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Exchange Rate Uncertainty and Trade Growth - A Comparison of Linear and Nonlinear (Forecasting) Models

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Exchange rate uncertainty and trade growth - a comparison of linear and nonlinear (forecasting) models

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Abstract

A huge body of empirical and theoretical literature has emerged on the relationship between foreign exchange (FX) uncertainty and international trade. Empirical findings about the impact of FX uncertainty on trade figures are at best weak and often ambiguous with respect to its direction. Almost all empirical contributions assume and estimate a linear relationship. Possible nonlinearity or state dependence of causal links between FX uncertainty and trade has been mostly ignored yet. In addition, widely used regression models have not been evaluated in terms of ex-ante forecasting. In this paper we analyze the impact of FX uncertainty on sectoral categories of multilateral exports and imports for 15 industrialized economies. We particularly provide a comparison of linear and nonlinear models with respect to ex-ante forecasting. In terms of average ranks of absolute forecast errors nonlinear models outperform both, a common linear model and some specification building on the assumption that FX uncertainty and trade growth are uncorrelated. Our results support the view that the relationship of interest might be nonlinear and, moreover, lacks of homogeneity across countries, economic sectors and when contrasting imports vs. exports.

Keywords: exchange rate uncertainty, GARCH, forecasting, international trade, nonlinear models
JEL Classification: F14, F17

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1 Introduction

The impact of exchange rate uncertainty on international trade has been generating a huge body of controversial theoretical and empirical literature.[1−11] Following a seminal argument risk averse traders will reduce traded quantities when facing costs involved with hedging FX uncertainty.[12] More generally, DeGrauwe[13] formalizes a positive (negative) impact of FX rate uncertainty on trade if the exporters' revenues are convex (concave) in the exchange rate. A similar ambiguity is derived by Viane and De Vries[14] who formally introduce price determination on forward markets. The latter contributions underscore the nature of markets, cost and demand functions, and preferences as major factors when determining the effect of FX volatility on international trade flows. These factors, however, may vary across different sectors of the economy, thereby questioning the adequacy of empirical models explaining international trade flows on an aggregated level. Restricting e.g. the income, price and exchange rate risk elasticities of trade to be identical across sectors could involve a presumably large aggregation bias[15] which might explain why the empirical literature is inconclusive about the dominating impact of FX uncertainty on trade. Klein[16] conducts an empirical investigation for disaggregated US bilateral exports to seven major industrialized economies. Nine categories of traded goods are considered and the case for a sector specific relationship is powerfully underscored. Therefore, the analysis herein rests on specific growth rates of multilateral exports and imports for 15 industrialized economies over 10 economic sectors.

Methodologically, the empirical literature proceeded incorporating major advances in econometric theory as for instance the concept of cointegration[17] or the introduction of autoregressive conditionally heteroskedastic time series processes ((G)ARCH).[18,19] However, two promising directions of empirical work have not been followed yet. Firstly, almost all empirical contributions, one exception is Baum et al.[9], a-priori postulate a linear relationship between the variables of interest. Among others, Viane and DeVries[14] conjecture, that the true relation may also be nonlinear. Secondly, there is almost no experience with respect to the performance of typical regression or dynamic models in terms of ex-ante forecasting. One reason why forecasting exercises have been constantly ignored yet could be that most existing empirical models characterizing trade patterns fail to pass simple regression diagnostics as, for instance, tests against serial error correlation.[20] In this paper we will provide a detailed comparison of linear vs. nonlinear model specifications. Furthermore, competing dynamic models are compared in both directions, in-sample fitting and ex-ante forecasting.

The remainder of the paper is organized as follows: Starting with a brief motivation, the next section describes the data, variable construction, and the issue of approximating FX uncertainty which is latent in nature. Section 3 provides the basic methodology. A vector error correction model (VECM) is outlined and after isolating the partial impact of FX uncertainty on trade a semiparametric extension is motivated. Diagnostic and selected estimation results are given. The forecasting exercises are described and interpreted in detail in Section 4. The paper ends with conclusions and directions for future research. An appendix provides further comments on the data used for the empirical analysis.

2 Data and a measure of FX uncertainty

2.1 The imperfect substitute model

The vast majority of the empirical literature analyzes the impact of FX uncertainty on trade based on some version of the so-called imperfect substitutes model.[15,21] For recent applications the reader may consult Baum et al.[9] or Klaassen.[10] In a bilateral version of this type of model foreign demand for domestic goods is some function

$$\mathcal{Q}_t = q\left(\mathcal{A}_t, \mathcal{A}_t^*, E\left[e_t|\Omega_{t-1}\right], E\left[v_t|\Omega_{t-1}\right]\right), \tag{1}$$

where $\mathcal{Q}_t$ is the quantity of (domestic) exports in time t, and $\mathcal{A}_t$ ($\mathcal{A}_t^*$) is the current domestic (foreign) economic activity. $E\left[e_t|\Omega_{t-1}\right]$ is the expected real FX rate conditional on Ω_{t-1} the set of information available up to time $(t-1)$, and $E\left[v_t|\Omega_{t-1}\right]$ is a conditional measure of the uncertainty (risk) associated with the former expectation. The inclusion of domestic economic activity in (1) is supported by Koray and Lastrapes[22] arguing that (at least) for large countries domestic conditions are likely to be important determinants of export flows. Moreover, numerous empirical studies[23,24] find domestic economic activity to have significant explanatory power for observed export patterns. In this paper we will analyze both perspectives, foreign demand for domestic goods and domestic demand for foreign goods. For the latter we formalize $\mathcal{M}_t$, the quantity of domestic imports, by means of a symmetric counterpart of (1) as

$$\mathcal{M}_t = m\left(\mathcal{A}_t, \mathcal{A}_t^*, E\left[e_t|\Omega_{t-1}\right], E\left[v_t|\Omega_{t-1}\right]\right). \tag{2}$$

As theoretical models (1) and (2) are based on partial equilibrium considerations potentially omitting important macroeconomic transmission channels. To this end, we will specify vector autoregressive (VAR) systems to start the empirical analysis which are suitable to embed a rich dynamic structure of the variables of interest. Moreover, VAR models allow a respecification as VECMs to cope with potential cointegration between nonstationary variables.

2.2 Selection of variables

In this paper we analyze sectoral trade flows for a cross section of 15 economies on a multilateral basis. In addition to determining reasonable approximations to the variables entering the theoretical models (1) and (2) the implementation of multilateral approaches requires some weighting scheme for the data. Therefore we discuss first the data and, in particular, the selection of variables in the next subsection. A more detailed description of the computation of weights, variable transformations, and data sources is given in the Appendix. Thereafter, we will discuss the approximation of FX uncertainty and provide estimation results on this issue.

2.2.1 Trade figures, economic activity and the real exchange rate

We concentrate on a set of 15 industrialized countries, $k = 1, \ldots 15$, namely Austria (AT), Belgium (BE), Canada (CA), Finland (FI), France (FR), Germany (GE), Greece (GC), Italy (IT), Ireland (IR), Japan (JP), the Netherlands (NL), Norway (NO), Sweden (SW), the United Kingdom (UK), and the USA (US). The set of countries includes the G7, most pre 2004 members of the European Union and Norway. Each country reports sectoral exports and imports over ten sectors, $j = 0, \ldots 9$, on a multilateral basis. We employ one-digit SITC categories which as described in Table I.

insert Table I about here

Given presample values to implement the VAR model, our sample of seasonally unadjusted monthly observations covers for most samples the period October 1981 to December 1998, thus providing 207 observations. The sample period ends immediately before the advent of the Euro reducing FX rate risk to zero for a major part of bilateral relationships covered by the cross section. With respect to GR sectoral import data is available only until December 1997. Owing to data limitations we exclude BE from the set of countries when analyzing import dynamics.

We compute country specific quantities of sectoral trade, foreign economic activity, of the real effective FX rate, and of a volatility measure taking into account the multilateral nature of trade flows. To augment the covered fraction of trade of the cross section members the latter quantities are based a second, larger set of nineteen economies containing the former cross section and, in addition, Switzerland (CH), Spain (SP), Mexico (MX), and Portugal (PR). We exclude the latter countries from the investigated cross section since CH and SP do not report trade flows on a sectoral basis and PR and MX report respective figures starting in 1984.

insert Table II about here

For the considered cross section Table II shows the average relative size of export (import) sectors over the period 1993:01 to 1998:01 in terms of total exports (imports). For most countries the majority of trade flows settles in sectors 6, 7, and 8. However, heavy oil exports of a volume exceeding 50% shift the main weight of the sectoral distribution of NO's exports to sector 3. The last column of Table II gives the percentage coverage the set of partner countries contributes to country k's total exports (imports). On average, the nineteen partner countries account for roughly 75% of total exports (73% of total imports). A noteworthy exception is JP with a coverage of approximately 46% for exports (40% for imports) since our set of partner countries omits some of JP's important trading partners (Singapore, Thailand, Malaysia, Korea, Hong Kong, and Chinese Taipei). Taking these countries into account, however, would not correspond with our focus on industrialized economies. On the other hand, excluding JP would substantially lower the coverage for a number of industrialized countries in our cross section.

Sector j real exports (imports) of a country k are the USD denominated nominal sectoral exports (imports) converted via the FX spot rate into national currency and deflated with national export (import) prices. Strictly speaking, the use of the latter price indices for realizing sectoral trade flows is particularly justified in the (unlikely) case that sectoral prices are perfectly correlated. Sector specific prices series, however, are not available for the considered cross section, sample period and sectoral classification. Trade figures enter the empirical analysis after taking natural logarithms and are denoted as $x_{kt}^{(j)}$ (exports) and $m_{kt}^{(j)}$ (imports), respectively.

As a natural measure of economic activity GDP figures are not available at the monthly frequency in general. Therefore we approximate domestic economic activity by the (natural logarithm of) industrial production for each country k, ip_{kt}. The quantity for foreign economic activity is a weighted average of the industrial production (in logs) in the respective partner countries, ip_{kt}^*. The real effective FX rate faced by traders in country k, e_{kt}, is a weighted average of the bilateral (log) real FX rates of country k and its trading partners. Bilateral nominal FX rates are mostly deflated using national wholesale prices. Note, that country specific weights are constant over time and among sectors but differ between the case of exports and imports. This implies that e_{kt} and ip_{kt}^* do not coincide for the analysis of exports and imports. To simplify notation, however, we do not explicitly discriminate these two cases in the following.

2.2.2 Modelling FX uncertainty

Being latent in nature numerous approximations of FX uncertainty are offered in the empirical literature. Absolute percentage changes of FX rates,[25] moving averages of historical FX rate variations measured in some past window of time,[16,22] or various measures based on the monthly sum of daily FX rate changes[9,10] have been considered. Reviewing the literature on applications of so-called autoregressive conditionally heteroskedastic time series processes[18,19] it turns out that the GARCH framework has been successful in a battery of empirical studies to capture stylized features of FX processes such as the martingale property, volatility clustering and leptokurtosis. In favor of the GARCH approach, moreover, Asseery and Peel[26] point out that GARCH based risk measures directly concentrate on "economically relevant" conditional second order moments. Finally, the GARCH model provides an unbiased estimator of the conditional expectation $E[(\Delta e_{kt})^2|\Omega_{t-1}]$ thereby mitigating problems involved when employing estimated explanatory variables.[27] For the latter reasons we will use GARCH based volatility measures to approximate FX uncertainty.

