Effects of Exchange Rate Volatility on the Volume and Volatility of Bilateral Exports*

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Abstract

We present an empirical investigation of a recently suggested but untested proposition that exchange rate volatility can have an impact on both the volume and variability of trade flows, considering a broad set of countries' bilateral real trade flows over the period 1980–1998. We generate proxies for the volatility of real trade flows and real exchange rates after carefully scrutinizing these variables' time series properties. Similar to the findings of earlier theoretical and empirical research, our first set of results show that the impact of exchange rate uncertainty on trade flows is indeterminate. Our second set of results provide new and novel findings that exchange rate volatility has a consistent positive and significant effect on the volatility of bilateral trade flows.

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1 Introduction

Since the breakdown of the Bretton Woods system of fixed exchange rates, a substantial body of theoretical and empirical literature has investigated the link between exchange rate volatility and international trade flows as this information contributes to our understanding of the transmission mechanism of exchange rate fluctuations on the economy. The general presumption is that an increase in exchange rate volatility will have an adverse affect on trade flows and consequently, the overall heath of the world economy. However, neither theoretical models nor empirical studies provide us with a definitive answer. An overview of the theoretical literature for the last two decades suggests that there is no clear-cut relationship one can pin down between exchange rate volatility and trade flows. Analytical results are based on specific assumptions and only hold in certain cases.[1]

Mirroring the diverse analytical findings, empirical research fails to reach firm conclusions: "...the substantial empirical literature examining the link between exchange-rate uncertainty and trade has not found a consistent relationship." (Bacchetta and van Wincoop (2000), p. 1093). The empirical results are, in general, sensitive to the choices of sample period, model specification, form of proxies for exchange rate volatility, and countries considered (developed versus developing).[2] More recently Baum, Caglayan and Ozkan (2004) rely on a nonlinear specification rather than linear alternatives while integrating the role of foreign income uncertainty in evaluating the impact of exchange rate uncertainty on trade flows. Although their findings for developed countries are mixed, a subsequent analysis by Grier and Smallwood (2006) using a group of developed and developing countries finds a significant role in developing countries' exports for exchange rate uncertainty as well as a strong role for income uncertainty in most countries.

In contrast to these studies, this paper presents an empirical investigation motivated by the theoretical findings of Barkoulas, Baum and Caglayan (2002) that exchange rate uncertainty should have an impact on both the *volume* and *variability* of trade flows. Our

[1]Several theoretical studies (Ethier (1973), Clark (1973), Baron (1976), Peree and Steinherr (1989)) have shown that an increase in exchange rate volatility will have adverse effects on the volume of international trade. Others, including Franke (1991), Sercu and Vanhulle (1992) have shown that exchange rate volatility may have a positive or ambiguous impact on the volume of international trade flows depending on aggregate exposure to currency risk (Viaene and deVries (1992)) and the types of shocks to which the firms are exposed (Barkoulas, Baum and Caglayan (2002)).

[2]Negative effects of exchange rate uncertainty on trade flows are recently reported by Arize, Osang and Slottje (2000), Sauer and Bohara (2001), while Gagnon (1993) finds insignificant effects. Baum, Caglayan and Ozkan (2004) report that the impact of exchange rate volatility on export flows differs in sign and magnitude across the countries studied.

investigation concentrates on bilateral trade flows between a broad set of data that contains information from 13 countries including the U.S., Canada, Germany, U.K., France, Italy, Japan, Finland, Netherlands, Norway, Spain, Sweden, and Switzerland for the period 1980–1998 on a monthly basis in each direction.[3] We investigate dozens of bilateral relationships and avoid the narrow focus on U.S. data or the G7 countries' data that has characterized much of the literature.

Our empirical work starts with a careful investigation of the time series properties of the real exchange rate and bilateral trade volume series.[4] We then implement a bivariate GARCH model on the exchange rate and trade volume data after transforming each series based on their specific time series properties (fractional differences *vs.* first differences *vs.* levels). Having generated internally consistent proxies for trade and exchange rate volatilities, we finally investigate the impact of exchange rate uncertainty on the volume and volatility of bilateral trade flows.

Our analysis reveals two sets of findings. The first set of findings shows that the relationship between exchange rate volatility and bilateral trade flows is indeterminate. We find that only 20 out of 156 models tested yield statistically significant steady-state effects of exchange rate volatility on the volume of trade flows. We find a positive relationship in 13 models and a negative relationship in seven models. This observation should not be too surprising as the recent empirical literature has recorded similar findings. Furthermore, these results are in line with the theoretical literature. Our second set of findings is new and novel as we provide empirical support to another proposition suggested in Barkoulas et al. (2002). Specifically, we show that exchange rate volatility has a meaningful empirical impact on the *volatility* of trade flows. We find that 84 out of 156 models tested provide support for a statistically significant steady-state effect of exchange rate volatility on trade volatility. We obtain a positive and significant relationship in 76 models and a negative and significant relationship in only eight models.

The rest of the paper is constructed as follows. Section 2 presents a variant of the Barkoulas et al. (2002) model and provides a theoretical basis for the empirical analysis. Section 3 discusses the data set and the empirical model that we employ. Section 4 documents our empirical findings while Section 5 concludes and draws implications for future theoretical and empirical research.

[3]The sample considered ends in December 1998 at the launch of the Euro.

[4]A preliminary analysis on these series, treated as nonstationary ($I(1)$) without confirmation, yielded irrelevant and spurious results for those series subsequently determined to exhibit non-unit-root behavior.

2 The Model

In this section we present a simplified version of the model that Barkoulas, Baum and Caglayan (2002) propose to investigate the effects of exchange rates on the level and variability of trade flows. The model assumes that each period exporters decide upon the quantities to export depending on the exchange rate level expected to prevail over the next period. The exchange rate, $\tilde{e}_t$, follows the random process given by

$$\tilde{e}_t = \bar{e} + \epsilon_t \tag{1}$$

where the mean of the process, $\bar{e}$, is publicly known. The stochastic component of the fundamentals follows $\epsilon_t = \rho\epsilon_{t-1} + \nu_t$ where $\nu_t \sim N(0, \sigma_\nu^2)$. Here, ν_t captures the information advantage policy makers have relative to the public over changes affecting the fundamentals.

Assuming that economic agents observe a noisy signal $S_t = \nu_t + \psi_t$ and that they know the fundamentals driving the exchange rate process ($\bar{e}, \rho$ and σ_ν^2), and ϵ_{t-1} at the beginning of each period, they may form the one-step-ahead forecast of the exchange rate that will prevail. The noise, ψ_t, is assumed to be normally distributed with mean zero and variance σ_ψ^2 ($\psi_t \sim N(0, \sigma_\psi^2)$) and is independent of the ν_t. Hence, the one-period ahead forecast of the exchange rate, conditional on the signal S_t takes the form: $E(\tilde{e}_t|S_t) = \bar{e} + \rho\epsilon_{t-1} + \lambda S_t$, where $\lambda = \frac{\sigma_\nu^2}{\sigma_\psi^2 + \sigma_\nu^2}$.

To find the impact of exchange rate on exports, we assume an expected utility function which is increasing in expected profits and decreasing in the variance of profits, conditional on the signal:

$$E\left(\tilde{U}|S_t\right) = E\left(\tilde{\pi}|S_t\right) - 1/2\ \gamma Var\left(\tilde{\pi}|S_t\right) \tag{2}$$

where the profit function is given as $\tilde{\pi} = (\tilde{e} - d)X - \frac{1}{2}X^2$. Here $d > 0$ and X and γ denote the volume of exports and the coefficient of risk aversion for exporters, respectively. Maximization of equation (2) with respect to X yields the optimal level of exports:

$$X = \frac{\bar{e} + \rho\epsilon_{t-1} + \lambda S_t - d}{1 + \gamma\lambda\sigma_\psi^2} \tag{3}$$

where $\bar{e} + \rho\epsilon_{t-1} + \lambda S_t > d$ is assumed to be satisfied for an economically meaningful (positive) optimal level of exports.

