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Abstract

This paper investigates empirically the effect of real exchange rate volatility on sectoral bilateral trade flows between the US and her top thirteen trading countries. Our investigation also considers those effects on trade flows which may arise through changes in income volatility and the interaction between income and exchange rate volatilities. We provide evidence that exchange rate volatility mainly affects sectoral trade flows of developing but not that of developed countries. We also find that the effect of the interaction term on trade flows is opposite that of exchange rate volatility yet there is little impact arising from income volatility.

JEL: F17, F31, C22.
Keywords: exchange rates, volatility, trade flows.

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1 Introduction

A review of the empirical and the theoretical literatures that span the period after the breakdown of the Bretton Woods agreement reveals that there is no consensus on the impact of exchange rate volatility on trade flows. Several theoretical studies arrive at the conclusion that exchange rate volatility can have a negative impact on trade flows.[1] Equally, several others conclude that the effect is uncertain or positive.[2] Interestingly, one cannot reach a firm conclusion from empirical studies, either. Results are conflicting and sensitive to various factors.[3]

When we focus on the recent empirical literature, we come across several possible reasons why researchers have reached conflicting conclusions. Early empirical research, which concentrated on aggregate US or G7 data, suggests that exchange rate uncertainty may have a positive or negative effect on trade flows.[4] Recent research that focuses on bilateral rather than aggregate trade data of developed countries concludes that exchange rate volatility has no or little effect on trade flows.[5] In this study, we utilize a broader dataset, which contains both the developed and developing top trade partners of the US. Hence, we avoid the narrow focus on the US or the developed country data that has characterized much of the literature.

We should point out that the inclusion of developed and developing

[1]See for instance Clark (1973), Baron (1976), Peree and Steinherr (1989).

[2]Franke (1991), Sercu and Vanhulle (1992) show that exchange rate volatility can have a positive or an ambiguous effect on trade flows. Barkoulas, Baum and Caglayan (2002) claim that the types of shocks that firms are exposed to will determine the relationship which may be positive, negative or ambiguous.

[3]Although researchers implementing gravity models consistently conclude that exchange rate volatility has a negative impact on trade flows, Clark , Tamirisa, Wei, Sadikov and Zeng (2004) indicate that this finding is not robust to a more general setting which embodies the recent theoretical advances in a gravity model.

[4]For instance, while Cushman (1983, 1988), Akhtar and Hilton (1984), Thursby and Thursby (1987), Kenen and Rodrik (1986), among others, find negative effects, Hooper and Kohlhagen (1978) Koray and Lastrapes (1989), and Gagnon (1993) report insignificant effects.

[5]See for instance Baum, Caglayan and Ozkan (2004) and Baum and Caglayan (2008) who employ bilateral trade flows from thirteen developed countries.

countries in our investigation is important as recent research suggests that exchange rate volatility has a significant negative impact on trade flows of developing countries. For instance, Grier and Smallwood (2007) conclude that while real exchange rate volatility has a significant negative impact on international trade for developing countries, there is no such effect for the advanced economies. Several other researchers also report similar findings for different sets of developing countries on the linkages between exchange rate volatility and trade flows.[6] Although one can claim that the presence of a significant relationship may be due to the lack of proper financial tools in developing countries that firms can use to hedge against exchange rate fluctuations, Wei (1999) cannot find empirical evidence to that end. In this paper, we utilize data from nine developed and five developing countries. Our 14-country dataset includes the US, Japan, Germany, UK, France, Italy, Netherlands, Ireland, Canada, South Korea, Singapore, Malaysia, China, and Brazil and covers the period between 1996–2007 on a monthly basis.

Although the use of country specific bilateral trade data is an improvement over aggregate trade data, sectoral trade data can help us further disentangle the linkages between exchange rate volatility and trade flows that may exist across sectors but not in bilateral data. Early literature that used sectoral data summarized the impact of exchange rate volatility on sectoral trade flows in one coefficient as researchers implemented panel data methodologies on data across several countries. In contrast, we focus on country-sector specific bilateral relationships and investigate dozens of models. Our data are organized with respect to bilateral sectoral trade flows between the US and her top 13 trading countries.

Another important factor that may affect the results in this literature is the method that one uses to generate a proxy for real exchange rate volatility.[7] Generally, the early research has used a moving average stan-

[6]See including Arize, Osang and Slottje (2000), Clark et al.(2004), Peridy (2003) and Sauer Bohara (2001).