A preliminary view at the first differences of most country specific effective real FX rates, $\Delta e_{kt} = e_{kt} - e_{kt-1}$, revealed marked patterns of volatility clustering, and at the same time a few processes showed one or two outlying observations. For some countries initial volatility estimates obtained when modelling Δe_{kt} directly turned out to give unsatisfactorily diagnostic features of standardized residuals or implausible signs of coefficient estimates. Therefore we decided to apply a trimming procedure replacing realizations of Δe_{kt} which exceed in absolute value 2.5 times their empirical standard deviation (σ_e), by $\pm 2.5\sigma_e$ preserving the initial sign of Δe_{kt}.

Conditional FX volatility time paths of the real effective FX uncertainty are (mostly) estimated by means of GARCH(1,1) models, i.e.

$$\Delta e_{kt} = \hat{\xi}_{kt}\tilde{v}_{kt}, \quad \xi_{kt} \sim N(0,1), \tag{3}$$

$$\tilde{v}_{kt}^2 = \hat{\delta}_{k0} + \hat{\delta}_{k1}(\Delta e_{kt-1})^2 + \hat{\beta}_{k1}\tilde{v}_{kt-1}^2. \tag{4}$$

Recall that the notation does not discriminate the cases of exports and imports. The GARCH(1,1) process as specified in (3) and (4) postulates a normal distribution for Δe_{kt} the variance of which is conditional on Ω_{t-1}. Positive estimates of the parameters in equation (3) ($\hat{\delta}_{k0} > 0, \hat{\delta}_{k1} > 0, \hat{\beta}_{k1} > 0$) are sufficient for positivity of the conditional variances $\tilde{v}_{kt}^2$. Covariance stationarity of the GARCH process $(\Delta e_{kt})^2$ requires $\delta_{k1} + \beta_{k1} < 1$. Since the GARCH model is a univariate specification the conditional variance estimates will also have to catch up other potential sources of time varying volatility. Opposite to other measures of exchange rate volatility, however, the analyst may augment (4) with exogenous variables if indicated by diagnostic tests.

insert Table III about here

2.2.3 Volatility estimates

Diagnostic tests and GARCH(1,1) parameter estimates are provided in Table III. Parameter estimates are fairly similar between the models estimated for exports and imports indicating that weights attached to partner countries remain similar when analyzing exports or imports (see also Table II). According to one sided significance tests two third of all empirical models show significant parameter estimates $\hat{\delta}_{k1}$ or $\hat{\beta}_{k1}$ at the 5% level. This underscores the existence of volatility clustering in monthly real effective FX rates. Due to sluggish and lagged adjustment practice of trading agents the current impact of volatility may have only minor importance for current growth rates of trade flows. However, given sufficiently smooth volatility paths current volatility is a meaningful approximation of FX uncertainty taken into account by traders. For those countries where both coefficient estimates $\hat{\delta}_{k1}$ and $\hat{\beta}_{k1}$ were insignificant (or negative) we also tried an ARCH(1) specification. Owing to better diagnostic features obtained when testing for remaining heteroskedasticity in $\hat{\xi}_{kt}$ we keep the ARCH(1) model for a few volatility processes (FR, GE, NL for exports and CA, FR, and GE for imports). This may be justified from an economic point of view. According to the ARCH-LM(1) test[18] applied to the estimated GARCH(1,1) residuals $\hat{\xi}_{kt}$, the estimated volatility models do not indicate any remaining conditional heteroskedasticity.

3 Estimation

3.1 The VECM

Apart from the measures of FX uncertainty all remaining variables, real sectoral exports (imports), domestic and foreign economic activity, and the real effective FX rate turned out to contain stochastic trends. We refrain from providing detailed results of ADF-tests applied to these respective series in levels and first differences but assure that with almost no exception $x_{kt}^{(j)}, m_{kt}^{(j)}, ip_{kt}, ip_{kt}^{*}, e_{kt}$ are found to be integrated of order one. Therefore we formalize a VECM specified in first differences that captures potential cointegrating relationships linking the stochastic trends of the nonstationary processes. Apart from separating long and short run dynamics, the error correction approach is likely to improve the diagnostic features of the empirical trade models owing to the rich dynamic structure. It is worthwhile to note that poor diagnostic features of empirical trade models were mostly ignored in the literature.[20] Since our volatility estimates turned out to be stationary and accounting for the seasonal pattern of the macroeconomic variables we employ the following conditional VECM of order p as a multivariate starting point for the empirical analysis:

$$\Delta\tilde{\mathbf{y}}_{kt} = \mu_k + \lambda_k\tilde{v}_{kt} + \Pi_k\bar{\mathbf{y}}_{kt-1} + \sum_{i=1}^{p}\Gamma_{ki}\Delta\tilde{\mathbf{y}}_{kt-i} + \Psi_k d_t + \tilde{\boldsymbol{\varepsilon}}_{kt}. \quad (5)$$

In (5) $\tilde{\mathbf{y}}_{kt}$ collects the nonstationary variables, i.e. $\tilde{\mathbf{y}}_{kt} = (x_{kt}^{(j)}, ip_{kt}, ip_{kt}^{*}, e_{kt})$ and $\tilde{\mathbf{y}}_{kt} = (m_{kt}^{(j)}, ip_{kt}, ip_{kt}^{*}, e_{kt})$ when investigating exports and imports, respectively. In case of cointegration with cointegration rank r, $0 < r < 4$, the matrix Π_k factorizes as $\Pi_k = \alpha_k\beta_k'$, where α_k is a $4 \times r$ matrix. As indicated by model selection criteria we allow for an intercept term in the cointegration relationship. Therefore $\bar{\mathbf{y}}_{kt}$ is defined as $\bar{\mathbf{y}}_{kt} = (\tilde{\mathbf{y}}_{kt}', 1)'$ and β is a $5 \times r$ matrix. Whereas β_k parameterizes the equilibrium relationships between the nonstationary variables the loading matrix α_k governs how lagged violations of the long-run relation(s) affect current adjustments of the components in $\tilde{\mathbf{y}}_{kt}$. In case the variables in $\tilde{\mathbf{y}}_{kt}$ fail to cointegrate, i.e. $r = 0$, the matrix Π_k disappears and trade dynamics are modelled via a conditional VAR specified in (stationary) first differences. Deterministic terms in d_t contain seasonal dummy variables and three event dummy variables capturing the widening of the Exchange Rate Mechanism (ERM) margins to 15% (1993:08), the suspension of ERM participation by IT and the UK (1992:09), and the German reunification and the entry of the UK to the ERM (1990:10). FX uncertainty $\tilde{v}_{kt}$ is the estimated conditional standard deviation as obtained from the GARCH(1,1) or ARCH(1) models outlined in the preceding Section. μ_k and λ_k are 4-dimensional parameter vectors and $\Gamma_{ki}, i = 1, \ldots, p$, and Ψ_k are parameter matrices accounting for the short run dynamics and deterministic patterns, respectively. The elements of $\tilde{\boldsymbol{\varepsilon}}_{kt}$ are assumed to be serially uncorrelated with zero mean and constant covariance. To facilitate the notation we have skipped the sectoral index j from the model in (5) but mention that all model parameters are country and sector specific.

On the basis of the entire available sample information the VECM in (5) is used to determine key parameters as the model order (p) or the cointegration rank (r). For this purpose we use the AIC model selection criterion and the Johansen trace test[28] as implemented in EViews 4.1. After the determination of the cointegration rank we will use in the following the estimated stationary equilibrium violations, $\widehat{ec}_{kt} = \hat{\beta}_k' \bar{\mathbf{y}}_{kt}$, as potential explanatory variables for trade growth dynamics. Since the variables in $\tilde{\mathbf{y}}_{kt}$ contain stochastic trends the estimator $\hat{\beta}_k$ is superconsistent. Therefore the asymptotic properties of the remaining model parameters will be unaffected when specifying the VECM with an estimated error correction term $\widehat{ec}_{kt}$ replacing the corresponding true quantity $ec_{kt} = \beta_k' \bar{\mathbf{y}}_{kt}$.[29]

3.2 The partial impact of volatility on trade

Since our interest concentrates on the relationship between trade growth and FX uncertainty we use the vector model in (5) to figure out potential dynamic impacts on trade growth. Determinants of trade are formalized in the VECMs first equation, which is now extracted from the model and denoted as

$$\Delta \tilde{y}_{kt} = \mu_{1k} + \lambda_{1k} \tilde{v}_{kt} + \alpha_{1k} \widehat{ec}_{t-1} + \sum_{i=1}^{p} \gamma_{ki} \Delta \tilde{\mathbf{y}}_{kt-i} + \psi_k d_t + \tilde{\varepsilon}_{kt} \qquad (6)$$

$$= \tilde{\tilde{X}}_{kt} \tilde{\phi}_k + \tilde{\varepsilon}_{kt}. \qquad (7)$$

In (6), $\tilde{y}_{kt}$ and $\tilde{\varepsilon}_{kt}$ are the first elements of $\tilde{\mathbf{y}}_{kt}$ and $\tilde{\boldsymbol{\varepsilon}}_{kt}$, respectively, and, analogously, μ_{1k}, λ_{1k}, α_{1k}, γ_{ki} and ψ_k denote the first rows of the corresponding parameter vectors or matrices in (5). Equation (7) is just a compact representation of (6) where $\tilde{\phi}_k$ is a column vector collecting all model parameters.

Estimation efficiency of the single equation model in (7) is likely to suffer from the large number of parameters or, put differently, from various presumably insignificant parameter estimates. Therefore we run a subset modelling strategy where sequentially remove those parameter estimates with the smallest $t-$ratio from the set of explanatory variables in $\tilde{\tilde{X}}_{kt}$. This iterative procedure continues until all estimated parameters show $t-$statistics which are at least unity in absolute value. Since we are finally interested in the partial impact of FX uncertainty on trade dynamics the volatility measure is not subject to this model reduction procedure. From this selection procedure we obtain the following (dynamic) regression model which is nested in (7):

$$\Delta \tilde{y}_{kt} = \widetilde{X}_{kt}\phi_k + \tilde{\varepsilon}_{kt}. \tag{8}$$

Note that the applied selection strategy can be expected to avoid unnecessarily strong restrictions in the sense that a test of the restrictions implied by (8) jointly against the model in (7) is likely to support the former at a conventional significance level of 5%, say.

To concentrate on the relationship between volatility and trade growth, we first adjust both processes for the linear impact of the right hand side variables in (8) by means of partial regression techniques.[30,31] For this purpose let $\tilde{y}_k$ denote the vector of stacked observations of the dependent variable in (8) and define similarly $\tilde{v}_k$ as the vector of the stacked volatility estimates $\tilde{v}_{kt}$. Moreover, $\widetilde{X}_k$ is a matrix containing all explanatory variables of the respective equation. Then a compact representation of (8) is

$$\tilde{y}_k \quad = \quad \widetilde{X}_k\phi_k + \tilde{\varepsilon}_k \ . \tag{9}$$

Now, let $X_k = \widetilde{X}_k \setminus \tilde{v}_k$ denote the set of all explanatory variables in (8) other than volatility and define

$$y_k = \left(I - X_k(X_k'X_k)^{-1}X_k'\right)\tilde{y}_k \quad \text{ and } v_k = \left(I - X_k(X_k'X_k)^{-1}X_k'\right)\tilde{v}_k, \tag{10}$$

where I is the $(T \times T)$ identity matrix. The partial linear impact of FX uncertainty on trade is then obtained from a bivariate regression model of the form

$$y_{kt} = c_k + v_{kt}\theta_k + \varepsilon_{kt}, \quad c_k = 0. \tag{11}$$

Although (11) is an equivalent representation of the regression (8) in the sense that $\theta_k = \lambda_{1k}$, the partial linear model may be more intuitive when generalizing the impact of volatility on trade towards a nonlinear relationship.