In contrast to other analytical studies, Barkoulas et al. (2002) investigate the impact of exchange rate volatility on trade flows because trade flow volatility "directly relates to smoothing the business cycle, which is an important argument in the macro welfare function" (2002, p. 471). We can readily obtain the variance of exports, for the stochastic nature of this variable is wholly derived from the signal S_t, conditional on other parameters and information known to the agent at time $t-1$. Hence, the variance of exports can be shown to be:

$$Var(X) = \frac{\lambda \sigma_{\nu}^2}{\left(1 + \gamma \sigma_{\psi}^2 \lambda\right)^2} \tag{4}$$

2.1 Impact of exchange rate uncertainty

Taking the derivatives of equations (3) and (4) with respect to σ_{ν}^2, we obtain simpler variants of the two relationships Barkoulas et al. (2002) discuss in their study. The first relationship is the impact of uncertainty on trade flows:

$$\frac{\partial X}{\partial \sigma_{\nu}^2} = \frac{\sigma_{\psi}^2}{\left(\sigma_{\psi}^2 + \sigma_{\nu}^2\right)^2} \frac{\left(1 + \gamma \lambda \sigma_{\psi}^2\right) S_t + \gamma \sigma_{\psi}^2 \left(d - \left(\bar{e} + \rho \epsilon_{t-1} + \lambda S_t\right)\right)}{\left(1 + \gamma \lambda \sigma_{\psi}^2\right)^2}. \tag{5}$$

This result implies that "[T]he effect of the variance of the stochastic elements in the fundamentals driving the exchange rate process on trade flows is ambiguous" (Barkoulas et al. (2002) p. 490) because the sign of the relationship depends on the behavior of the signal S_t. Next we look at the impact of volatility of the fundamentals in the exchange rate process on the volatility of trade flows:

$$\frac{\partial Var(X)}{\partial \sigma_{\nu}^2} = \lambda \frac{(2 - \lambda) + \gamma \lambda^2 \sigma_{\psi}^2}{\left(1 + \gamma \lambda \sigma_{\psi}^2\right)^3} > 0. \tag{6}$$

Here we have an unambiguous relationship: trade flow volatility is positively related to the variance of the fundamental forces driving the exchange rate process.

In what follows below, we discuss our data and the mechanism that generates measures of exchange rate and trade volatility as well as the model that we will implement to test for the linkages between exchange rate volatility and the mean and the variance of trade flows. As discussed below we find significant bivariate GARCH effects for every country considered in our sample for both the trade volume and real exchange rate series.

3 Data

Our primary empirical investigation is carried out with monthly data on bilateral aggregate real exports, in each direction, over the period between January 1980 and December 1998 for 13 countries: U.S., Canada, Germany, U.K., France, Italy, Japan, Finland, Netherlands, Norway, Spain, Sweden, and Switzerland. These data are constructed from bilateral export series available in the IMF's *Directions of Trade Statistics* (DOTS) and export price deflators, consumer price indices and monthly spot foreign exchange rates from the IMF's *International Financial Statistics* (IFS). The export data are expressed in current US dollars; they are converted to local currency units (LCU) using the spot exchange rate vis-à-vis the US dollar, and deflated by the country's export price deflator to generate real exports. The real exchange rate is computed from the spot exchange rate and the local and US consumer price indices, and is expressed in logarithmic form. Since the series entering the computation of the real exchange rate are not seasonally adjusted, the log(real exchange rate) series is adjusted using seasonal dummies.

As a control variable in our analysis we also use measures of foreign GDP extracted from *International Financial Statistics*. To match the monthly frequency of export data, we must generate a proxy for monthly foreign GDP as the available data is on a quarterly basis.[5] Hence, we apply the proportional Denton benchmarking technique (Bloem et al., 2001) to the quarterly real GDP series in order to produce monthly GDP estimates. The proportional Denton benchmarking technique uses the higher-frequency movements of an associated variable in our case monthly industrial production as an interpolator within the quarter, while enforcing the constraint that the sum of monthly GDP flows equals the observed quarterly total.

3.1 Generating proxies for the volatility of trade volumes and real exchange rates

In order to investigate the impact of real exchange rate uncertainty on the volume and volatility of trade flows, we must provide a proxy that captures the volatility of both the exchange rate and trade flow series. The volatility measures are estimated using a bivariate GARCH system for the real exchange rate and the volume of trade flow data.[6] This strategy allows us to estimate internally consistent conditional variances of both series which we use as proxies for exchange rate and trade flow volatility.

Prior to estimation of the GARCH system, it is crucial to scrutinize the time series properties of the data. Implementing the GARCH system without an appropriate char-

[5] Although it would be possible to use monthly industrial production itself to generate such a proxy, we chose not to use industrial production in that context, since it provides a limited measure of overall economic activity.

[6] Alternatively, it is possible to use a moving standard deviation of the series. However, this approach induces substantial serial correlation in the constructed series.

acterization of the order of integration of each series would lead to spurious conclusions. Consequently, we subject these series to a rigorous analysis of their order of integration, and find that many of them are not adequately characterized as unit root ($I(1)$) processes as has been commonly assumed in the literature. With this evidence, we apply appropriate transformations to each log trade volume and log real exchange rate series. Denoting the appropriately transformed log real exchange rate and log real export series by s_t and x_t respectively, the bivariate GARCH model for bilateral trade volumes and real exchange rates takes the following form:

$$s_t = \beta_0 + \beta_1 s_{t-1} + \beta_2 x_{t-1} + \beta_3 \epsilon_t + \beta_4 \epsilon_{t-1}, \quad (7)$$

$$x_t = \gamma_0 + \gamma_1 s_{t-1} + \gamma_2 x_{t-1} + \gamma_3 \nu_t + \gamma_4 \nu_{t-1}, \quad (8)$$

$$\mathbf{H}_t = \mathbf{C}'\mathbf{C} + \mathbf{A}' u_{t-1} u'_{t-1} \mathbf{A} + \mathbf{B}' \mathbf{H_{t-1}} \mathbf{B}. \quad (9)$$

Equation (7) defines the conditional mean of the log real exchange rate (s_t) as a function of its own lag and lagged trade volume as well as a first-order moving average innovation. To preserve symmetry, the conditional mean of log trade volume, x_t in equation (8), is defined in terms of its own lag and the lagged real exchange rate with a moving average innovation of order one. The vector of innovations is defined as $u_t = [\epsilon_t, \nu_t]'$. The diagonal elements of $\mathbf{H}_t$ are the conditional variances of log trade volume and log real exchange rate, respectively. The matrix $\mathbf{C}$ is parameterized as lower triangular, while matrices $\mathbf{A}$ and $\mathbf{B}$ are 2×2 matrices, so that there are therefore eleven estimated parameters in equation (9). We assume that the errors are jointly conditionally normal with zero means and conditional variances given by an ARMA(1,1) structure as expressed in equation (9). The system is estimated using the multivariate GARCH–BEKK model introduced by Karolyi (1995) as implemented in RATS 6.10.

3.2 Modeling the dynamics of the mean and the variance of trade flows

In this study, we investigate two sets of relationships. Both sets of relationships require us to introduce lags of the independent variables to capture the delayed effects in each relationship. In particular, earlier research has shown that there may be considerable lags associated with the impact of exchange rate volatility on trade flows. Furthermore, we must take into account the dynamics of the dependent variable arising from the time lags associated with agents' decisions to purchase and the completion of that transaction. Hence, these two issues require us to use an estimated model which is computationally tractable and yet sufficiently flexible to capture the dynamic pattern that exists between the variables.

We employ the following distributed lag structure to study the relationship between trade flows and exchange rate volatility:

$$x_t = \alpha + \gamma \sum_{j=1}^{6} \delta^j x_{t-j} + \beta_1 \sum_{j=1}^{6} \delta^j \sigma^2_{s_{t-j}} + \beta_2 \sum_{j=1}^{6} \delta^j \Delta y_{t-j} + \beta_3 \sum_{j=1}^{6} \delta^j s_{t-j} + \xi_t \tag{10}$$

where we introduce the first difference of log real GDP (Δy_t) of the importing country as a control variable in our basic equation.[7] The lag parameter δ is set to a specific value to ensure dynamic stability in that relationship while we estimate a single coefficient associated with each of the variables expressed in distributed lag form: γ, β_1, β_2 and β_3, respectively.[8]

To study the impact of exchange rate volatility on the variability of trade flows, we employ a similar model

$$\sigma^2_{x_t} = \alpha + \lambda \sum_{j=1}^{6} \delta^j \sigma^2_{x_{t-j}} + \phi_1 \sum_{j=1}^{6} \delta^j \sigma^2_{s_{t-j}} + \phi_2 \sum_{j=1}^{6} \delta^j \Delta y_{t-j} + \phi_3 \sum_{j=1}^{6} \delta^j s_{t-j} + \zeta_t \tag{11}$$

where the dependent variable is trade flow variability, $\sigma^2_{x_t}$. In this relationship we are interested in the sign and the significance of the coefficient of exchange rate volatility, $\sigma^2_{s_{t-j}}$. As control variables, we introduce the log real exchange rate (s_t) as well as the first difference of log real GDP (Δy_t) of the importing country into this basic relationship. Similar to the previous model of equation (10), we choose the lag parameter δ to ensure dynamic stability of the relationship.

