mexico	-0.215*	(0.085)	1.133**	(0.137)	-
Netherlands	0.945**	(0.100)	1.088**	(0.056)	+
New Zealand	-0.477**	(0.116)	0.654**	(0.091)	-
Norway	0.187	(0.151)	1.147**	(0.091)	+
Poland	0.378	(0.456)	1.519**	(0.320)	-
Portugal	0.274^+	(0.154)	0.891**	(0.098)	-
Singapore	-2.067**	(0.226)	0.864**	(0.105)	+
Spain	0.324**	(0.115)	1.259**	(0.079)	-
Sweden	0.337**	(0.118)	1.428**	(0.099)	+
Switzerland	0.777**	(0.108)	0.882**	(0.066)	+
UK	0.345*	(0.158)	1.508**	(0.328)	-
USA	0.476**	(0.075)	0.844**	(0.045)	-

$R^2 = 0.310$ $\overline{R}^2 = 0.302$ $DW = 1.950$ $N = 4257$

Own Source: foreign exchange rate exposure β, orthogonalized world index R^o_{Welt}, standard errors $\sigma_.$. 1%, 5%, 10% significance levels are labelled by **, *, $^+$. 'CurrAcc' indicates the sign of the current trade balance in the whole time span: + if exports>imports, – otherwise. $\overline{R}^2$ is the adjusted R^2 and DW is an abbreviation for Durbin-Watson Statistic. N is the number of observations. Our data set is unbalanced. For some countries observations are missed for the first months of our sample.

validation of hypothesis 1 is inappropriate due to high collinearity. We therefore reformulate the hypothesis.

Hypothesis' 1 (Exposure) *The foreign exchange rate exposure measured by β depends positively on the current trade balance surplus.*

Consequently, we summarize the available information within a new variable called current trade balance surplus or current trade balance deficit. This variable is the difference between the sum of exports and the sum of imports of all sub-categories which are part of the current balance. To take into account the importance of international trade we calculate the value of the current trade balance relative to the gross domestic product of the respective economy. For each country $i = 1, ..., 27$ we denote this variable $\Delta CB_i/GDP_i$ and run a simple bivariate regression which uses $\Delta CB_i/GDP_i$ as a regressor:

$$\begin{array}{cclcll} \beta_i & = & 0.3250^{**} & + & 0.0526^{*} & \Delta\; CB_i/GDP_i \\ & & (0.052) & & (0.020) & \end{array} \qquad (2)$$

$N = 26$, $R^2 = 0.156$, $\overline{R}^2 = 0.121$

Significance level: $1\% =^{**}$, $5\% =^{*}$

Heteroscedasticity-robust standard errors are included in parentheses. Both the constant term and the macroeconomic trade variable are highly significant.[10] The result indicates that the higher the current account surplus, the higher the estimated exposure coefficient is. The interpretation of the result is as follows: If the current trade balance surplus relative to the gross domestic product increases by one percentage point, the foreign exchange rate exposure rises by 0.0526 on average.

[10]Performing the same regression by using foreign exchange exposure coefficients of single equation estimation both coefficients are very similar in magnitude and significance as well as R^2 increased.

The inclusion of Singapore would yield statistically insignificant results. The distortion caused by this single observation would even reverse the sign of the exposure coefficient. The distortion found for Singapore in the full sample is not observable for any other economy in the sample as was tested by performing a leave-one-out robust check. Therefore, we assume that our results are quite robust with respect to the countries chosen. As our considerations imply, we can improve our regression fit by including an indicator variable I(Emerging) for those economies being on the threshold of becoming fully-industrialized. It comprises the following nations: Czech Republic, Greece, Hungary, Ireland, Poland, Portugal, and Spain. A linear regression gives the subsequent result.

$$\beta_i = \underset{((0.117))}{0.1935} + \underset{(0.022)}{0.0819^{**}} \; \Delta\, CB_i/GDP_i \; \underset{(0.174)}{0.4485^{*}} \; I(Emerging) \tag{3}$$

$$N = 26, \quad R^2 = 0.282, \quad \overline{R}^2 = 0.219$$

Significance level: $1\% =^{**}$, $5\% =^{*}$

Including the indicator variable I(.) considerably improves the economic and statistical significance of $\Delta CB_i/GDP_i$. The additional indicator, too, is significant and shows that emerging countries have a strictly higher foreign exchange rate exposure given their $\Delta CB_i/GDP_i$ than the other economies in the sample.

Robustness Check

To assess the validity of our results we performed several robustness checks supporting our findings with respect to different time spans. Each robustness check is based on a new set of exposure coefficients.[11]

[11] Results are not presented. They will be sent upon request from the authors.

To control for the influence of the Euro, we first restrict the sample period and use the data from January 1991 to December 1998. Subsequently, we divide the full sample of 162 observations into six equal subsamples. Then, we identify the impact of the trade balance on the foreign exchange rate exposure for each subsample.

Table 3: Subsample Regressions

First Obs	Feb91	Feb91	May93	Aug95	Nov97	Feb00	May02
Last Obs	Dec99	Apr93	Jul95	Oct97	Jan00	Apr02	Jul04
Const	0.191	0.464*	0.285*	0.146	0.279	0.019	0.327^{+}
	(0.114)	(0.190)	(0.134)	(0.279)	(0.235)	(0.135)	(0.161)
ΔCB/GDP	0.082**	0.192^{+}	0.109**	0.055	0.064	0.040^{+}	0.041*
	(0.025)	(0.093)	(0.036)	(0.058)	(0.048)	(0.020)	(0.017)
$I(Emerging)$	0.900**	-0.338	1.222**	0.594	0.073	-0.279	0.255
	(0.295)	(0.849)	(0.426)	(0.468)	(0.467)	(0.297)	(0.237)
R^2	0.302	0.179	0.417	0.079	0.081	0.256	0.083
$\overline{R}^2$	0.238	0.097	0.363	-0.005	-0.002	0.191	0.004
N	25	23	25	25	25	26	26

Own Source: ΔCB/GDP is the ratio of the current trade balance to GDP of each country. $I(Emerging)$ is an indicator variable which controls for emerging countries such as Czech Republic, Greece, Hungary, Ireland, Poland, Portugal, and Spain. First Obs/Last Obs indicates the first/last observation which are used to calculate the foreign exchange exposure and the corresponding mean value of the covariate. $\overline{R}^2$ is the adjusted R^2. N is the number of observations. Our data set is unbalanced. For some countries observations are missed for the first months of our sample. 1%, 5%, 10% significance levels are labelled by **, *, $^{+}$.

The findings shown in Table 3 confirm previous results. For each subsample the ratio of the current trade balance to GDP has a positive impact on the foreign exchange exposure. This statement also holds for the pre-Euro period as shown in column two. Only in two out of seven subsamples the coefficient is insignificant.[12]Hence, our findings are in accordance with the results of Bartram and Karoly (2006) who

[12]Results shown in Table 3 change only slightly if Equation (2) instead of Equation (3) is applied for each subsample.

found a decline of the foreign exchange rate exposure of nonfinancial firms after the introduction of the Euro.

5 Conclusion

Based on national data from 27 countries, in this paper we measure foreign exchange rate exposure of different nations in an extended version of the Adler-Dumas model. Our results show that export and import activities of economies are capable of explaining estimated national foreign exchange exposure coefficients. The analysis of the large set of time series measuring exchange rate exposure and foreign trade has brought up some unresolved research questions. How robust are results with respect to alternative data and further determinants of currency exposure? How would the measured relationship develop if equations were estimated at the industry level? It is to be hoped that future research will supply adequate answers.

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