3.3 A semiparametric model

In the light of the theoretical discussion concerning the relation between FX uncertainty and trade growth one may doubt the adequacy of a basically linear specification. Therefore a semiparametric approach is discussed next, which is able to nest a wide range of relations between y_{kt} and v_{kt}. Combined with suitable tools for inference such a framework is convenient to detect both, local or global deviations from the so far postulated linear relationship. The semiparametric regression model is given as follows:

$$\begin{aligned} y_{kt} &= E[y_{kt}|v = v_{kt}] + \epsilon_{kt} \\ &= a_k(v) + \epsilon_{kt}. \end{aligned} \tag{12}$$

By assumption the error terms in (12) have conditional zero mean and finite variance,

$$E[\epsilon_{kt}|v] = 0, \; \mathrm{Var}[\epsilon_{kt}|v] = \zeta_k^2(v) < \infty. \tag{13}$$

Given the nonparametric nature of the regression model in (12) on the one hand and recalling on the other hand that both variables y_{kt} and v_{kt} are obtained from linear projections the model in (12) actually formalizes a semiparametric approach. We evaluate the (unknown) conditional mean, $a_k(v)$, using the locally linear estimator[32,33] which is the first component of $a_k = (a_k^{(0)}, a_k^{(1)})'$ that solves the minimization problem

$$\min_{a_k} Q(v) = \min_{a_k^{(0)}, a_k^{(1)}} \sum_{t=1}^{T} K\left(\frac{v - v_{kt}}{h}\right) [y_{kt} - a_k^{(0)} - a_k^{(1)}(v - v_{kt})]^2. \tag{14}$$

$K(.)$ and h are a symmetric kernel function and the bandwidth parameter, respectively. Obviously $\hat{a}_k(v)$ solves locally a common least squares problem. Weights associated to sample values y_{kt} depend on the distance between v_{kt} and v, the bandwidth h and the employed kernel function. For our purposes locally linear estimation is implemented by means of the Gaussian kernel

$$K(u) = \frac{1}{\sqrt{2\pi}} \exp\left(-\frac{1}{2}u^2\right).$$

A particular problem in semiparametric regression is to select the bandwidth parameter h.[34] Owing to the large number of empirical models employed for estimation and recursive forecasting, a data driven bandwidth selection is infeasible to implement for this empirical study. Therefore a common rule of thumb bandwidth choice is preferred, namely

$$h = \sigma_v \left(\frac{3}{4T}\right)^{-0.2}, \tag{15}$$

where σ_v is the empirical standard deviation of v_{kt} and T is the sample size.

To illustrate the precision of semiparametric estimates pointwise confidence bands for $\hat{a}_k(v)$ could be obtained from quantiles of the Gaussian distribution and some variance estimate $\hat{\zeta}_k^2(v)$ or from resampling techniques as outlined in Neumann and Kreiss.[35,36] The latter, applied in this study, have the advantage to account for the potential of heteroskedastic error terms where the particular form of heteroskedasticity is left unspecified.

3.4 Results

Having introduced the basic tools employed to infer on the relationship between FX uncertainty and trade growth, the partial linear model (11) and the semiparametric specification (12), we will now provide some model diagnostics for the former and selected estimation results for both models applied. Since we have investigated 150 export and 140 import equations we refrain from reporting test statistics in detail but will rather provide test decisions on an aggregated level.

insert Table IV about here

3.4.1 Diagnostic results

Explaining the dynamics of trade growth the employed single equation models (8) yield degrees of explanation of 0.60 on average with an empirical standard error of 0.18. Diagnostic results for the single equation (error correction) models are shown in the left hand side panels of Table IV. The homoskedasticity assumption of error terms is tested by means of Lagrange Multiplier (LM) tests against an ARCH(1)-specification (A1), and against various forms of unconditional heteroskedasticity:[36] A shift in the error variance occurring in the second half of the sample period (H2), heteroskedasticity governed by the level of FX uncertainty, $\tilde{v}_{tk}$, (H3) or a trending error variance (H4). Note that particulary two types of heteroskedasticity (A1 and H2) are of specific importance for the present investigation. On the one hand, one may conjecture that the error terms in (8) have different unconditional variances in the sequel of changing macroeconomic policies or the introduction of sophisticated financial innovations to hedge FX rate risk. On the other hand, since the seminal article by Engle[18] there is little doubt about the finding that variables measured on financial markets as e.g. FX rates show patterns of conditional heteroskedasticity. Moreover, we test for structural stability (ST) via an F-type test comparing the accuracy of fit offered by the empirical model (8) with a corresponding measure obtained after splitting the sample in two subsamples of almost equal size. To provide a test against (higher order) serial error correlation Table IV also gives results for the LM-test[36,37] against joint autocorrelation up to order ℓ (ARℓ). Alternative values $\ell = 1, 12$ are selected which are natural when analyzing monthly data. Aggregating over 10 economic sectors Table IV provides absolute rejection frequencies of the respective null hypotheses obtained at the 5% significance level by country for exports (upper panel) and imports (lower panel), respectively. Since the analysis of exports (imports) covers 150 (140) data sets one would expect on an aggregated level about 7 to 8 rejections of the respective null hypotheses even if the data meet standard assumptions of econometric modelling.

Apparently the homoskedasticity assumption is violated for numerous empirical models. In particular, the unconditional error variance is not stable over the first and second half of the sample period for 57 (out of 150 export) or 44 (out of 140 import) equations. The results on testing the homoskedastic model against a trending variance mirror the latter results since the corresponding test statistic (H4) obtains 56 or 46 rejections, respectively. When testing the homoskedastic model against an ARCH(1) alternative or against heteroskedasticity driven by our measure of FX uncertainty the absolute frequencies of rejecting the null hypothesis are somewhat smaller. Summarizing these diagnostic results it is evident that for reliable inference in models like (8) or (12) one should apply heteroskedasticity consistent techniques.

With respect to testing on structural stability we obtain 35 and 23 rejections of the respective null hypothesis when analyzing export and import dynamics, respectively. Some rejections of structural invariance coincide with strong evidence in favor of heteroskedasticity (e.g. Italian exports or imports), such that the applied F-distribution is hardly suitable to provide critical values. The strongest case for structural instability is obtained when modelling Japanese exports where the null hypothesis of structural invariance is rejected for 7 out of 10 sectors and, in the same time, only weak evidence is obtained against the assumption of homoskedasticity. Since structural stability is an important condition when it comes to forecasting issues the latter results may call for some respecification of the employed models or of the applied subset modelling strategy. Regarding the forecasting exercises, however, it is worthwhile mentioning that the issue of potential structural variation will be mitigated by running the model selection procedure for each (recursive) sample separately.

Testing against serial correlation it turns out that in particular for 30 (34) empirical export (import) equations error terms exhibit some overall autocorrelation up to lag 12. This might indicate some misspecification of seasonal dynamics or shortcomings of the adopted subset model selection strategy. Given the evidence in favor of heteroskedasticity, however, some of the reported rejections for AR12 may falsely indicate serial correlation owing to size distortions of the LM-test. The evidence in favor of first order serial correlation is much weaker (only 10 or 14 rejections for export and import models, respectively). Note that for the forecasting exercises discussed in the next section higher order serial correlation is of minor importance relative to first order correlation since we will concentrate on one step ahead forecasting.

insert Figure 1 and Figure 2 about here

3.4.2 Estimation Results

Estimation results for selected sectors of the US and trade patterns observed for sector 7 over a subset of the cross section are shown in Figure 1 and Figure 2, respectively. Note that sector 7 is (almost uniformly) the most active sector of international trade over the set of economies considered in our study (see Table II).

The left (right) hand side panels of Figure 1 show both estimates of the partial relation between FX uncertainty and export (import) growth, linear (dashed line) and semiparametric estimates (solid curves). To indicate significance of the latter estimates 95% confidence intervals are given that are obtained by means of a heteroskedasticity consistent bootstrap procedure.[35] To facilitate the interpretation of the estimates we also provide horizontal lines through $\hat{y}_{kt} = 0$ indicating a scenario where by assumption FX uncertainty has no impact on trade growth at all. Moreover, each graph provides the (partial) degree of explanation (R_p^2) obtained from model (11) and the corresponding slope estimate $\hat{\theta}_k$. The (partial) degree of explanation turns out to be low for both, the linear (being at most 0.045) and the semiparametric estimator. Obviously, the relationship between FX uncertainty and trade growth is not uniform over different sectors, and, moreover, may differ for a given sector when contrasting conditional estimates of export and import growth. Some results indicate an overall positive relationship (US-exports, sector 8, US-imports, sector 0) whereas an overall negative relationship is found for other samples (e.g. US-exports and imports, sector 4). As indicated by the confidence intervals the estimated average local impact of FX uncertainty on trade growth is mostly insignificant. Conditional on specific levels of FX uncertainty the slope of the semiparametric estimates differs from the linear estimates. The latter finding is particularly relevant for scenarios of high FX uncertainty (US exports in sector 5, imports in sector 4). Locally the linear relationship is not covered by the semiparametric confidence bands in a few cases (e.g. Imports sectors 0 and 8, exports sector 5). Moreover the latter confidence bands do not uniformly cover the zero line indicating that although the dependence of trade growth on FX uncertainty is weak over wide ranges of the conditioning variable it is not uniformly insignificant. In scenarios of relatively low or high FX uncertainty a systematic impact on trade growth might be present. As pointed out before, however, the latter result is not uniform over sectors with respect to its sign.

Similar to Figure 1, Figure 2 shows results obtained for sector 7 selected over the cross section. Again the empirical results do hardly allow any uniform interpretation such that the relation of interest appears to be sector and country specific and also fails uniformity when contrasting results for import and export growth. All linear slope estimates $\hat{\theta}_k$ turn out to be insignificant at the 5% level. For the majority of semiparametric estimates (e.g. all export estimates), however, the provided confidence intervals do not uniformly cover the zero line thereby indicating a locally significant relationship between the two variables.

4 Forecasting

Forecasting is an important area of applied econometrics which provides a complementary means for model comparison. To uncover the dependence of trade growth on FX uncertainty, however, forecasting exercises have not been used yet. In the spirit of the concept of Granger causality one would expect some link between the variables of interest if forecasts of trade growth conditional on FX volatility improve forecasts obtained when excluding volatility from the conditioning information set. As a means for model comparison forecasting performance may be preferred over in-sample fitting since factors as the number of model parameters or the flexibility of the assumed functional relation between dependent and explanatory variables affect this criterion nontrivially. Therefore this section will compare the scope of linear and nonlinear models in forecasting trade growth conditional on FX uncertainty. Before discussing the forecasting design, however, two further model specifications used for forecasting are motivated.

4.1 Two further competitors

4.1.1 No causal relation

From the estimation results presented in the last section one may draw the conclusion that the true (partial) relation between FX uncertainty and trade is at most weak if it exists at all. In the latter case the best forecast of trade growth conditional on volatility is just "Zero" after controlling for remaining explanatory variables by means of partial regression. For this reason we will also provide forecasting results obtained under the assumption that trade growth is unaffected by FX uncertainty.