4 Empirical results

4.1 Timeseries properties of trade volume and real exchange rate series

In the existing literature, it has commonly been assumed that trade volume series (real exports) and real exchange rates, in level or log form, are nonstationary ($I(1)$) processes given evidence from univariate unit root tests. Given that the low power of those tests to reject the unit root null is well known, it may be quite inappropriate to make a blanket assumption that all such bilateral series are properly characterized by a unit root. We find

[7] Unit root tests provide clear evidence that the y_t series is nonstationary.

[8] We tried different values for δ in the range of (0.3, 0.5). These results, which are available from the authors upon request, are similar to those we report here for $\delta = 0.4$. We also experimented with lag length, and found that six lags were sufficient to capture the series' dynamics.

that while few series appear to be stationary ($I(0)$) processes, there is significant evidence of fractional integration (long memory) behavior with $I(d), 0 < d < 1$ among the series.[9] As there is a meaningful difference in terms of predictability between unit root (random walk) processes and fractionally integrated processes, we treat those processes for which both $I(0)$ and $I(1)$ nulls can be rejected as fractional.

Our findings of significant departures from nonstationarity in the trade volume and real exchange rate series have strong implications for forecasting of these series. Under the unit root null commonly accepted in the literature, the level series are random walks, and their optimal forecast is the naïve (no-change) model. In contrast, long memory series exhibit greater persistence (and forecastability) than their "short-memory" (stationary) alternative. If a choice must be made between $I(0)$ and $I(1)$ behavior, the unit root null cannot be rejected for the preponderance of the trade volume and real exchange rate series. However, if the fractional alternative is considered, the unit root null (and absence of forecastability) can be decisively rejected for a significant number of these series.

We classify each of the trade volume and real exchange rate series as $I(0), I(d)$ or $I(1)$ given the results of tests against both stationary and nonstationary alternatives performed by the Stata routine *modlpr* (Baum and Wiggins, 2000). While only four out of 156 log real exchange rate series are stationary, 14 series are properly characterized as fractional, and the remaining 138 exhibit a simple unit root process ($I(1)$).[10] For the log trade flow series, 10 out of the 156 series are classified as stationary; 116 series contain a unit root while the remaining 30 series exhibit long memory properties, statistically distinguishable from both $I(0)$ and $I(1)$.[11]

Appendix Table A presents summary findings from our investigation of the order of integration of each of the bilateral trade flow and real exchange rate series. The $\hat{d}$ parameter is the point estimate of the order of integration generated by the *modlpr* routine. The *pval* values reflect the tests, respectively, for that parameter equalling zero (i.e., the series is $I(0)$) and unity (i.e., the series is $I(1)$). Based on these tests, the *Classif.* column specifies our determination of the order of integration. Those series classified as $I(d), d > 1$ have been differenced and then fractionally differenced by order $(d - 1)$.

[9] For a survey of the applications of fractionally integrated time series processes in economics, see Baillie (1996).

[10] Of the 14 fractional series, eight yield a d estimate significantly exceeding unity. Those series were first-differenced and then fractionally differenced with $d^* = d - 1$.

[11] Transformation of the series via fractional differencing was performed by Stata routine *fracdiff* (Baum, 2006) using the *modlpr* point estimate of d.

4.2 Generation of proxies for conditional variance

We have employed the bivariate GARCH model described above to estimate $\mathbf{H_t}$, the conditional covariance matrix of log real trade flows and log real exchange rates, for each point in time.[12] Although the conditional covariance between GARCH errors is not currently employed in our analysis, it is important to note that this measure of contemporaneous correlation is generally nonzero, signifying that estimation of Equations (7–9) as a system is the preferred approach to modeling the two conditional variances.

Table 1: Conditional variance and covariance estimates for US exports

Impt.	$\bar{\sigma}^2_{x_t}$	$\bar{\sigma}^2_{s_t}$	$\overline{covar}$	IQR $\sigma^2_{x_t}$	IQR $\sigma^2_{s_t}$	IQR covar
UK	0.0156	0.0011	-0.0008	0.0104	0.0006	0.0011
FR	0.0216	0.0010	-0.0010	0.0051	0.0000	0.0003
DE	0.0134	0.0011	-0.0007	0.0053	0.0004	0.0007
IT	0.0208	0.0010	-0.0008	0.0046	0.0005	0.0008
NL	0.0204	0.0011	-0.0007	0.0067	0.0003	0.0009
NO	0.0614	0.0009	-0.0003	0.0080	0.0003	0.0011
SE	0.0398	0.0012	-0.0009	0.0041	0.0005	0.0008
CH	0.0200	0.0013	-0.0011	0.0018	0.0003	0.0004
CA	0.0065	0.0002	0.0001	0.0004	0.0001	0.0001
JP	0.0103	0.0013	-0.0008	0.0015	0.0003	0.0006
FI	0.1095	0.0011	-0.0007	0.0226	0.0003	0.0019
ES	0.0420	0.0011	-0.0004	0.0194	0.0004	0.0013

We present two summary statistics, mean and interquartile range, for the three elements of the conditional covariance matrix: US exports in Table 1 and German exports in Table 2.[13] In each of these tables, it is evident that the conditional variances of trade flows—in terms of either mean or interquartile range across the sample—differ quite widely across partner countries, while the conditional variances (and IQRs) of real exchange rates for the US are similar for most countries with the exception of Canada (perhaps reflecting the close economic relationship between those NAFTA partners). The conditional covariance is negative for all partners except Canada. Similarly, the conditional variance of German real exports is very small for partner countries Netherlands, France and Switzerland, and an order of magnitude larger for non-European partners US, Canada and Japan. The IQR of the conditional variance of German real exports is exceedingly small for the

[12] Detailed estimation results from the bivariate GARCH models are available on request from the authors.

[13] These statistics for the other 11 exporting countries are available on request.

Table 2: Conditional variance and covariance estimates for DE exports

Impt.	$\bar{\sigma}^2_{x_t}$	$\bar{\sigma}^2_{s_t}$	$\overline{covar}$	IQR $\sigma^2_{x_t}$	IQR $\sigma^2_{s_t}$	IQR covar
US	0.0091	0.0011	0.0002	0.0028	0.0001	0.0005
UK	0.0127	0.0006	-0.0000	0.0043	0.0002	0.0006
FR	0.0183	0.0001	-0.0002	0.0030	0.0000	0.0001
IT	0.0283	0.0004	0.0003	0.0037	0.0002	0.0004
NL	0.0092	0.0000	-0.0001	0.0001	0.0000	0.0000
NO	0.0247	0.0003	0.0007	0.0044	0.0002	0.0010
SE	0.0125	0.0005	-0.0001	0.0010	0.0001	0.0002
CH	0.0125	0.0002	-0.0001	0.0027	0.0001	0.0002
CA	0.0231	0.0012	0.0003	0.0058	0.0002	0.0007
JP	0.0138	0.0009	-0.0002	0.0048	0.0003	0.0002
FI	0.0195	0.0004	0.0004	0.0069	0.0003	0.0009
ES	0.0466	0.0003	0.0004	0.0046	0.0002	0.0005

Netherlands, perhaps reflecting the close monetary links between those partners during the sample period.

4.3 Regression results

In this section we initially discuss our regression results on the effects of exchange rate volatility on trade flows. We then focus on the role of exchange rate volatility on trade flow volatility. In our discussion, we concentrate on the sign and the significance of point and interval estimates of β_1 and ϕ_1, obtained from equations (10) and (11), along with their corresponding steady state values, to explain the effects of exchange rate volatility on the mean and variance of trade flows, respectively. We compute the steady state $\hat{\beta}_1^{SS} = \left(\hat{\beta}_1 \sum_{j=1}^{6} \delta^j\right) / \left(1 - \hat{\gamma} \sum_{j=1}^{6} \delta^j\right)$ and the steady state $\hat{\phi}_1^{SS} = \left(\hat{\phi}_1 \sum_{j=1}^{6} \delta^j\right) / \left(1 - \hat{\lambda} \sum_{j=1}^{6} \delta^j\right)$.