[7]Although generally researchers consider the effect of real exchange rate variability on

dard deviation of the past monthly exchange rates or variants of ARCH methodology to generate a proxy for exchange rate volatility. We utilize daily spot exchange rates to proxy for exchange rate volatility employing a method proposed by Merton (1980). This method, also used by researchers including Baum et al. (2004) and Klaassen (2004), exploits daily exchange rate movements to proxy for monthly exchange rate volatility. Furthermore, both studies indicate that this approach yields a more representative measure of volatility avoiding problems associated with proxies derived from ARCH methodology or moving standard deviations.

Last but not least, our empirical model takes the form of a simple distributed lag model where we allow each variable to affect trade flows up to six lags, which is shown to be adequate to capture the explanatory variables' impact. We keep those models that yield a stable dynamic relationship and discard the remaining (29) models which are dynamically unstable. In total, we scrutinize 229 models where we discuss the impact of volatility measures across sectors and countries. To address an interesting suggestion raised by Baum et al. (2004), we also allow for income volatility and an interaction term between income and exchange rate volatilities in our model to test if these variables play an important role in determining sectoral trade flows.

Our investigation shows that the effect of real exchange rate volatility on trade flows is significant in about 36% of the models (84 out of 229) at the 5% significance level. The percentage of significant models rises up to 45% (45 out of 100) for the developing countries and falls to 30% (39 out of 129) for the developed nations that our dataset includes.[8] The effect of exchange rate volatility on trade flows is slightly negative for the developing countries at the median while it is slightly positive for the developed nations. These results are similar to findings reported in earlier research which used

trade flows, nominal exchange rate variability has also been used in the past. For instance, Tenreyro (2004) shows that nominal exchange rate volatility does not affect trade flows.

[8] At the 10% level, the impact of exchange rate volatility on trade flows is significant for 98 cases when we consider the full data. The same figure is 48 for the developing countries and 40 for the developed nations.

bilateral trade data.

When we investigate the effects of income volatility and the interaction term between exchange rate volatility and income volatility on trade flows, we come across some interesting observations. To understand the overall impact of exchange rate volatility on trade flows, we first discuss the impact of the interaction term on trade flows. It turns out that this term is significant in almost all cases when exchange rate volatility plays a significant role in the model. Furthermore, it takes the opposite sign to that of exchange rate volatility, reversing the impact of exchange rate volatility on trade flows. From this perspective, it is apparent that omitting the interaction term from the analysis would lead to the wrong policy prescriptions. Finally, we turn to the impact of income volatility on trade flows. We observe that income uncertainty has a significant effect in only 21% of the models. The sign of this coefficient is negative at the median. However, this variable seems to play a more important role when we concentrate on exports of the US to her trading partners as the ratio of significant income volatility increases to 33%. This is not surprising as the income of the trading partners over the period under investigation was much more volatile than that of the US.

The reminder of this paper is organized as follows. Section 2 outlines the model, discusses our volatility measures and provides information on the data. Section 3 reports the empirical results and section 4 concludes.

2 Model Specification

Most of the early research which concentrated on the impact of exchange rate volatility on trade flows used country level aggregate or bilateral trade flow data. However, as Bini-Smaghi (1991) indicates, because sectoral data do not constrain income and price elasticities across sectors, one should employ sector specific data when exploring the linkages between trade flows and exchange rate movements. Yet, there are only a handful of studies that utilize sectoral data.[9] These studies follow an Armington (1969) approach and estimate both the price and output elasticities. In particular, to capture export flows from country i to j, the model takes the form

$$X_{ijt} = f(P_{ijt}, Y_j, \sigma_{ijt}) \tag{1}$$

where X, P, Y and σ denote exports, relative price, output and exchange rate volatility, respectively. The price and output elasticities (coefficients associated with relative prices and output) are estimated in a panel context using sectoral trade flow data for each sector. Naturally, this approach yields a single sector specific price and output elasticity along with the impact of exchange rate volatility, which is then compared across sectors.

Our approach differs from the above specification as we model the impact of exchange rate volatility for each sector-country specific trade flow separately. Given that we have 14 countries where data are ordered with respect to sectoral i) exports of 13 countries to US and ii) exports of the US to the same set of countries, we estimate 258 models where we can compare the effects of variables of interest across sectors or countries.[10] The model that we investigate in this study can be written as

$$X_{kt}^{i \to j} = f\left(Y_j, s_t, \sigma_{s,t-n}, \sigma_{Y,t-n}, \sigma_{s,t-n} \times \sigma_{Y,t-n}\right) \tag{2}$$

where $i \to j$ implies exports from country i to country j and k stands for the sector. We introduce the real exchange rate, s and real exchange rate volatility and income volatility (σ_s and σ_Y, respectively) in our model. The joint impact of the two volatilities as suggested by Baum et al (2004) is captured by $\sigma_s \times \sigma_Y$. In our investigation, we are interested in the sign and the significance of the coefficients associated with exchange rate and income volatilities as well as that of the interaction term between income

[9] See Klein (1990), Belanger et al.(1992), Peridy (2003), De Vita and Abbott (2004), Saito (2004), Mckenzie (1999), Doyle (2001) and Byrne, Darby and MacDonald (2006).