4.1.2 A threshold model

Eyeball inspection of the semiparametric estimates in Figure 1 or Figure 2 suggests for a few data sets that the slope of $\hat{a}_k(v)$ varies over the support of v. Preferring parametric models relative to the semiparametric approach for the reasons of estimation and forecasting efficiency one may therefore also employ a basically linear model allowing for a shift in the slope coefficient or the intercept term. Since volatility clustering is a stylized feature of FX variations one may regard the relation between trade and volatility to differ across states of low and high volatility. Such an assumption is straightforward to implement by means of a dummy variable model,[30] i.e.

$$y_{kt} = c_k + v_{tk}\theta_k + \left(c_k^{(+)} + v_{tk}\theta_k^{(+)}\right) I_{(v_{tk}>0)} + \varepsilon_{tk}. \tag{16}$$

In (16) $I_{(.)}$ denotes an indicator variable which is equal to 1 if v_{kt} is positive. Owing to our practice of adjusting volatility by means of partial regression $v_{tk} = 0$ is suitable to separate states of relatively high and low volatility. In addition, for the vast majority of analyzed data sets the zero threshold is rather close to the empirical median of v_{tk}. For the linear projections in (10) it turns out that the volatility measures v_{kt} and $\tilde{v}_{kt}$ are highly correlated, having correlation coefficients of 0.94 on average with an empirical standard deviation of 0.04. If the relationship between volatility and trade growth is stable across alternative states of volatility the parameters governing threshold effects $c_k^{(+)}$ and $\theta_k^{(+)}$ are not different from zero. Vice versa, nonlinear dynamics would be indicated if forecasts based on the threshold specification (16) outperform a linear forecasting scheme.

4.2 The forecasting design

Ex-ante forecasting exercises are performed for the linear specification (11), the semiparametric model (12) estimated by means of the local linear estimator (14) and the threshold model (16). In addition to the latter specifications building on some a-priori assumed relationship between FX uncertainty and trade growth we will also compare their outcomes with "unconditional" forecasts of zero implying that there is no relation between the two variables of interest. A causal relation linking the variables is indicated if the latter forecasting rule is outperformed by some of the former.

Each forecasting scheme is applied recursively by increasing the actual sample size from $t^* = 88$ to $t^* = T - 1$ such that 120 forecasts are computed for most data sets. Let $\hat{y}_{kt^*+1}$ denote a one step ahead forecast for y_{kt^*+1} conditional on knowledge of explanatory variables in time $t^* + 1$ and some model estimate obtained from the first t^* observations. Then, one step ahead forecast errors are defined as

$$\hat{u}_{kt^*+1} = y_{kt^*+1} - \hat{y}_{kt^*+1}.$$

To assess the accuracy of a particular model in forecasting different criteria could be considered.

In the first place, forecasting schemes could be evaluated according to randomness of the respective one step ahead forecast errors. A sensible forecasting model should deliver serially uncorrelated sequences $\hat{u}_{kt^*+1}$ which are easily diagnosed by means of a suitable LM-test.

Secondly, to measure forecasting accuracy y_{kt^*+1} and $\hat{y}_{kt^*+1}$ could be regarded as dichotomous random variables. Along these lines a forecasting model is accurate if the distributional properties of the forecasts $\hat{y}_{kt^*+1}$ come close to the corresponding features of the actual quantities y_{kt^*+1}. Intuitively appealing to formalize the latter idea, contingency tables are often used in applied statistics. As a formal criterion summarizing the information content of a contingency table we consider the so-called Henrikkson Merton statistic.[38] Initially proposed to evaluate investment performance this statistic (hm) aggregates the conditional probabilities of forecasting a positive or negative value of the dependent variable, whenever the actual realization in $t^* + 1$ is positive or negative,

$$\begin{aligned} \text{hm} &= \text{Prob}(\hat{y}_{kt^*+1} \geq 0 \wedge y_{kt^*+1} \geq 0 | y_{kt^*+1} \geq 0) \\ &\quad + \text{Prob}(\hat{y}_{kt^*+1} < 0 \wedge y_{kt^*+1} < 0 | y_{kt^*+1} < 0). \end{aligned} \tag{17}$$

A successful forecasting scheme should deliver hm-statistics larger than unity. Critical values for this test statistic depend on the number of available forecasts and can be obtained from simulation.

In the third place one may rank competing models according to the mean absolute forecast error (MAFE). For the empirical analysis of trade growth it turned out that for most data sets this measure is largely affected by only a few outlying observations y_{kt^*+1} such that the MAFE is hardly informative for both, causality linking volatility and trade and model comparison. Since four forecasts are available for each observation a scale invariant measure of relative performance is the average rank of absolute forecast errors. Although rank statistics will not be informative for the risk of (singular) large forecast errors average ranks are informative for causality analysis as well as model comparison. In case of no causality "zero" forecasts should show an average rank at least smaller than 2.5 since imposing a valid restriction is supposed to improve forecasting precision. Similarly, if there is some linear relation the linear model will be suitable to provide best linear forecasts conditional on the data. In this case the average rank of such forecasts should be smaller than 2.5. Accordingly, a case where nonlinear models as the threshold or semiparametric forecasting rules deliver average rank statistics smaller than the respective outcome of the linear forecasting scheme could be interpreted as evidence in favor of a nonlinear relation linking FX uncertainty and trade growth.

4.3 Results

Forecast error correlation: The right hand side panels of Table IV show absolute rejection frequencies obtained from LM-tests against serial correlation of one step ahead forecast errors at the 5% significance level. Similar to ex-post diagnostics the results are given in form of aggregates over 10 economic sectors. With respect to autocorrelation of ex-ante forecast errors no striking differences are obtained when comparing the outcomes of forecasting export growth on the one hand and import growth on the other. First order error correlation is diagnosed in about 15.5% of all employed forecasting models which exceeds the nominal significance level by far. When testing for serial correlation up to order 12 we again encounter the problem that seasonal patterns of trade growth may not be entirely captured by the selected single equation models. The corresponding test statistic (AR12) yields a rejection of the hypothesis of uninformative one step ahead forecast errors for about 41.2% of all empirical models. Owing to heteroskedasticity and the presence of a few huge outliers in most sequences of forecast errors, however, we do not interpret the latter findings as indicating severe misspecification of the employed forecasting schemes. Comparing alternative forecasting procedures it turns out that on average the semiparametric model yields error sequences which show serial dependence less often. For example with respect to first order testing the latter procedure gives 19 rejections of the respective null hypothesis when forecasting import or export growth whereas the linear regression shows significant autocorrelation for 25 and 23 error sequences when forecasting export and import growth, respectively. For both, export and import models, 24 error sequences obtained from "zero" forecasts show significant first order autocorrelation.

Henrikkson Merton tests: Table V reports country and sector specific hm-test statistics characterizing alternative forecasting schemes for export growth. Moreover, hm-statistics are given for country and sector specific pooled predictions and for an aggregate obtained over all one step ahead forecasts of export growth. Since the relative forecasting performance of alternative procedures may be different over states of lower and higher FX uncertainty relative to states of medium FX uncertainty we also provide hm-statistics for pooled forecasts where the conditioning variable v_{tk} is outside its interquartile range. Similar to the hm-statistics obtained for pooled forecasts of export growth Table V shows analogous results for pooled forecasts of import growth. Note that whereas for each single data set the number of observations used to determine the hm-statistic is small (120 in most cases) the respective number entering the hm-statistics for pooled forecasts is much larger. For instance pooling over 10 sectors will deliver about 1200 single forecasts. The hm-statistic obtained for all forecasts is based on 17849 one step ahead predictions. Critical values for the hm-test will depend on the number of available predictions. For this study we use simulated critical values taking the exact number of available predictions into account. To determine the latter we have generated 10000 sequences of bivariate and independent Gaussian random sequences and used one of these as a forecast for the other.

insert Table V about here

Almost all test statistics vary closely around unity which should not be too surprising given the low partial degree of explanation reported for particular samples in Figure 1 and Figure 2. Only a few hm-statistics indicate significantly successful forecasting models. To facilitate the interpretation of the results bold entries in Table V indicate hm-statistics exceeding unity with 5% significance. In a few cases of single data sets (specific on country and sector) nonlinear forecasts of export growth outperform linear forecasts significantly (e.g. export forecasts for BE or CA, sector 0, NO, sector 3) whereas the opposite pattern of a significant hm-statistic obtained from linear modelling and insignificant hm-statistics for nonlinear forecasts is observed only once (NO, sector 5). For a few data sets (SW, sectors 1 and 7, GE sector 4) the hm-statistics are about 1.3 and, thus, show that for these samples FX uncertainty is helpful in determining the future direction of export growth. Regarding the pool of all export growth forecasts the threshold specification delivers a hm-statistic of 1.02 which is small but owing to the huge number of forecasts significant at the 5% level. Both competitors, the linear and semiparametric forecasts, show insignificant hm-statistics on the pooled level. As already seen for the estimation results (Figure 1 and Figure 2) the pattern of hm-statistics is again not uniform neither over sectors nor over countries. Pooling over all sectors in particular the direction of Swedish and Norwegian trade figures can be detected conditional on FX uncertainty. The latter finding is robust over the entire support of the conditioning variable. Focussing the attention on scenarios of higher and lower FX uncertainty it turns out that when pooling over countries the direction of trade can be determined conditional on volatility in sectors 1, 8, and 7 with the latter being the most active sector of international trade flows. Recall, however, that all findings obtained on pooled levels do not uniformly hold over sectors or countries. With respect to forecasting the direction of import growth conditional on FX uncertainty it turns out that hm-statistics are somewhat smaller on average and significantly exceed unity only in a few cases. Sector and country specific hm-test statistics are not given here to economize on space but are available from the authors upon request.

insert Table VI about here

Average ranks of AFE: Table VI shows average rank statistics obtained over four competing forecasting procedures. Analogously to Table V sector and country specific results are given only for forecasts of export growth whereas average statistics obtained after pooling one step ahead forecasting errors are shown for exports and imports. The latter results are also given whenever the conditioning variable indicates a state of relatively low or high FX uncertainty. To facilitate the interpretation of the results average ranks being significantly smaller than 2.5 are given in bold entries. On the level of forecast errors pooled over both dimensions (country and sector) it turns out that for both, export and import forecasts, the average ranks obtained for the nonlinear model are between 2.25 and 2.35, whereas for the linear and "zero" forecasts the corresponding numbers vary between 2.65 and 2.75. All statistics differ significantly from 2.5 thereby providing a strong argument in favor of a nonlinear relationship linking FX uncertainty and trade growth on the pooled level. The same pattern of relative performance is also obtained when pooling forecast errors for each sector over the cross section. Pooling along the other dimension delivers the same pattern numerically, even though a few country specific statistics fail significance. Moreover, the relative performance of linear and "zero" forecasts on the one hand and nonlinear forecasts on the other hand, is, abstracting from a few exceptions, more or less uniform over country and sector specific forecasts of export growth. Numerous average ranks significantly smaller than 2.5 are obtained for the threshold model as well as for the semiparametric forecasts even if "only" 120 one step ahead forecast errors are evaluated. The frequency of cases where "zero" or linear predictors perform significantly better on average than nonlinear schemes is negligible.

5 Conclusions and outlook

In this paper we investigate the impact of FX uncertainty on international trade. Distinguishing 10 economic sectors we analyze the dynamics of import and export growth for 15 industrialized economies on a multilateral basis.

Regarding the degree of explanation of partial models it turns out that the causal links operating from FX uncertainty to trade growth are weak throughout. This finding is in line with most of the empirical literature on the topic even though predecessors have mostly analyzed aggregated trade flows. The fact that no uniform pattern of the estimated relationships can be identified across sectors and countries assigns a prominent role to sector and country specific characteristics of trade markets. These characteristics may be sector specific cost and demand functions, preferences or habits of traders that may differ owing to the particular features of the goods traded.

However, forecasting exercises evaluated by means of average rank statistics for absolute forecast errors indicate the existence of a relationship between FX uncertainty and trade growth and, furthermore, support the conclusion that this relationship is nonlinear in nature.

Our analysis focuses on the one step forecasting horizon. As direction of future research it appears fruitful to also compare alternative approaches with respect to forecasting trade growth conditional on FX uncertainty at longer horizons. In this case, considering medium and long term measures of volatility becomes particularly important.