Given that we estimate dozens of bilateral relationships, Appendix Table B details the parameter estimates for each bilateral relationship. This table presents the exporting country (in the order U.S., U.K., France, Germany, Italy, Netherlands, Norway, Sweden, Switzerland, Canada, Japan, Finland, Spain) and its trading partner, the impact of exchange rate volatility on trade, $\hat{\beta}_1$, the steady state impact of exchange rate volatility on trade flows $\hat{\beta}_1^{SS}$, the impact of exchange rate volatility on trade volatility, $\hat{\phi}_1$ and the steady state impact of exchange rate volatility on trade volatility, $\hat{\phi}_1^{SS}$, as well as their corresponding p-values. Using this table, we provide and discuss the summary statistics pertaining to each exporting country in Tables 3 and 4 below.

Table 3: Coefficient estimates and impact of β_1

Expt.	*# Sig.*	*med sig* $\hat{\beta}_1$	*# Sig.*	*med sig* $\hat{\beta}_1^{SS}$	*Impact*
US	2	154.294	2	106.017	0.109
UK	1	278.527	1	395.592	0.309
FR	2	692.414	2	262.969	0.133
DE	1	370.864	1	173.544	0.085
IT	3	246.962	3	101.681	0.062
NL	1	921.117	1	657.932	0.381
NO	2	-202.251	3	-51.748	-0.027
SE	2	-8.350	2	-4.312	-0.003
CH	0		0		
CA	2	-165.442	2	-67.063	-0.072
JP	0		0		
FI	2	-60.749	2	-32.956	-0.022
ES	1	178.803	1	136.109	0.085

Table 3 presents summary information on our first set of results regarding the linkages between exchange rate volatility and trade flows from the exporter's perspective. The first column gives the exporting country in the order above. In column two we display the number of times (out of a possible 12) that the impact of exchange rate uncertainty on trade flows is distinguishable from zero at the five per cent level, followed by the median value of $\hat{\beta}_1$ when it is significantly different from zero. In the fourth column we present the number of times that the corresponding steady state impact of exchange rate volatility on trade flows is significant at five per cent. Column five presents the median $\hat{\beta}_1^{SS}$ when the coefficient is significant. Finally the last column gives the overall impact of exchange rate uncertainty on trade flows in percentage terms, computed as $\left(\hat{\beta}_1^{SS} \cdot \bar{\sigma}^2_{s_t}\right)$. This quantity measures the impact of a 100 per cent increase in exchange rate volatility on the transformed log level of trade flows.

Observing the table, the first feature one notices is that the sign of the median significant $\hat{\beta}_1$ and that of its steady-state value is positive in seven cases and negative in four cases. Scrutiny of Appendix Table B indicates that the greatest number of significant positive effects (3) is registered by Italy and that of significant negative effects (2) is registered by Norway and Canada.

An evaluation of the literature reveals that researchers investigating the association between exchange rate volatility and trade flows have generally concluded that the there is no systematic relationship between the two variables. We arrive at a similar observation. When we consider the entire set of 156 bilateral models, we observe that only 20 out of 156 models yield statistically significant steady-state effects of exchange rate volatility on the volume of trade flows. We find a positive relationship in 13 models and a negative relationship in seven models.[14] In the last column, we look at the impact of exchange rate uncertainty on trade flows using the median steady state value of the impact of exchange rate volatility on trade flows. Overall, we observe that this effect ranges between $(-0.072, 0.381)$: a 100% increase in uncertainty can lead to about a 7% fall in trade flows for Canada while it can lead to an expansion of 38% for the Netherlands. The average impact across all countries is around 9.4%. In summary, these results suggest that although the sign of exchange rate uncertainty on trade is indeterminate there seems to be a positive impact of exchange rate uncertainty on trade for the countries that are considered here.

Table 4: Coefficient estimates and impact of ϕ_1

Expt.	*# Sig.*	*med sig* $\hat{\phi}_1$	*# Sig.*	*med sig* $\hat{\phi}_1^{SS}$	*% Impact*
US	7	7.837	7	7.424	24.119
UK	3	0.696	4	21.591	11.657
FR	6	27.221	6	14.132	20.632
DE	3	25.574	3	11.547	29.476
IT	5	4.533	5	3.118	4.248
NL	7	13.536	8	7.134	14.839
NO	4	93.589	4	67.997	25.044
SE	7	10.274	7	5.079	9.377
CH	11	14.269	11	9.025	8.821
CA	10	7.500	10	7.506	12.735
JP	7	22.993	7	16.784	46.739
FI	4	29.554	5	7.540	7.959
ES	6	15.948	7	8.130	6.710

Table 4 presents summary information on our second set of results explaining the linkages between exchange rate volatility and trade flow volatility from the exporter's perspective. The setup of the table is similar to that of Table 3 with one exception. Given that the dependent variable in equation (11) is the variability of trade flows and not its logarithm, we present a percentage impact measure in the last column. That is, the impact of a 100 per cent increase in exchange rate volatilty on trade flow volatility is computed

[14] At the ten per cent level of significance, we find 30 nonzero coefficients: 14 positive, 16 negative.

as $100\left(\hat{\beta}_1^{SS} \cdot \bar{\sigma}_{s_t}^2 / \bar{\sigma}_{x_t}^2\right)$ which expresses the impact as a percentage of the mean volatility of trade flows. The results we display here are new and novel as we provide empirical support to another proposition suggested in Barkoulas et al. (2002) which has not been tested. Specifically, we show that exchange rate volatility has a meaningful empirical impact on the *volatility* of trade flows. We find that 84 out of 156 models tested provide support for a statistically significant steady-state effect of exchange rate volatility on trade volatility. We obtain a positive and significant relationship in 76 models and a negative and significant relationship in only eight models.[15] Once again, scrutiny of Appendix Table B indicates that the greatest number of significant effects (11) is registered by Switzerland of which we observe nine positive and two negative relationships. Canada scores the second highest number of significant effects after Switzerland, registering seven positive and three negative significant relationships.

The overall impact of a 100% increase in exchange rate volatility on trade volatility has a mean estimated value of 17.1%, ranging from 4.2% for Italy to 46.7% for Japan. The mean effects are consistently positive. These findings have strong implications for both the behavior of exporters and forecasters. For exporters, these sizable changes in the volatility of trade flows will have marked effects on the value of their real options to export. Although those option values are only one of the countervailing forces on the volume of trade, the effects we detect are sizable enough to play a role in the expansion or contraction of trade. Likewise, these findings suggest that the predictability of trade flows will vary inversely with exchange rate volatility. The reliability of any forecasting model of trade volume will be weakened in times of heightened exchange rate volatility.

5 Conclusions

In this paper, we investigate the impact of exchange rates on the level and volatility of trade flows for a broad set of bilateral data. We first show that a sizable number of bilateral trade volume and real exchange rate series are not properly characterized as unit root processes, and we produce appropriate fractionally differenced forms of those series where the unit root hypothesis (and that of stationarity) is clearly rejected. Improper classification of these series as unit root processes may have caused a number of studies in the literature to reach erroneous conclusions.

We then generate internally consistent measures of trade and exchange rate volatility employing a bivariate GARCH methodology. Using these proxies, we investigate the impact

[15] At the ten per cent level of significance, we find 91 nonzero coefficients: 82 positive, nine negative.

of exchange rate volatility on the mean and the variance of trade flows as suggested by Barkoulas, Baum and Caglayan (2002). Our first set of results suggest that the impact of exchange rate volatility on trade flows is indeterminate. Only for a handful of models (20 out of 156) do we obtain significant relationships: significant and positive in 13 models and significantly negative in the remaining seven models. Given the earlier theoretical and empirical findings in the literature, these findings are not surprising.

Our second set of findings is new and novel as we provide empirical support to a proposition of Barkoulas et al. (2002). We empirically show that for 84 out of 156 potential models exchange rate volatility turns out to have a meaningful steady-state impact on the volatility of trade flows. In particular, we obtain a positive and significant relationship in 76 models and a negative and significant relationship in only eight models. These consistent findings have important implications for both exporters and those engaged in forecasting international trade flows. Coupled with earlier findings from the literature, these results suggest that further investigation of the effects of exchange rate volatility on developed countries' *trade volume* is not likely to be fruitful. In contrast, the strong interactions we have detected among the *volatilities* of real exchange rates and trade volumes imply that further study of this relationship may be warranted, particularly with regard to the trade flows between developed and developing countries.

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Table A. Classification of integration order of log real exports and log real exchange rate

		log[Real Exports]				log[Real Exchange Rate]			
Expt.	Impt.	$\hat{d}$	$pval[I(0)]$	$pval[I(1)]$	Classif.	$\hat{d}$	$pval[I(0)]$	$pval[I(1)]$	Classif.
US	UK	0.575	0.004	0.010	I(d)	0.819	0.001	0.276	I(1)
US	FR	1.112	0.005	0.500	I(1)	1.037	0.000	0.825	I(1)
US	DE	1.059	0.000	0.723	I(1)	1.046	0.000	0.783	I(1)
US	IT	1.092	0.002	0.580	I(1)	1.082	0.000	0.620	I(1)
US	NL	0.595	0.003	0.014	I(d)	1.007	0.000	0.965	I(1)
US	NO	0.775	0.000	0.174	I(1)	1.066	0.000	0.692	I(1)
US	SE	1.103	0.002	0.534	I(1)	1.446	0.000	0.007	I(d)
US	CH	0.644	0.002	0.031	I(d)	0.903	0.000	0.560	I(1)
US	CA	0.864	0.000	0.410	I(1)	1.633	0.000	0.000	I(d)
US	JP	1.256	0.000	0.122	I(1)	1.402	0.001	0.015	I(d)
US	FI	0.654	0.034	0.037	I(d)	1.226	0.000	0.173	I(1)
US	ES	0.675	0.000	0.050	I(d)	1.141	0.000	0.395	I(1)
UK	US	1.004	0.000	0.980	I(1)	0.819	0.001	0.276	I(1)
UK	FR	0.917	0.000	0.614	I(1)	0.826	0.000	0.293	I(1)
UK	DE	0.829	0.010	0.301	I(1)	0.807	0.000	0.245	I(1)
UK	IT	0.776	0.007	0.176	I(1)	1.006	0.000	0.970	I(1)
UK	NL	0.652	0.008	0.036	I(d)	0.758	0.000	0.143	I(1)
UK	NO	0.655	0.009	0.037	I(d)	1.144	0.000	0.384	I(1)
UK	SE	0.925	0.004	0.649	I(1)	0.947	0.000	0.750	I(1)
UK	CH	0.887	0.000	0.495	I(1)	0.906	0.000	0.570	I(1)
UK	CA	0.774	0.003	0.173	I(1)	0.951	0.000	0.768	I(1)
UK	JP	1.081	0.000	0.627	I(1)	1.086	0.001	0.602	I(1)
UK	FI	0.835	0.002	0.318	I(1)	1.177	0.000	0.284	I(1)
UK	ES	-0.049	0.748	0.000	I(0)	0.751	0.013	0.132	I(1)
FR	US	0.624	0.011	0.023	I(d)	1.037	0.000	0.825	I(1)
FR	UK	0.717	0.007	0.088	I(1)	0.826	0.000	0.293	I(1)
FR	DE	1.080	0.000	0.628	I(1)	0.952	0.000	0.772	I(1)
FR	IT	0.894	0.000	0.522	I(1)	1.020	0.000	0.904	I(1)
FR	NL	0.459	0.114	0.001	I(0)	0.939	0.000	0.713	I(1)
FR	NO	0.698	0.003	0.068	I(1)	0.467	0.122	0.001	I(0)
FR	SE	0.825	0.002	0.290	I(1)	0.797	0.000	0.220	I(1)
FR	CH	1.091	0.000	0.583	I(1)	0.821	0.003	0.281	I(1)
FR	CA	0.943	0.001	0.731	I(1)	0.945	0.001	0.738	I(1)
FR	JP	1.161	0.000	0.330	I(1)	0.922	0.001	0.638	I(1)
FR	FI	0.781	0.000	0.186	I(1)	0.989	0.001	0.949	I(1)
FR	ES	0.609	0.005	0.018	I(d)	1.029	0.000	0.859	I(1)
DE	US	0.848	0.001	0.360	I(1)	1.046	0.000	0.783	I(1)
DE	UK	1.152	0.002	0.359	I(1)	0.807	0.000	0.245	I(1)
DE	FR	1.090	0.000	0.588	I(1)	0.952	0.000	0.772	I(1)

Appendix Table A, continued

		log[Real Exports]				log[Real Exchange Rate]			
Expt.	Impt.	$\hat{d}$	$pval[I(0)]$	$pval[I(1)]$	Classif.	$\hat{d}$	$pval[I(0)]$	$pval[I(1)]$	Classif.
DE	IT	0.925	0.000	0.651	I(1)	1.120	0.001	0.467	I(1)
DE	NL	0.604	0.003	0.017	I(d)	1.059	0.000	0.722	I(1)
DE	NO	0.570	0.009	0.009	I(d)	0.535	0.002	0.005	I(d)
DE	SE	0.918	0.000	0.620	I(1)	0.857	0.001	0.387	I(1)
DE	CH	1.192	0.000	0.247	I(1)	0.701	0.029	0.071	I(1)
DE	CA	1.078	0.000	0.635	I(1)	0.844	0.001	0.347	I(1)
DE	JP	1.121	0.000	0.467	I(1)	0.931	0.000	0.677	I(1)
DE	FI	0.831	0.006	0.307	I(1)	1.021	0.000	0.901	I(1)
DE	ES	0.752	0.002	0.134	I(1)	1.150	0.000	0.367	I(1)
IT	US	0.610	0.009	0.019	I(d)	1.082	0.000	0.620	I(1)
IT	UK	0.904	0.001	0.562	I(1)	1.006	0.000	0.970	I(1)
IT	FR	1.059	0.000	0.724	I(1)	1.020	0.000	0.904	I(1)
IT	DE	1.120	0.000	0.470	I(1)	1.120	0.001	0.467	I(1)
IT	NL	0.764	0.002	0.154	I(1)	1.145	0.000	0.380	I(1)
IT	NO	0.480	0.007	0.002	I(d)	0.910	0.000	0.585	I(1)
IT	SE	0.773	0.000	0.171	I(1)	0.992	0.014	0.962	I(1)
IT	CH	1.116	0.000	0.484	I(1)	0.969	0.000	0.851	I(1)
IT	CA	1.196	0.000	0.238	I(1)	0.706	0.002	0.075	I(1)
IT	JP	1.108	0.000	0.515	I(1)	0.974	0.003	0.874	I(1)
IT	FI	0.610	0.005	0.019	I(d)	0.402	0.221	0.000	I(0)
IT	ES	1.087	0.000	0.599	I(1)	1.171	0.001	0.303	I(1)
NL	US	0.698	0.002	0.068	I(1)	1.007	0.000	0.965	I(1)
NL	UK	0.912	0.002	0.595	I(1)	0.758	0.000	0.143	I(1)
NL	FR	0.952	0.000	0.773	I(1)	0.939	0.000	0.713	I(1)
NL	DE	0.908	0.001	0.577	I(1)	1.059	0.000	0.722	I(1)
NL	IT	0.729	0.000	0.102	I(1)	1.145	0.000	0.380	I(1)
NL	NO	0.408	0.032	0.000	I(d)	0.694	0.003	0.064	I(1)
NL	SE	0.715	0.005	0.085	I(1)	0.928	0.000	0.665	I(1)
NL	CH	1.009	0.000	0.958	I(1)	0.999	0.001	0.993	I(1)
NL	CA	0.832	0.013	0.309	I(1)	0.975	0.003	0.881	I(1)
NL	JP	1.057	0.000	0.729	I(1)	0.968	0.000	0.847	I(1)
NL	FI	0.754	0.001	0.138	I(1)	1.088	0.001	0.596	I(1)
NL	ES	0.607	0.023	0.018	I(d)	1.192	0.000	0.247	I(1)
NO	US	0.374	0.084	0.000	I(0)	1.066	0.000	0.692	I(1)
NO	UK	0.889	0.000	0.504	I(1)	1.144	0.000	0.384	I(1)
NO	FR	0.301	0.084	0.000	I(0)	0.467	0.122	0.001	I(0)
NO	DE	0.677	0.000	0.051	I(1)	0.535	0.002	0.005	I(d)
NO	IT	0.875	0.091	0.451	I(1)	0.910	0.000	0.585	I(1)
NO	NL	0.836	0.006	0.322	I(1)	0.694	0.003	0.064	I(1)