A DATA

A.1 Computation of data series

The computation of real effective FX rates or foreign economic activity requires an appropriate weighting scheme taking the relative importance of trading partners for each member of the cross section into account. Most appropriately, one would refer to sectoral trade flows to quantify the sector specific importance of a country as trading partner. For the wide range of countries analyzed in this study bilateral sectoral trade data is unavailable. To this end, we follow the procedure in Klein[16] and base the computation of weights on aggregate trade data that are available on a bilateral basis. This implies that weights are constant across sectors. The weight $w_{k\ell}$ attached to a partner country ℓ is the ratio of aggregate bilateral exports from country k to the partner ℓ, $a_{k\ell}$, divided by the sum of country k's exports to all partner countries. Although the latter weights vary over time we use time invariant measures $\bar{a}_{k\ell}$ by averaging monthly data over the period 1993:01 to 1998:01. Then, weights $w_{k\ell}$ are determined as

$$w_{k\ell} = \frac{\bar{a}_{k\ell}}{\sum_\ell \bar{a}_{k\ell}} \ , \quad \sum_\ell w_{k\ell} = 1, \quad \ell = 1, \ldots 19, \quad k = 1, \ldots 15, \quad \ell \neq k \ .$$

Taking the perspective of country k, our measure of foreign economic activity is accordingly

$$ip^*_{kt} = \sum_\ell w_{k\ell} \ln \left(ip_{\ell t} \right), \quad \ell \neq k,$$

with $ip_{\ell t}$ denoting industrial production of partner ℓ. Similarly real effective FX rates are computed as

$$e_{kt} = \sum_\ell w_{k\ell} \ln \left(\frac{s_{k\ell t} wp_{\ell t}}{wp_{kt}} \right) \ , \quad \ell \neq k,$$

where $s_{k\ell t}$ is the price of country k's currency in terms of country ℓ's currency. As in Baum et al.[9] bilateral nominal FX rates are deflated by means of wholesale price indices.

A.2 Data sources and further comments

Sectoral trade flows and industrial production data are from the OECD databases "Monthly Statistics of International Trade" (March 2001) and "Main Economic Indicators", respectively. National currency export and import price data are from the IMF database "International Financial Statistics" (IFS). Nominal FX rates (national currency per USD) are retrieved from the IFS and are transformed into real FX rates using IFS wholesale price indices. Base year for all indices is 1995.

Export figures of BE exclude those of Luxembourg. A few observations of GC's sector 9 exports are interpolated using Tramoseats as implemented in EViews 4.1. Furthermore, GC sectoral import data are contained in the 2001 issue of the "Monthly Statistic of International Trade" database until December 1997 only.

We use export price indices (IFS line 76) for FI, GE, GC, JP, SW, and the US. For CA, IR, IT, NL, SP, and UK export prices (IFS line 74) are used. Export price series covering our full sample period are unavailable for AT, BE, and NO. Alternatively, we prefer wholesale price indices (IFS line 63) to consumer price indices. In the case of PT, no wholesale price series is available covering our full sample period and we refer to consumer prices (all items, IFS line 64) instead. Export prices for FR are retrieved from Datastream.

For AT, BE, CA, CH, FI, GE, GC, IR, IT, JP, NL, SP, SW, UK, and the US we use import prices (IFS line 75, for AT line 63, for CH line 76) to deflate nominal imports. For NO we employ the consumer price index of imported goods of the OECD "Main Economic Indicators" database. For PT no import price series is available such that we substitute it by the consumer price index (all items). The import price index for FR is retrieved from Datastream. Moreover, for FR a consistent wholesale price series is not available. Therefore we use the consumer price index (all items, Datastream) to convert nominal into real FX rates in this case.

Industrial production data for Germany refer to Western Germany until reunification and thereafter to the reunified Germany. Industrial Production data for Mexico is from the IFS database. Quarterly industrial production of Switzerland is from the IFS database and interpolated to the monthly frequency using EViews 4.1 (linear-match-last method).

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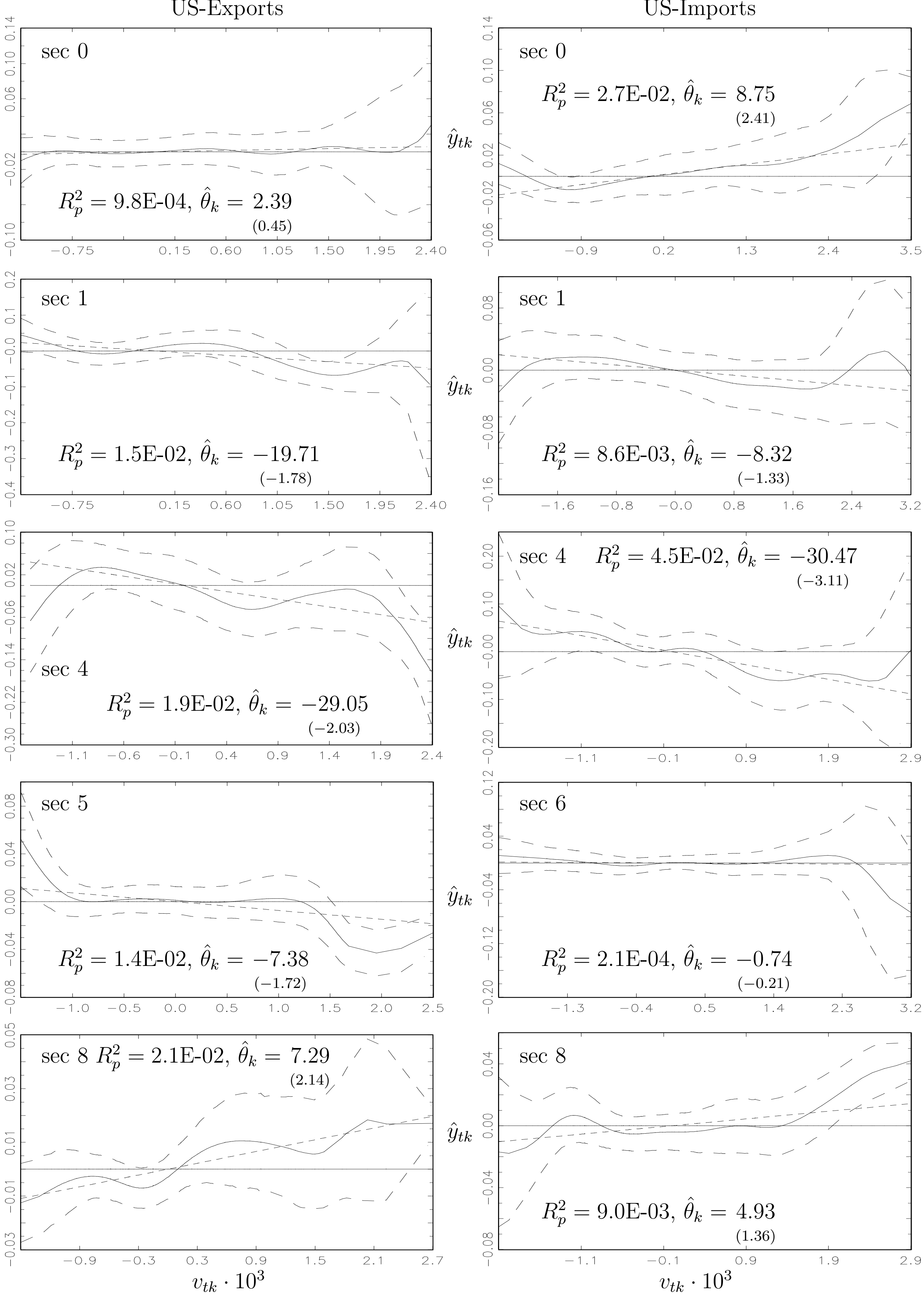

Figure 1: Linear (dashed) and semiparametric estimates (solid) of $\hat{y}_{tk} = E[y_{tk}|v_{tk}]$ for US exports and imports in selected sectors. 95% confidence intervals for the semiparametric estimates (wide dashes) and a horizontal line indicating $E[y_{tk}|v_{tk}] = 0$ are also shown. R_p^2 is the partial degree of explanation, and $\hat{\theta}$ is the slope estimate from the linear regression (11) ($t-$ratios in parentheses).

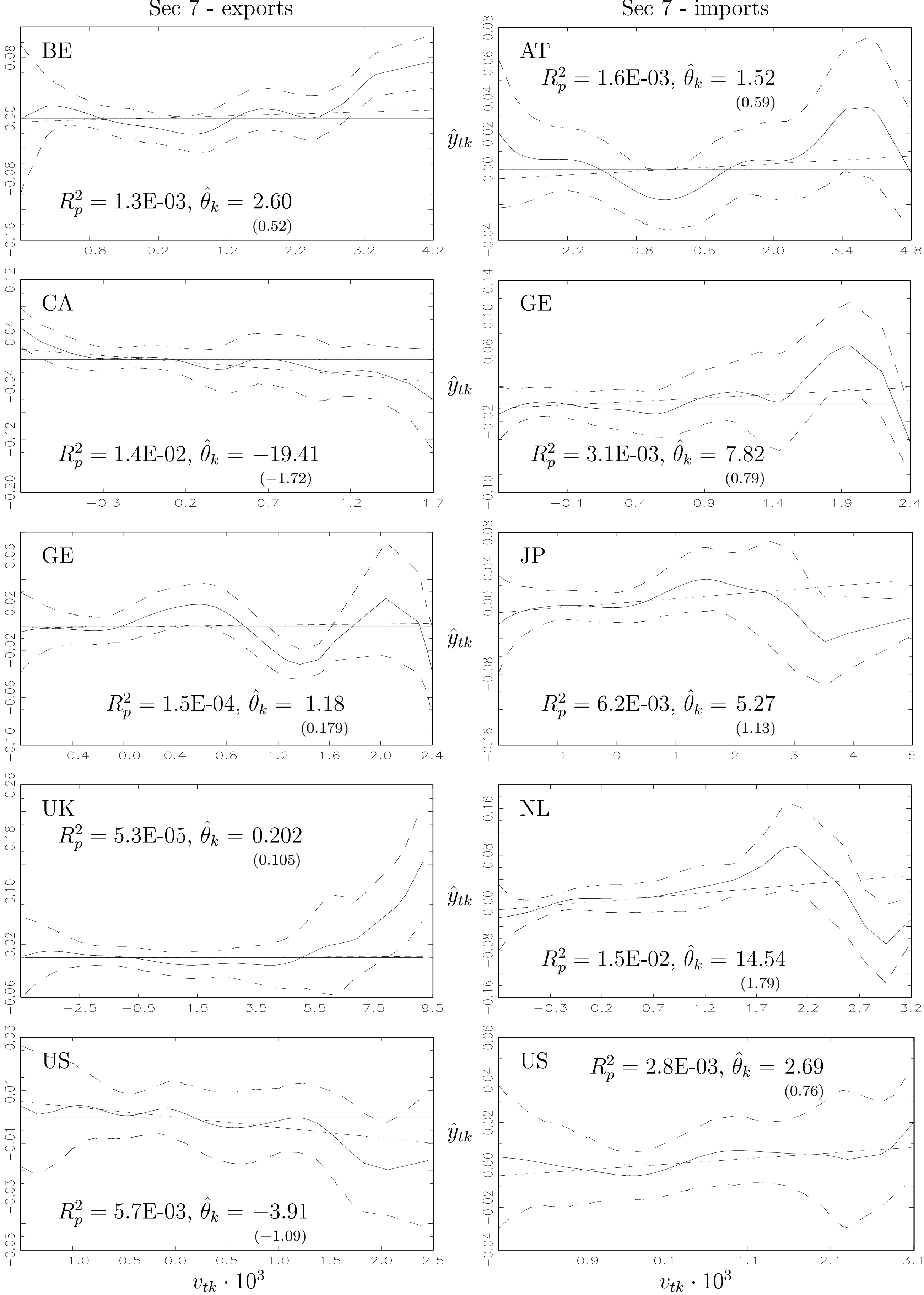

Figure 2: Linear (dashed) and semiparametric estimates (solid) of $\hat{y}_{tk} = E[y_{tk}|v_{tk}]$ obtained when analyzing exports or imports in sector 7 for selected economies. 95% confidence intervals for the semiparametric estimates (wide dashes) and a horizontal line indicating $E[y_{tk}|v_{tk}] = 0$ are also shown. R_p^2 is the partial degree of explantation, and $\hat{\theta}$ is the slope estimate from the linear regression (11) ($t-$ratios in parentheses).