Appendix Table A, continued

		log[Real Exports]				log[Real Exchange Rate]			
Expt.	Impt.	$\hat{d}$	$pval[I(0)]$	$pval[I(1)]$	Classif.	$\hat{d}$	$pval[I(0)]$	$pval[I(1)]$	Classif.
NO	SE	0.823	0.008	0.284	I(1)	0.966	0.000	0.836	I(1)
NO	CH	0.796	0.001	0.218	I(1)	0.620	0.001	0.022	I(d)
NO	CA	0.287	0.045	0.000	I(d)	0.849	0.002	0.363	I(1)
NO	JP	0.225	0.442	0.000	I(0)	0.768	0.005	0.162	I(1)
NO	FI	0.845	0.027	0.349	I(1)	1.352	0.000	0.034	I(d)
NO	ES	0.418	0.188	0.000	I(0)	0.851	0.001	0.368	I(1)
SE	US	0.892	0.006	0.515	I(1)	1.446	0.000	0.007	I(d)
SE	UK	0.725	0.000	0.097	I(1)	0.947	0.000	0.750	I(1)
SE	FR	0.685	0.011	0.057	I(1)	0.797	0.000	0.220	I(1)
SE	DE	0.992	0.000	0.960	I(1)	0.857	0.001	0.387	I(1)
SE	IT	1.007	0.000	0.967	I(1)	0.992	0.014	0.962	I(1)
SE	NL	0.859	0.002	0.395	I(1)	0.928	0.000	0.665	I(1)
SE	NO	0.796	0.000	0.218	I(1)	0.966	0.000	0.836	I(1)
SE	CH	0.846	0.001	0.351	I(1)	0.806	0.000	0.240	I(1)
SE	CA	0.728	0.014	0.101	I(1)	1.145	0.000	0.382	I(1)
SE	JP	1.229	0.001	0.167	I(1)	1.046	0.001	0.783	I(1)
SE	FI	1.005	0.001	0.974	I(1)	1.048	0.000	0.773	I(1)
SE	ES	0.263	0.358	0.000	I(0)	0.470	0.007	0.001	I(d)
CH	US	0.375	0.040	0.000	I(d)	0.903	0.000	0.560	I(1)
CH	UK	0.682	0.000	0.055	I(1)	0.906	0.000	0.570	I(1)
CH	FR	0.705	0.002	0.074	I(1)	0.821	0.003	0.281	I(1)
CH	DE	1.454	0.000	0.006	I(d)	0.701	0.029	0.071	I(1)
CH	IT	0.983	0.001	0.916	I(1)	0.969	0.000	0.851	I(1)
CH	NL	0.237	0.362	0.000	I(0)	0.999	0.001	0.993	I(1)
CH	NO	0.294	0.117	0.000	I(0)	0.620	0.001	0.022	I(d)
CH	SE	0.974	0.001	0.873	I(1)	0.806	0.000	0.240	I(1)
CH	CA	0.457	0.018	0.001	I(d)	0.802	0.001	0.232	I(1)
CH	JP	1.301	0.000	0.069	I(1)	0.915	0.001	0.610	I(1)
CH	FI	1.057	0.000	0.732	I(1)	0.992	0.000	0.963	I(1)
CH	ES	0.658	0.002	0.039	I(d)	0.999	0.000	0.996	I(1)
CA	US	0.802	0.001	0.232	I(1)	1.633	0.000	0.000	I(d)
CA	UK	0.861	0.016	0.402	I(1)	0.951	0.000	0.768	I(1)
CA	FR	0.716	0.001	0.087	I(1)	0.945	0.001	0.738	I(1)
CA	DE	0.833	0.000	0.314	I(1)	0.844	0.001	0.347	I(1)
CA	IT	0.974	0.000	0.876	I(1)	0.706	0.002	0.075	I(1)
CA	NL	0.954	0.000	0.781	I(1)	0.975	0.003	0.881	I(1)
CA	NO	0.695	0.004	0.066	I(1)	0.849	0.002	0.363	I(1)
CA	SE	1.089	0.001	0.590	I(1)	1.145	0.000	0.382	I(1)
CA	CH	0.509	0.009	0.003	I(d)	0.802	0.001	0.232	I(1)

Appendix Table A, continued

		log[Real Exports]				log[Real Exchange Rate]			
Expt.	Impt.	$\hat{d}$	$pval[I(0)]$	$pval[I(1)]$	Classif.	$\hat{d}$	$pval[I(0)]$	$pval[I(1)]$	Classif.
CA	JP	0.813	0.015	0.258	I(1)	1.083	0.001	0.615	I(1)
CA	FI	0.865	0.003	0.415	I(1)	0.964	0.103	0.827	I(1)
CA	ES	1.009	0.001	0.959	I(1)	0.927	0.000	0.660	I(1)
JP	US	0.958	0.001	0.801	I(1)	1.402	0.001	0.015	I(d)
JP	UK	1.043	0.000	0.794	I(1)	1.086	0.001	0.602	I(1)
JP	FR	1.111	0.000	0.504	I(1)	0.922	0.001	0.638	I(1)
JP	DE	1.496	0.000	0.003	I(d)	0.931	0.000	0.677	I(1)
JP	IT	1.433	0.000	0.009	I(d)	0.974	0.003	0.874	I(1)
JP	NL	0.834	0.000	0.316	I(1)	0.968	0.000	0.847	I(1)
JP	NO	0.587	0.008	0.013	I(d)	0.768	0.005	0.162	I(1)
JP	SE	1.017	0.000	0.920	I(1)	1.046	0.001	0.783	I(1)
JP	CH	1.073	0.000	0.660	I(1)	0.915	0.001	0.610	I(1)
JP	CA	1.088	0.000	0.595	I(1)	1.083	0.001	0.615	I(1)
JP	FI	0.786	0.002	0.195	I(1)	0.954	0.002	0.779	I(1)
JP	ES	0.434	0.029	0.001	I(d)	1.137	0.005	0.408	I(1)
FI	US	0.723	0.003	0.094	I(1)	1.226	0.000	0.173	I(1)
FI	UK	0.839	0.000	0.331	I(1)	1.177	0.000	0.284	I(1)
FI	FR	0.833	0.002	0.313	I(1)	0.989	0.001	0.949	I(1)
FI	DE	1.094	0.000	0.571	I(1)	1.021	0.000	0.901	I(1)
FI	IT	1.138	0.000	0.406	I(1)	0.402	0.221	0.000	I(0)
FI	NL	0.730	0.000	0.102	I(1)	1.088	0.001	0.596	I(1)
FI	NO	0.714	0.001	0.084	I(1)	1.352	0.000	0.034	I(d)
FI	SE	0.770	0.004	0.165	I(1)	1.048	0.000	0.773	I(1)
FI	CH	0.716	0.005	0.086	I(1)	0.992	0.000	0.963	I(1)
FI	CA	0.604	0.018	0.017	I(d)	0.964	0.103	0.827	I(1)
FI	JP	1.137	0.001	0.409	I(1)	0.954	0.002	0.779	I(1)
FI	ES	0.358	0.105	0.000	I(0)	0.851	0.000	0.368	I(1)
ES	US	0.907	0.001	0.575	I(1)	1.141	0.000	0.395	I(1)
ES	UK	0.718	0.003	0.089	I(1)	0.751	0.013	0.132	I(1)
ES	FR	0.730	0.002	0.103	I(1)	1.029	0.000	0.859	I(1)
ES	DE	1.247	0.000	0.135	I(1)	1.150	0.000	0.367	I(1)
ES	IT	1.194	0.000	0.240	I(1)	1.171	0.001	0.303	I(1)
ES	NL	0.806	0.000	0.242	I(1)	1.192	0.000	0.247	I(1)
ES	NO	0.625	0.000	0.024	I(d)	0.851	0.001	0.368	I(1)
ES	SE	1.109	0.000	0.510	I(1)	0.470	0.007	0.001	I(d)
ES	CH	0.556	0.034	0.007	I(d)	0.999	0.000	0.996	I(1)
ES	CA	0.910	0.000	0.588	I(1)	0.927	0.000	0.660	I(1)
ES	JP	1.451	0.000	0.007	I(d)	1.137	0.005	0.408	I(1)
ES	FI	1.079	0.000	0.635	I(1)	0.851	0.000	0.368	I(1)

Table B. Regression estimates of β_1, ϕ_1

		Real export equation				Variance of real export equation			
Expt.	Impt.	$\hat{\beta}_1$	*pval*	$\hat{\beta}_1^{SS}$	*pval*	$\hat{\phi}_1$	*pval*	$\hat{\phi}_1^{SS}$	*pval*
US	UK	103.3337	0.008	83.8417	0.002	7.8370	0.008	7.4243	0.000
US	FR	-519.6215	0.211	-201.6121	0.208	119.3401	0.000	72.6998	0.000
US	DE	-23.8024	0.522	-9.2032	0.520	20.5725	0.000	9.5330	0.000
US	IT	26.1070	0.371	9.9905	0.371	2.2558	0.006	2.5990	0.003
US	NL	18.3681	0.748	14.0985	0.748	0.3900	0.826	0.4886	0.825
US	NO	-37.8373	0.377	-15.1473	0.374	5.8683	0.005	4.5626	0.003
US	SE	34.1978	0.157	15.0978	0.153	-0.3737	0.498	-0.2607	0.509
US	CH	205.2539	0.000	128.1923	0.000	0.4563	0.691	0.2824	0.684
US	CA	102.6969	0.305	50.4083	0.301	2.5140	0.031	1.7356	0.022
US	JP	-26.7986	0.446	-10.2121	0.441	0.2211	0.773	0.1672	0.767
US	FI	-101.3692	0.071	-43.6677	0.073	6.2791	0.397	5.7345	0.388
US	ES	7.9572	0.820	4.3731	0.820	34.0219	0.000	23.4086	0.000
UK	US	-47.4579	0.121	-21.7696	0.127	0.6063	0.632	0.4128	0.625
UK	FR	65.9681	0.162	27.2500	0.162	0.7339	0.472	0.6642	0.463
UK	DE	-74.0797	0.072	-31.9119	0.071	0.6963	0.000	1.2787	0.000
UK	IT	146.9991	0.131	54.6242	0.129	-1.8243	0.772	-1.2250	0.775
UK	NL	92.8041	0.382	67.7022	0.373	3.2034	0.199	4.1938	0.164
UK	NO	-27.8727	0.259	-21.3762	0.243	1.3685	0.509	0.9736	0.500
UK	SE	-29.9305	0.387	-11.9774	0.386	-1.6318	0.515	-1.3369	0.526
UK	CH	-544.2749	0.083	-216.1605	0.089	32.2678	0.000	41.9034	0.000
UK	CA	-4.9579	0.902	-2.1280	0.902	-1.3057	0.347	-2.1053	0.356
UK	JP	9.9852	0.517	3.8188	0.517	0.8602	0.245	0.6491	0.213
UK	FI	3.6079	0.974	1.4291	0.974	-88.8993	0.023	-78.6483	0.031
UK	ES	278.5274	0.005	395.5920	0.005	21316.2457	0.138	8513.8091	0.006
FR	US	-12.0625	0.895	-11.5212	0.895	2.5012	0.022	3.8739	0.014
FR	UK	19.9777	0.674	8.3158	0.673	27.5521	0.000	17.1770	0.000
FR	DE	-87.4248	0.007	-37.8022	0.008	0.2916	0.105	0.5614	0.102
FR	IT	28.5183	0.400	10.5461	0.400	0.5098	0.584	0.3626	0.569
FR	NL	207.5288	0.648	340.1703	0.650	-32.2309	0.350	-26.5787	0.386
FR	NO	-7.5063	0.950	-3.0052	0.950	496.8816	0.000	233.8855	0.000
FR	SE	49.5603	0.257	24.4489	0.264	-18.4444	0.000	-19.9917	0.008
FR	CH	1472.2525	0.000	563.7397	0.000	-0.5312	0.954	-0.3496	0.953
FR	CA	-241.9200	0.702	-93.7576	0.701	-7.1732	0.814	-5.7025	0.816
FR	JP	-4.5557	0.943	-1.9331	0.943	26.8890	0.000	12.2468	0.000
FR	FI	-10.9376	0.864	-4.6734	0.864	-1.2273	0.922	-1.0345	0.922
FR	ES	-14.0895	0.917	-7.2822	0.917	28.2462	0.004	16.0169	0.000
DE	US	35.1712	0.739	16.3653	0.739	25.5738	0.011	11.5470	0.000
DE	UK	-26.2196	0.597	-10.3736	0.596	-0.3210	0.806	-0.4879	0.808
DE	FR	249.3127	0.663	106.3976	0.660	-4.7810	0.864	-3.3018	0.865

Appendix Table B, continued

Expt.	Impt.	Real export equation $\hat{\beta}_1$	*pval*	$\hat{\beta}_1^{SS}$	*pval*	Variance of real export equation $\hat{\phi}_1$	*pval*	$\hat{\phi}_1^{SS}$	*pval*
DE	IT	3.2980	0.906	1.1954	0.906	5.5246	0.167	3.4753	0.129
DE	NL	-528.5679	0.387	-612.1704	0.379	-0.8986	0.156	-0.6305	0.199
DE	NO	-55.3479	0.406	-30.7639	0.399	41.1121	0.000	14.4970	0.000
DE	SE	370.8643	0.000	173.5436	0.000	0.0492	0.981	0.0338	0.981
DE	CH	-155.7528	0.432	-64.5705	0.429	4.1305	0.465	3.0722	0.452
DE	CA	85.9718	0.246	33.8379	0.241	10.9737	0.001	8.2033	0.001
DE	JP	25.7694	0.509	10.2606	0.507	1.2650	0.577	0.9012	0.567
DE	FI	-2.5428	0.940	-1.1099	0.940	-5.1805	0.183	-4.1724	0.230
DE	ES	43.7451	0.632	19.1764	0.631	23.7308	0.549	13.9267	0.209
IT	US	-34.1072	0.510	-30.9813	0.506	8.6305	0.000	5.0919	0.000
IT	UK	-26.1237	0.820	-10.7343	0.819	7.9825	0.540	7.8579	0.509
IT	FR	384.6436	0.000	166.0694	0.001	4.5329	0.039	2.5671	0.001
IT	DE	-18.2476	0.308	-7.5721	0.307	3.5846	0.180	2.1948	0.109
IT	NL	-12.2590	0.150	-5.5000	0.149	-0.5554	0.779	-0.5372	0.805
IT	NO	-190.0252	0.542	-107.3941	0.540	15.7538	0.415	11.1299	0.406
IT	SE	160.8268	0.000	69.2768	0.000	-16.3333	0.014	-14.7029	0.050
IT	CH	246.9624	0.001	101.6815	0.002	5.2224	0.417	3.0250	0.319
IT	CA	13.1490	0.827	5.0515	0.827	1.6237	0.000	3.1185	0.000
IT	JP	-42.2010	0.214	-16.7673	0.215	28.5026	0.000	15.3339	0.000
IT	FI	98.5173	0.121	54.4082	0.107	10.6729	0.376	10.2613	0.330
IT	ES	14.4798	0.852	5.9950	0.852	20.5530	0.430	16.4827	0.346
NL	US	-66.8163	0.353	-29.9306	0.354	4.9418	0.000	6.1917	0.000
NL	UK	-46.2648	0.283	-19.6929	0.283	13.5365	0.000	4.6002	0.000
NL	FR	-152.9732	0.589	-66.7382	0.588	-14.7104	0.221	-10.0929	0.224
NL	DE	-411.2626	0.391	-180.8958	0.390	220.9644	0.000	105.1642	0.000
NL	IT	-0.0510	0.995	-0.0187	0.995	1.7537	0.077	1.9895	0.042
NL	NO	921.1166	0.020	657.9320	0.021	-3.8753	0.671	-7.5510	0.671
NL	SE	-50.5608	0.699	-23.3629	0.699	22.6364	0.000	19.3938	0.000
NL	CH	-224.0569	0.433	-94.4531	0.431	19.2474	0.302	13.1400	0.289
NL	CA	-0.0827	0.999	-0.0335	0.999	5.6981	0.001	8.0764	0.000
NL	JP	35.5579	0.591	14.2682	0.586	2.0765	0.663	1.8351	0.653
NL	FI	-14.1614	0.057	-5.4321	0.053	0.0932	0.000	0.1767	0.000
NL	ES	-79.4032	0.154	-47.0916	0.145	124.1367	0.000	75.8347	0.000
NO	US	70.0577	0.363	69.2903	0.350	56.2525	0.000	39.9621	0.000
NO	UK	-133.2653	0.017	-51.7479	0.015	22.0008	0.118	15.7056	0.088
NO	FR	-46.8546	0.574	-41.7187	0.580	-94.0071	0.076	-68.6784	0.090
NO	DE	-203.9999	0.311	-83.9124	0.306	121.0135	0.000	59.8727	0.000
NO	IT	-530.3131	0.170	-199.8371	0.174	66.1638	0.006	76.1212	0.006
NO	NL	-454.0712	0.090	-178.1301	0.090	188.9931	0.000	125.1913	0.000