Table I: One-digit SITC sectors

j	Description
0	Food and live animals
1	Beverages and tobacco
2	Crude materials, inedible, except fuels
3	Mineral fuels, lubricants and related materials
4	Animal and vegetable oils, fats and waxes
5	Chemicals and related products, n.e.s
6	Manufactured goods
7	Machinery and transport equipment
8	Miscellaneous manufactured articles
9	Commodities and transactions n.e.c

Source: OECD, Monthly Statistic of International Trade

Table II: Relative size of sectoral trade flows

sec	0	1	2	3	4	5	6	7	8	9	cover
Exports											
AT	3.39	0.65	3.89	1.16	0.07	9.32	27.88	39.83	13.67	0.14	74.55
BE	9.02	0.82	2.31	3.03	0.42	17.54	26.58	27.92	8.77	3.59	81.35
CA	6.30	0.55	11.26	9.89	0.26	5.64	15.90	39.20	5.37	5.63	90.67
FI	2.47	0.33	8.53	2.42	0.08	6.32	37.36	35.62	6.30	0.56	65.60
FR	10.83	3.04	2.35	2.48	0.24	14.70	15.95	40.23	9.97	0.21	75.01
GE	4.15	0.68	1.77	1.14	0.26	13.34	15.96	49.66	10.24	2.80	72.12
GC	18.27	5.93	6.56	8.26	4.67	5.01	20.38	7.61	21.54	1.77	60.03
IT	5.23	1.25	0.96	1.44	0.41	7.85	21.90	37.49	22.58	0.89	84.47
IR	15.09	1.78	2.00	0.44	0.09	21.81	4.74	34.02	14.60	5.43	73.32
JP	0.41	0.10	0.67	0.53	0.02	6.55	11.00	70.22	8.27	2.24	46.12
NL	16.08	2.43	5.54	7.71	0.86	16.59	12.73	27.69	10.07	0.31	81.35
NO	8.00	0.07	2.60	51.97	0.25	6.30	15.45	12.10	3.15	0.10	82.70
SW	1.94	0.32	7.18	2.63	0.15	9.17	23.41	46.56	8.45	0.19	73.34
UK	4.37	2.67	1.64	6.38	0.13	13.54	14.07	43.43	12.61	1.16	74.77
US	6.93	1.36	5.29	1.90	0.35	10.31	8.87	49.30	11.47	4.23	62.87
Imports											
AT	5.23	0.41	4.13	4.91	0.19	10.51	18.68	37.68	17.87	0.40	79.78
CA	5.09	0.47	3.23	4.03	0.14	8.06	12.78	51.38	11.63	3.19	85.45
FI	5.51	0.66	6.95	10.34	0.18	12.14	14.18	37.90	10.98	1.17	71.07
FR	8.83	1.20	3.35	7.94	0.38	12.21	15.92	35.69	14.19	0.28	77.60
GE	8.09	1.00	4.20	7.39	0.29	8.91	15.72	34.42	15.39	4.58	71.43
GC	12.20	2.05	3.33	8.94	0.35	12.46	18.44	30.42	11.50	0.31	73.24
IT	9.74	1.01	7.21	8.11	0.79	12.86	16.34	29.51	9.56	4.88	80.14
IR	7.18	1.09	1.96	3.70	0.36	12.53	11.07	41.92	12.34	7.85	71.14
JP	13.68	1.47	9.39	17.71	0.24	7.13	11.63	22.76	13.99	2.01	40.03
NL	10.33	1.35	4.91	8.50	0.74	12.06	15.16	33.51	13.30	0.15	77.96
NO	5.50	0.67	7.19	3.68	0.36	9.45	17.68	39.19	16.13	0.16	74.72
SW	6.03	0.90	3.43	7.89	0.26	10.99	15.78	40.55	14.04	0.14	78.39
UK	7.98	1.55	3.53	3.93	0.36	9.92	16.02	41.59	14.30	0.83	77.73
US	3.75	0.82	2.66	8.83	0.19	5.46	11.71	45.93	17.07	3.57	62.85

Notes: Own computations based on data from OECD, Monthly Statistic of International Trade. Average percentage shares over the period 1993:01 to 1998:01. 'cover' is the percentage share of total aggregate exports (imports) with the rest of the world that is captured by the set of partner countries considered.

Table III: (G)ARCH estimation and diagnostic results

	Exports					Imports				
	Δe_{kt}		GARCH(1,1)		$\hat{\xi}_{kt}$	Δe_{kt}		GARCH(1,1)		$\hat{\xi}_{kt}$
	A1	A5	$\hat{\delta}_{k1}$	$\hat{\beta}_{k1}$	A1	A1	A5	$\hat{\delta}_{k1}$	$\hat{\beta}_{k1}$	A1
AT	0.28	0.41	0.13* (1.95)	0.83* (8.11)	0.99	0.41	0.52	0.12* (1.93)	0.84* (8.74)	0.95
BE	0.28	0.27	0.16* (1.87)	0.47 (1.52)	0.47	-	-	-	-	-
CA	0.50	0.76	0.05 (0.74)	0.53 (1.06)	0.85	0.59	0.89	0.05 (0.66)	-	0.86
FI	0.00*	0.01*	0.12* (1.71)	0.79* (6.04)	0.63	0.00*	0.02*	0.13* (1.80)	0.78* (6.06)	0.64
FR	0.09	0.31	0.11 (1.16)	-	0.86	0.20	0.56	0.10 (1.08)	-	0.95
GE	0.37	0.69	0.11 (1.38)	-	0.71	0.36	0.47	0.10 (1.20)	-	0.76
GC	0.00*	0.00*	0.18* (2.66)	0.82* (11.56)	0.09	0.00*	0.00*	0.19* (2.76)	0.81* (11.26)	0.12
IT	0.00*	0.00*	0.15 (1.61)	0.79* (5.33)	0.85	0.00*	0.00*	0.15* (1.67)	0.79* (5.43)	0.93
IR	0.15	0.03*	0.04 (0.86)	0.70* (2.21)	0.65	0.01*	0.11	0.11* (1.68)	0.58* (2.76)	0.86
JP	0.45	0.44	0.05 (0.77)	0.71* (1.77)	0.94	0.58	0.46	0.05 (0.71)	0.71* (1.68)	0.87
NL	0.01*	0.22	0.13 (1.31)	-	0.63	0.02*	0.15	0.10 (1.09)	0.28 (0.47)	0.71
NO	0.33	0.07	0.15* (2.28)	0.74* (6.17)	0.50	0.23	0.07	0.19* (2.44)	0.72* (6.10)	0.52
SW	0.01*	0.00*	0.06 (1.61)	0.91* (18.34)	0.65	0.02*	0.02	0.05 (1.17)	0.92* (14.29)	0.64
UK	0.01*	0.16	0.11* (1.66)	0.71* (4.40)	0.64	0.01*	0.13	0.10 (1.57)	0.70* (4.09)	0.56
US	0.68	0.65	0.043 (0.85)	0.76 (1.64)	0.60	0.69	0.56	0.05 (1.12)	0.82* (3.10)	0.51

Notes: p-values obtained from ARCH LM-tests of orders 1 and 5 (A1, A5) for Δe_{tk} and LM-tests on remaining ARCH effects in $\hat{\xi}_{kt}$ (A1). Parameter estimates ($t-$ratios in parentheses) for the GARCH(1,1) or, if indicated, for ARCH(1) processes. A star indicates significance at the 5% level. Owing to parameter restrictions we use one sided tests for the (G)ARCH-parameters. All $t-$ratios are obtained from Quasi Maximum Likelihood estimation.[39]

Table IV: Ex-post model diagnostics and ex-ante autocorrelation

	Heteroskedasticity							LIN		THM		SPA		ZERO	
	A1	H2	H3	H4	ST	AR1	AR12	AR1	AR12	AR1	AR12	AR1	AR12	AR1	AR12
	Exports														
AT	1	2	0	1	3	0	0	1	1	1	2	0	1	1	2
BE	2	2	1	3	3	1	1	1	5	2	5	0	5	1	5
CA	2	5	0	6	1	2	5	2	9	2	10	1	8	2	8
FI	2	5	0	3	2	1	0	2	4	2	4	2	4	2	4
FR	2	2	0	4	2	0	2	1	5	0	4	1	3	1	6
GE	4	3	0	3	0	0	2	3	0	3	0	3	1	3	0
GC	7	5	1	3	0	1	1	2	3	1	3	2	3	1	3
IR	1	3	1	4	2	1	0	3	1	3	1	2	2	3	2
IT	3	10	2	10	6	1	2	2	6	1	6	0	6	2	5
JP	1	2	0	2	7	1	4	2	8	2	7	2	5	2	8
NL	2	3	1	2	1	0	4	1	5	1	4	1	2	1	4
NO	3	2	0	2	2	0	0	0	2	0	1	0	2	1	2
SW	1	2	3	3	4	2	3	3	5	2	4	2	6	2	6
UK	2	4	4	3	1	0	3	2	4	2	5	3	5	2	4
US	2	7	1	7	1	0	3	0	3	0	3	0	2	0	3
agg	35	57	14	56	35	10	30	25	61	22	59	19	55	24	62
	Imports														
AT	1	0	1	1	1	0	3	2	6	2	6	1	6	1	6
CA	1	2	1	2	1	1	5	0	6	0	6	1	5	1	6
FI	1	3	0	1	0	1	0	0	3	0	3	0	2	0	3
FR	0	4	1	3	2	1	0	2	1	2	1	1	2	2	2
GE	1	2	0	0	2	2	5	3	5	3	5	2	3	3	6
GC	2	7	0	7	2	1	2	0	3	1	4	1	4	0	3
IR	1	3	1	5	2	3	3	3	5	3	5	3	5	3	5
IT	4	6	2	8	5	1	3	2	6	2	6	2	5	2	6
JP	2	3	0	3	1	0	0	3	4	2	4	0	1	3	3
NL	2	1	1	1	0	1	4	1	5	1	5	1	2	1	5
NO	0	1	0	1	1	1	0	1	2	0	1	1	1	1	2
SW	4	2	2	3	2	1	4	1	4	2	4	0	1	1	3
UK	0	2	0	3	1	0	3	1	5	1	6	1	5	1	5
US	3	8	2	8	3	1	2	4	8	4	9	5	9	5	8
agg	22	44	11	46	23	14	34	23	63	23	65	19	51	24	63

Notes: Absolute frequencies of rejecting particular null hypotheses at the 5% significance level for various in-sample diagnostics (left hand side panels) and serial correlation of one step ahead forecast errors (right hand side). The homoskedastic model is tested against ARCH(1), shift in variance, variance governed by volatility, and trend in variance (H1 to H4). ST is short for an F-test on structural stability. LM1 and LM12 are LM-tests against first order autocorrelation and autocorrelation up to order 12. LIN, THM, SPA and ZERO are short for four competing forecasting schemes, the linear regression (11), a threshold model (16), the semiparametric model (12) and unconditional "zero" forecasts. Ten sectors are modelled for each country such that 10 is the maximum entry per cell.