Appendix Table B, continued

		Real export equation				Variance of real export equation			
Expt.	Impt.	$\hat{\beta}_1$	*pval*	$\hat{\beta}_1^{SS}$	*pval*	$\hat{\phi}_1$	*pval*	$\hat{\phi}_1^{SS}$	*pval*
NO	SE	164.5970	0.302	71.2096	0.298	8.1527	0.152	5.1226	0.154
NO	CH	-33.1558	0.635	-14.3591	0.635	3.3487	0.139	2.9438	0.085
NO	CA	158.2745	0.499	77.0290	0.499	-6.9962	0.900	-5.3248	0.900
NO	JP	187.8229	0.056	156.3670	0.043	76.0517	0.140	52.4186	0.123
NO	FI	-271.2360	0.002	-107.2903	0.001	-9.3403	0.631	-8.3818	0.652
NO	ES	305.0758	0.257	359.3654	0.242	61.7997	0.118	81.5952	0.100
SE	US	-50.2359	0.033	-21.5820	0.030	2.1562	0.639	2.5294	0.628
SE	UK	-89.4304	0.246	-39.5601	0.246	2.9466	0.759	2.2505	0.757
SE	FR	-25.3562	0.229	-10.5559	0.191	50.0573	0.000	28.8917	0.000
SE	DE	0.0000		0.0000		0.0000		0.0000	
SE	IT	33.5369	0.004	12.9578	0.005	1.3135	0.000	0.7921	0.000
SE	NL	0.0000		0.0000		0.0000			
SE	NO	4.9552	0.685	1.9906	0.685	0.8847	0.001	0.5258	0.000
SE	CH	-6.4271	0.836	-3.1526	0.836	5.6329	0.000	2.8214	0.000
SE	CA	-49.5683	0.100	-20.6839	0.099	-0.9266	0.569	-1.2066	0.562
SE	JP	-1.1197	0.974	-0.4349	0.974	27.1008	0.000	21.2163	0.000
SE	FI	8.0670	0.794	3.5416	0.793	10.2743	0.036	5.0791	0.002
SE	ES	-32.2545	0.510	-36.4145	0.513	21.2496	0.026	24.4971	0.004
CH	US	100.6357	0.700	89.0091	0.700	-0.9983	0.968	-1.2062	0.968
CH	UK	-12.2312	0.845	-4.8044	0.846	3.0478	0.000	5.3442	0.000
CH	FR	-138.2950	0.345	-58.8559	0.344	90.1019	0.000	50.9807	0.000
CH	DE	-150.1917	0.443	-57.6999	0.443	72.5818	0.000	36.5348	0.000
CH	IT	115.3418	0.204	40.7878	0.196	32.8882	0.000	17.2688	0.000
CH	NL	-217.6892	0.535	-338.9688	0.532	-6.5274	0.030	-11.8417	0.037
CH	NO	147.9770	0.443	118.7998	0.452	4.2893	0.000	1.4964	0.000
CH	SE	69.9777	0.057	33.7433	0.059	10.5923	0.000	4.4999	0.000
CH	CA	-79.7055	0.409	-41.5846	0.404	178.0281	0.000	146.8086	0.000
CH	JP	-164.0721	0.330	-64.2667	0.327	41.8447	0.000	24.9425	0.000
CH	FI	-239.1513	0.056	-95.8735	0.054	-0.6593	0.000	-1.2647	0.000
CH	ES	-26.9308	0.617	-13.8316	0.615	14.2686	0.000	9.0248	0.000
CA	US	172.5636	0.118	82.8787	0.118	-0.9709	0.266	-1.8192	0.281
CA	UK	-35.0111	0.423	-15.1360	0.418	8.3436	0.042	6.3665	0.011
CA	FR	-184.0007	0.000	-70.9786	0.000	-6.8674	0.029	-5.2253	0.032
CA	DE	6.5610	0.965	2.5433	0.965	36.7944	0.000	46.8149	0.000
CA	IT	-18.7513	0.723	-7.3173	0.723	12.4737	0.000	10.4393	0.000
CA	NL	-54.4869	0.394	-22.5887	0.393	35.1676	0.000	21.7721	0.000
CA	NO	-24.0995	0.910	-8.9486	0.910	-83.8880	0.028	-149.7674	0.040
CA	SE	60.8360	0.211	25.5989	0.208	-0.2331	0.000	-0.2897	0.000
CA	CH	281.0534	0.609	178.4916	0.609	-96.2737	0.250	-71.9009	0.309

Appendix Table B, continued

		Real export equation				Variance of real export equation			
Expt.	Impt.	$\hat{\beta}_1$	*pval*	$\hat{\beta}_1^{SS}$	*pval*	$\hat{\phi}_1$	*pval*	$\hat{\phi}_1^{SS}$	*pval*
CA	JP	-146.8839	0.006	-63.1473	0.006	1.0846	0.036	2.0195	0.037
CA	FI	-20.0663	0.768	-8.4238	0.767	27.7081	0.005	36.0545	0.002
CA	ES	-7.9608	0.856	-3.2825	0.856	6.6572	0.000	8.6459	0.000
JP	US	-90.0212	0.107	-37.9444	0.116	22.9928	0.004	17.2832	0.003
JP	UK	4.8195	0.959	1.8059	0.959	0.0509	0.399	0.0320	0.386
JP	FR	-75.8574	0.265	-27.0624	0.258	0.3257	0.690	0.6045	0.687
JP	DE	-26.7734	0.734	-9.4786	0.734	40.9277	0.000	16.7835	0.000
JP	IT	-13.4777	0.496	-4.5886	0.496	1.1225	0.048	0.9753	0.013
JP	NL	-44.5306	0.631	-16.9568	0.631	-4.9295	0.136	-5.7131	0.171
JP	NO	-3.3598	0.941	-1.9108	0.941	70.2135	0.000	39.9931	0.000
JP	SE	-8.5436	0.714	-3.4635	0.714	1.6687	0.203	1.2462	0.198
JP	CH	-111.5143	0.096	-45.1504	0.089	18.4773	0.000	13.2341	0.000
JP	CA	-2.5133	0.962	-0.9561	0.962	12.4415	0.000	14.5971	0.000
JP	FI	33.9026	0.399	12.9902	0.391	2.8689	0.068	5.4809	0.087
JP	ES	-15.7349	0.794	-9.0662	0.793	76.7602	0.000	50.0075	0.000
FI	US	-54.2566	0.070	-23.1683	0.065	-0.6835	0.410	-0.4843	0.427
FI	UK	-69.4737	0.434	-29.8717	0.438	45.5482	0.000	31.2726	0.000
FI	FR	-6.8437	0.867	-2.8094	0.866	0.9376	0.069	1.1699	0.064
FI	DE	-42.8838	0.138	-17.9978	0.128	-3.9498	0.825	-7.0409	0.851
FI	IT	94.9044	0.001	36.9193	0.000	13.5601	0.024	7.5402	0.000
FI	NL	-16.9688	0.163	-7.5720	0.163	1.2119	0.000	1.7738	0.000
FI	NO	-47.7913	0.728	-20.3539	0.728	-1.3397	0.877	-2.1223	0.877
FI	SE	9.5430	0.368	4.0916	0.366	0.3701	0.139	0.2238	0.146
FI	CH	-32.9340	0.446	-13.8587	0.445	2.4883	0.114	3.1870	0.049
FI	CA	-216.4032	0.000	-102.8314	0.001	50.4946	0.000	32.9048	0.000
FI	JP	109.8669	0.656	43.1325	0.653	4.8048	0.323	7.6104	0.320
FI	ES	2.2475	0.966	3.1126	0.966	6.7662	0.643	5.1568	0.632
ES	US	31.1856	0.537	14.4296	0.535	22.2292	0.000	16.5785	0.000
ES	UK	-8.4846	0.815	-3.5197	0.815	2.1346	0.000	1.6746	0.000
ES	FR	83.5621	0.502	31.6703	0.508	-421.8557	0.348	-385.9789	0.346
ES	DE	-19.6414	0.499	-8.9134	0.496	9.6665	0.001	5.0960	0.000
ES	IT	-22.3578	0.554	-8.5856	0.552	5.9369	0.332	3.7111	0.060
ES	NL	-23.8522	0.452	-10.5617	0.452	2.0177	0.000	1.1793	0.000
ES	NO	-107.0392	0.252	-52.9509	0.248	64.6549	0.005	55.1751	0.001
ES	SE	-13.0100	0.644	-6.0245	0.644	0.6015	0.626	0.7125	0.599
ES	CH	178.8033	0.000	136.1091	0.001	11.6507	0.054	8.1295	0.022
ES	CA	-11.4802	0.873	-4.5231	0.872	0.1903	0.954	0.3132	0.954
ES	JP	6.4106	0.917	2.2473	0.917	0.8303	0.829	1.0529	0.824
ES	FI	-47.6794	0.445	-18.6284	0.441	85.6243	0.043	54.9440	0.005