Table V: Henrikkson-Merton tests

		Exports																	Imports	
Sec		AT	BE	CA	FI	FR	GE	GC	IR	IT	JP	NL	NO	SW	UK	US	agg	agg*	agg	agg*
0	LIN	1.08	0.91	1.17	1.08	1.03	1.08	0.93	1.15	0.93	1.08	0.94	0.99	0.98	1.12	0.96	1.04	1.01	1.00	1.01
	THM	1.14	**1.22**	**1.20**	1.00	0.89	1.12	0.89	**1.18**	1.01	1.13	0.89	0.99	0.94	1.03	0.86	**1.04**	1.00	0.97	1.00
	SPA	0.94	**1.29**	**1.16**	1.04	0.91	1.05	0.93	1.13	1.04	1.14	1.02	0.94	1.02	1.06	0.97	**1.05**	1.02	0.97	0.99
1	LIN	1.10	0.83	1.06	0.94	0.93	1.00	1.03	1.09	0.93	1.12	1.01	1.08	**1.34**	0.94	1.09	1.04	**1.07**	1.02	1.01
	THM	1.06	0.89	1.07	0.97	0.95	1.04	1.09	1.04	0.90	1.10	0.88	1.09	**1.29**	1.06	0.98	1.03	**1.08**	1.00	1.04
	SPA	0.98	1.01	0.98	0.97	0.97	1.03	1.05	1.02	0.91	1.14	0.93	0.96	**1.31**	1.10	1.06	1.03	**1.06**	1.03	1.02
2	LIN	0.98	0.87	0.96	0.98	0.95	0.86	1.09	1.03	0.88	0.91	1.02	0.98	1.00	1.03	0.93	0.96	0.97	1.02	1.01
	THM	1.12	**1.21**	0.97	1.03	0.85	0.95	1.05	0.98	0.84	0.86	1.02	0.95	1.10	1.12	0.96	1.00	1.00	0.98	1.00
	SPA	1.13	1.02	1.03	1.05	1.05	0.94	1.07	0.83	0.78	0.93	1.03	1.00	0.98	0.95	0.97	0.98	0.98	0.98	0.99
3	LIN	0.88	1.00	0.89	0.93	1.08	0.84	0.90	1.06	1.05	1.08	1.07	1.10	1.10	1.06	1.01	1.00	0.99	1.03	1.02
	THM	0.87	1.03	1.08	0.94	1.03	1.02	0.94	0.95	0.89	0.92	0.83	**1.15**	1.12	0.95	1.08	0.99	0.99	1.02	1.01
	SPA	0.88	1.00	1.00	1.04	1.11	0.93	0.93	0.96	0.86	0.83	0.90	**1.17**	1.05	0.98	1.00	0.98	0.99	1.05	**1.06**
4	LIN	1.08	1.04	1.10	0.94	0.94	**1.23**	0.79	0.97	1.04	1.00	0.99	0.87	1.06	0.92	1.02	0.99	1.01	1.00	0.98
	THM	1.02	1.02	0.92	0.96	1.12	**1.24**	1.08	0.94	1.05	0.95	1.01	0.99	1.09	**1.22**	1.03	1.03	**1.07**	1.03	1.02
	SPA	1.03	1.02	1.00	1.00	1.10	**1.28**	1.08	0.83	1.01	0.95	0.94	1.05	1.05	1.07	0.97	1.02	1.01	0.99	0.99
5	LIN	0.97	0.91	0.92	1.13	0.98	1.09	0.92	0.89	1.02	1.13	0.75	**1.15**	1.11	0.95	1.12	1.01	0.98	1.02	1.03
	THM	0.85	0.99	0.95	1.04	0.99	1.04	0.86	1.01	1.05	0.93	0.91	1.15	1.07	1.12	0.97	1.00	1.00	1.03	1.02
	SPA	0.93	1.04	1.00	1.06	1.00	0.95	0.91	0.94	0.99	0.97	0.91	1.12	1.03	1.13	0.97	1.00	0.98	1.01	1.00
6	LIN	1.05	1.04	0.88	1.09	0.94	0.96	0.92	1.05	0.95	1.13	1.08	1.09	1.00	0.91	1.03	1.02	1.01	**1.04**	1.02
	THM	1.15	1.12	0.89	1.02	1.04	0.80	1.00	1.00	0.96	1.00	1.12	1.11	1.04	1.11	0.87	1.02	1.00	**1.06**	**1.07**
	SPA	1.12	1.05	0.95	1.07	1.04	0.92	1.01	0.99	1.07	0.95	**1.18**	1.09	1.01	1.08	0.91	1.03	1.02	1.03	1.04

Table V: Henrikkson-Merton tests (cont)

		Exports																	Imports	
Sec		AT	BE	CA	FI	FR	GE	GC	IR	IT	JP	NL	NO	SW	UK	US	agg	agg*	agg	agg*
7	LIN	1.03	1.03	1.03	0.97	0.94	0.93	1.08	1.02	0.94	1.13	0.97	1.03	**1.29**	0.94	0.97	1.03	1.04	1.01	1.03
	THM	1.13	1.02	1.08	0.93	0.82	0.98	1.03	0.95	1.09	0.98	0.95	0.98	**1.26**	0.97	1.01	1.02	**1.06**	1.02	1.01
	SPA	1.10	1.04	0.96	0.90	1.04	0.96	0.98	0.88	1.01	0.96	1.14	1.06	**1.15**	1.04	1.00	1.02	**1.06**	**1.05**	1.03
8	LIN	0.96	1.08	1.02	1.02	0.93	1.03	0.97	**1.19**	0.98	1.13	1.08	1.05	0.85	0.91	1.05	1.02	**1.07**	0.99	1.00
	THM	0.95	0.98	1.03	0.98	0.99	1.07	1.03	**1.18**	0.89	1.06	1.12	1.12	1.07	0.96	1.03	1.03	**1.10**	0.99	1.00
	SPA	0.94	0.95	1.02	1.04	1.11	0.96	0.97	1.02	1.06	1.12	1.08	1.06	1.08	0.95	1.05	1.03	1.05	1.00	1.01
9	LIN	0.98	1.03	1.14	1.00	0.97	0.97	1.02	0.88	0.87	0.76	1.08	0.99	0.97	0.93	1.00	0.99	0.99	0.99	0.96
	THM	0.90	1.10	0.84	0.96	**1.20**	0.82	1.03	1.11	0.97	0.93	0.97	0.93	1.01	1.03	1.00	1.01	1.00	0.98	0.96
	SPA	0.88	0.99	0.88	1.03	1.15	0.86	1.03	0.97	0.96	0.77	0.99	0.90	0.94	1.04	0.87	0.97	0.95	0.96	0.91
agg	LIN	1.02	0.97	1.02	1.01	0.97	1.00	0.99	1.03	0.96	1.04	1.00	1.04	**1.08**	0.97	1.02	1.01	–	–	–
	THM	1.03	**1.06**	1.00	0.99	0.98	1.01	1.02	1.03	0.97	0.99	0.97	**1.05**	**1.11**	**1.05**	0.99	**1.02**	–	–	–
	SPA	1.00	1.04	1.00	1.02	1.04	0.99	1.01	0.95	0.97	0.98	1.01	**1.05**	**1.07**	1.04	0.99	1.01	–	–	–
agg*	LIN	1.01	0.99	1.03	1.01	0.94	1.02	0.97	1.01	0.93	**1.13**	1.03	1.04	**1.13**	0.93	1.04	–	1.01	–	–
	THM	1.02	1.06	1.01	1.02	0.98	1.02	1.00	**1.08**	0.96	1.06	0.98	**1.08**	**1.15**	1.04	0.98	–	**1.03**	–	–
	SPA	0.93	1.04	1.01	1.02	1.04	1.00	1.03	0.96	0.94	1.00	1.01	**1.08**	**1.10**	1.03	1.01	–	1.01	–	–
	Imports																			
agg	LIN	0.99	–	1.02	1.01	1.00	1.02	1.01	1.01	0.99	0.99	0.98	1.01	**1.06**	1.04	0.98	–	–	**1.01**	–
	THM	1.00	–	1.01	0.96	1.02	1.03	0.99	1.01	1.00	1.03	1.01	0.99	1.02	0.98	1.00	–	–	1.01	–
	SPA	1.00	–	1.02	1.01	1.04	0.99	0.99	1.04	1.02	1.03	0.97	1.00	1.00	0.98	0.95	–	–	1.01	–
agg*	LIN	0.96	–	1.03	0.99	1.01	1.01	1.02	1.01	1.02	1.02	0.97	1.00	**1.07**	1.01	0.93	–	–	–	1.01
	THM	1.00	–	**1.07**	0.94	1.03	1.03	1.00	1.02	1.02	1.03	1.02	0.98	1.01	0.98	1.01	–	–	–	1.01
	SPA	1.03	–	1.05	1.01	1.02	1.00	1.00	1.02	**1.07**	1.03	0.96	1.01	0.99	0.96	0.91	–	–	–	1.01

Notes: Country and sector specific hm-statistics indicating the accuracy of three competing forecasting schemes (LIN, THM, SPA) to predict conditionally the correct sign of export growth. agg and agg* denote unconditional aggregates and aggregates obtained over states of unusually low and high FX uncertainty, respectively. Results for imports are given on aggregate levels only. Bold entries indicate hm-statistics significantly exceeding unity. Critical values are estimated by means of own simulations.

Table VI: Average ranks of one step ahead forecast errors

		Exports																	Imports	
Sec		AT	BE	CA	FI	FR	GE	GC	IR	IT	JP	NL	NO	SW	UK	US	agg	agg*	agg	agg*
0	LIN	2.56	2.66	2.65	2.81	2.63	2.52	2.77	2.75	2.62	2.85	2.88	3.08	2.92	**2.26**	2.56	2.70	2.75	2.78	2.80
	THM	**2.13**	2.39	**2.18**	**2.01**	**2.26**	2.42	2.28	**2.22**	2.46	**2.08**	**2.08**	**1.98**	**2.04**	2.56	2.56	**2.24**	**2.22**	**2.22**	**2.23**
	SPA	2.41	2.68	2.37	**2.31**	2.50	2.41	**2.24**	**2.16**	2.40	**2.27**	2.31	**1.92**	**2.21**	2.85	2.43	**2.37**	**2.32**	**2.29**	**2.27**
	ZERO	2.91	**2.27**	2.80	2.88	2.60	2.64	2.71	2.88	2.52	2.80	2.73	3.03	2.83	2.33	2.45	2.69	2.71	2.70	2.69
1	LIN	2.56	2.78	2.34	2.94	2.80	2.83	2.79	2.58	2.98	2.98	3.04	2.52	2.74	2.83	2.70	2.76	2.83	2.67	2.76
	THM	**2.31**	2.35	2.69	**2.17**	**2.22**	**2.19**	**2.18**	2.47	**2.29**	**1.89**	**1.95**	2.32	**2.12**	**2.17**	2.40	**2.25**	**2.14**	**2.33**	**2.24**
	SPA	2.48	2.38	2.48	**2.21**	**2.24**	**2.23**	2.30	2.52	**1.98**	**1.91**	**2.09**	2.48	**2.13**	**2.24**	2.41	**2.27**	**2.25**	**2.34**	**2.25**
	ZERO	2.66	2.48	2.48	2.68	2.74	2.76	2.74	2.43	2.74	3.22	2.92	2.68	3.02	2.76	2.49	2.72	2.79	2.66	2.75
2	LIN	2.58	2.42	2.78	2.94	2.64	2.39	3.00	2.76	2.98	2.92	2.85	2.71	2.48	2.49	2.65	2.70	2.76	2.73	2.74
	THM	2.41	2.72	2.35	**2.17**	2.36	2.69	**2.00**	**2.15**	**2.17**	**2.07**	**2.25**	**2.30**	2.41	2.49	2.47	**2.34**	**2.25**	**2.28**	**2.29**
	SPA	2.44	2.42	**2.17**	**1.97**	2.42	2.70	**1.95**	2.32	**2.13**	**2.25**	**2.21**	2.34	2.58	2.52	2.45	**2.33**	**2.29**	**2.32**	**2.30**
	ZERO	2.57	2.44	2.70	2.92	2.58	**2.22**	3.05	2.77	2.71	2.77	2.69	2.65	2.53	2.49	2.43	2.63	2.69	2.66	2.67
3	LIN	2.83	2.57	2.32	2.96	2.82	2.38	3.16	**2.14**	2.73	2.46	2.67	2.45	2.74	2.62	2.74	2.63	2.74	2.83	2.80
	THM	2.33	2.52	2.67	**2.17**	**2.16**	2.66	**2.17**	2.84	**2.22**	2.44	2.34	2.44	**2.20**	2.47	2.30	**2.40**	**2.27**	**2.20**	**2.25**
	SPA	**2.27**	2.38	2.80	**2.26**	**2.23**	2.80	**2.14**	2.91	2.39	2.55	2.40	2.47	**2.05**	**2.19**	**2.22**	**2.41**	**2.32**	**2.21**	**2.25**
	ZERO	2.57	2.52	**2.22**	2.61	2.79	**2.16**	2.54	**2.11**	2.67	2.55	2.59	2.64	3.01	2.73	2.74	2.56	2.67	2.77	2.69
4	LIN	2.73	2.76	2.39	2.67	2.70	2.50	2.63	2.77	2.86	3.02	3.16	2.48	2.65	**2.11**	3.01	2.70	2.73	2.69	2.80
	THM	**2.07**	**2.27**	2.48	2.57	2.43	2.31	2.38	**2.17**	**2.26**	**1.96**	**1.73**	2.68	2.43	3.04	**1.99**	**2.32**	**2.26**	**2.34**	**2.24**
	SPA	2.32	2.36	2.81	2.34	**2.23**	**2.22**	2.58	2.38	**1.99**	**2.18**	**2.02**	2.64	**2.13**	2.77	**2.16**	**2.34**	**2.30**	**2.32**	**2.25**
	ZERO	2.88	2.62	2.33	2.42	2.64	2.98	2.41	2.67	2.89	2.84	3.09	**2.20**	2.78	**2.08**	2.84	2.65	2.71	2.65	2.72
5	LIN	2.80	2.81	2.75	2.58	2.94	2.48	2.59	3.02	2.90	2.63	2.87	2.48	2.40	**2.25**	2.48	2.66	2.67	2.61	2.66
	THM	**2.19**	**2.23**	**2.29**	2.43	**2.05**	2.45	2.53	**1.98**	**2.08**	**2.28**	**2.10**	2.42	2.46	2.81	2.58	**2.32**	**2.36**	2.44	**2.41**
	SPA	2.48	2.33	2.32	2.39	**2.07**	2.43	2.41	**2.18**	**2.22**	2.33	2.49	2.38	2.58	2.70	2.42	**2.38**	**2.38**	**2.36**	**2.30**
	ZERO	2.52	2.64	2.64	2.59	2.94	2.63	2.47	2.83	2.80	2.76	2.54	2.73	2.57	**2.24**	2.52	2.63	2.60	2.59	2.62
6	LIN	2.75	2.41	2.92	2.78	2.62	2.55	**2.11**	2.52	2.85	2.74	2.88	2.84	2.94	2.33	2.77	2.67	2.74	2.70	2.73
	THM	**2.20**	2.55	**2.10**	2.31	2.29	2.56	2.91	2.32	**2.24**	**2.08**	**1.98**	**2.12**	**2.05**	2.75	**2.22**	**2.31**	**2.23**	**2.24**	**2.26**
	SPA	**2.17**	2.58	**2.25**	**2.10**	2.56	2.30	2.91	2.59	**2.21**	**2.29**	**2.17**	**2.09**	**2.05**	2.67	2.39	**2.35**	**2.27**	**2.30**	**2.23**
	ZERO	2.88	2.47	2.73	2.81	2.52	2.59	**2.07**	2.57	2.70	2.89	2.97	2.95	2.96	**2.25**	2.62	2.67	2.76	2.76	2.77
7	LIN	2.52	2.38	2.79	2.49	2.62	2.97	2.44	2.53	2.71	2.68	2.88	3.03	2.64	2.31	2.70	2.65	2.71	2.69	2.76
	THM	2.45	2.63	**2.23**	2.58	2.46	**2.07**	2.50	2.43	2.33	**2.19**	**2.20**	**1.97**	**2.16**	2.75	2.38	**2.35**	**2.25**	**2.29**	**2.22**
	SPA	2.42	2.62	**2.25**	2.64	2.45	**2.05**	2.52	2.49	**2.29**	2.39	**2.07**	**2.08**	**2.18**	2.76	**2.06**	**2.35**	**2.30**	**2.36**	**2.23**
	ZERO	2.61	2.38	2.73	**2.28**	2.47	2.92	2.55	2.54	2.67	2.73	2.86	2.92	3.02	2.18	2.87	2.65	2.74	2.66	2.79

Table VI: Average ranks of one step ahead forecast errors (cont)

		Exports																	Imports	
Sec		AT	BE	CA	FI	FR	GE	GC	IR	IT	JP	NL	NO	SW	UK	US	agg	agg*	agg	agg*
8	LIN	2.73	**2.24**	2.74	2.95	3.03	2.35	2.65	2.72	2.80	2.93	2.86	2.74	2.58	2.76	2.92	2.73	2.80	2.74	2.75
	THM	2.30	2.78	2.30	**2.13**	**1.98**	2.68	2.41	**1.98**	**2.22**	**2.02**	**2.13**	2.33	2.44	**2.20**	**2.00**	**2.26**	**2.14**	**2.30**	**2.26**
	SPA	2.38	2.77	**2.17**	**1.94**	**2.16**	2.58	2.29	2.31	2.34	**2.03**	**2.10**	**2.22**	2.54	2.52	**2.09**	**2.30**	**2.21**	**2.30**	**2.30**
	ZERO	2.59	**2.21**	2.79	2.98	2.83	2.38	2.66	3.00	2.64	3.01	2.92	2.71	2.43	2.52	2.98	2.71	2.84	2.66	2.69
9	LIN	2.59	2.93	2.29	2.66	2.46	2.62	2.59	**2.32**	2.91	2.87	2.76	2.92	2.72	2.44	2.67	2.65	2.61	2.69	2.73
	THM	2.51	**1.96**	2.67	2.32	2.60	2.42	**2.30**	2.74	2.33	**2.22**	**2.01**	**1.98**	2.33	2.59	2.36	**2.36**	**2.40**	**2.31**	**2.28**
	SPA	2.40	**2.05**	2.76	2.45	2.49	2.32	**2.12**	2.77	**2.08**	2.37	2.53	**2.17**	**2.24**	2.48	**2.27**	**2.37**	**2.38**	**2.38**	**2.40**
	ZERO	2.50	3.06	**2.27**	2.58	2.45	2.64	2.99	**2.17**	2.67	2.55	2.70	2.94	2.71	2.48	2.70	2.63	2.62	2.63	2.60
agg	LIN	2.67	2.60	2.60	2.78	2.73	2.56	2.67	2.61	2.83	2.81	2.88	2.72	2.68	**2.44**	2.72	2.69	–	–	–
	THM	**2.29**	2.44	**2.40**	**2.29**	**2.28**	2.45	**2.36**	**2.33**	**2.26**	**2.12**	**2.08**	**2.25**	**2.26**	2.58	**2.32**	**2.31**	–	–	–
	SPA	**2.38**	2.46	2.44	**2.26**	**2.34**	**2.40**	**2.35**	2.46	**2.20**	**2.26**	**2.24**	**2.28**	**2.27**	2.57	**2.29**	**2.35**	–	–	–
	ZERO	2.67	2.51	2.57	2.67	2.66	2.59	2.62	2.60	2.70	2.81	2.80	2.75	2.79	**2.41**	2.67	2.65	–	–	–
agg*	LIN	2.62	2.62	2.65	2.89	2.74	2.70	2.68	2.74	2.84	2.82	2.95	2.88	2.66	2.49	2.75	–	2.74	–	–
	THM	**2.32**	2.43	**2.32**	**2.22**	**2.29**	**2.27**	**2.32**	**2.15**	**2.26**	**2.04**	**1.98**	**2.11**	**2.25**	2.55	**2.27**	–	**2.25**	–	–
	SPA	2.44	2.41	**2.36**	**2.17**	**2.32**	**2.27**	**2.41**	**2.38**	**2.24**	**2.18**	**2.17**	**2.16**	**2.25**	2.51	**2.24**	–	**2.30**	–	–
	ZERO	2.62	2.55	2.67	2.72	2.65	2.76	2.59	2.73	2.65	2.96	2.90	2.85	2.85	2.45	2.74	–	2.71	–	–
agg	LIN	2.71	–	2.79	2.77	2.72	2.58	2.72	2.56	2.70	2.71	2.76	2.75	2.76	2.68	2.75	–	–	2.71	–
	THM	**2.32**	–	**2.22**	**2.24**	**2.29**	**2.40**	**2.28**	2.44	**2.34**	**2.31**	**2.24**	**2.24**	**2.19**	**2.31**	**2.31**	–	–	**2.29**	–
	SPA	**2.28**	–	**2.20**	**2.24**	**2.31**	**2.43**	**2.31**	2.50	**2.34**	**2.31**	**2.26**	**2.30**	**2.29**	**2.35**	**2.33**	–	–	**2.32**	–
	ZERO	2.68	–	2.79	2.75	2.68	2.60	2.70	2.49	2.62	2.66	2.74	2.71	2.75	2.67	2.60	–	–	2.67	–
agg*	LIN	2.74	–	2.80	2.90	2.67	2.62	2.67	2.63	2.71	2.85	2.84	2.84	2.72	2.72	2.83	–	–	–	2.75
	THM	**2.34**	–	**2.22**	**2.15**	**2.34**	**2.38**	**2.34**	**2.44**	**2.34**	**2.16**	**2.19**	**2.15**	**2.26**	**2.24**	**2.21**	–	–	–	**2.27**
	SPA	**2.24**	–	**2.17**	**2.13**	**2.35**	**2.36**	**2.38**	**2.39**	**2.25**	**2.18**	**2.18**	**2.24**	**2.37**	**2.34**	**2.34**	–	–	–	**2.28**
	ZERO	2.68	–	2.81	2.82	2.63	2.63	2.61	2.54	2.71	2.81	2.78	2.76	2.65	2.70	2.63	–	–	–	2.70

Notes: Average ranks of one step ahead forecast errors in absolute value obtained from four competing forecasting schemes (LIN, THM, SPA, ZERO). Country and sector specific results are given for exports. agg and agg* denote unconditional aggregates and aggregates obtained over states of unusually low and high FX uncertainty, respectively. Results for imports are given on aggregate levels only. Bold entries indicate average ranks which are significantly smaller than 2.5.

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