[10] Sectors 4 and 5 for Ireland are excluded from the analysis due to missing data.

and exchange rate volatilities, $\sigma_s \times \sigma_Y$. All variables are allowed to have up to n lags which is set to 6 in our empirical investigation.

Prior to providing information on our data and the empirical model that we implement, we explain how we generate a proxy for exchange rate and income volatilities. In the next subsection, we provide details of the Merton (1980) methodology that we use to derive such a proxy for exchange rate volatility. To generate income volatility, we use a volatility proxy driven from a simple ARCH model. For those income series that do not present ARCH effects, we employ a rolling standard deviation of the variable. The interaction term in the model is then the product of the two variance terms.

2.1 Generating Exchange Rate Volatility

To generate a proxy of exchange rate volatility, one can pursue different methodologies. One of the most commonly employed methods to proxy volatility is the moving standard deviation of exchange rate changes. As this methodology includes the past 12 or 24 months of data, the proxy may contain substantial correlation. Alternatively, it is possible to use ARCH/GARCH models to generate such a proxy. This approach may find weak persistence of shocks and the generated proxy will be very much model dependent. In this study we adopt a measure of risk proposed by Merton (1980).[11] This measure considers the daily changes in the exchange rates between each pair of countries in our data set to calculate monthly exchange rate volatility. Given that traders export their products to several countries, the exchange rate volatility perceived by an exporter in a sector will differ across the countries which she trades with by design.

To implement Merton's methodology, we calculate the daily real exchange rate series (s_t^d) for the countries in our data set. Hence, we first

[11]Researchers use Merton's (1980) methodology to generate proxies for exchange rate, interest rate, (monetary) policy or stock market volatilities. See for instance Baum, Caglayan, Ozkan and Talavera (2006) for an implementation of Merton's method on stock returns.

compute daily prices by interpolating the relative prices for all countries within the month while taking into account the intervening business days. Then, we generate the daily real exchange rate series by multiplying the daily spot exchange rate series with the exporting country to domestic country price ratio. Finally, we calculate the squared first difference of the log real exchange rate series and deflate it by the number of elapsed days between observations

$$\varsigma_t^d = \left(100\frac{\Delta s_t^d}{\sqrt{\Delta \phi_t}}\right)^2, \tag{3}$$

where the denominator (ϕ_t) captures the calendar time difference between each successive observation on the s process. For our case $\phi_t \in [1, 5]$ due to weekends and holidays. The value we compute in equation (3) is the daily volatility faced by the exporter. We then define the monthly volatility as $\Phi_t [s_t] = \sqrt{\sum_{t=1}^{T} \varsigma_t^d}$ where the time index for exchange rate volatility is at the monthly frequency.

The price series for each country are taken from the *Main Economic Indicators* published by *Organization for Economic Cooperation and Development* (OECD) and the exchange rate series are downloaded from the *Pacific Exchange Rate Service* which is provided by the University of British Columbia (UBC)'s Sauder School of Business.

2.2 Generating Industrial Production Volatility

Our empirical investigation requires a proxy for real income volatility for the importing countries on a monthly basis. Given that we will be exploring the behavior of sectoral trade flows, we believe that it would be preferable to use monthly industrial production series. Our choice is appropriate as most of the trade between countries is intra-sectoral. We should note that some researchers interpolate GDP to monthly frequency when they use aggregate data. However, this process may add significant noise into the process in particular for the case of developing countries.

To generate a measure of monthly income volatility, σ_y, we first test whether the the real income series exhibit time-varying heteroskedasticity. Observing that the industrial production series for Germany, France, Italy, Canada, Singapore, Korea, Malaysia, Brazil and the US exhibit ARCH effects, we use ARCH methodology to generate a proxy for income volatility. For the remaining countries (namely Japan, UK, Netherlands, Ireland and Canada) we compute the standard deviation of the log differences of industrial production using a 12-month moving window.

2.3 The Dynamic Model of Exports

In our empirical investigation, we concentrate on the log difference of deseasonalized sectoral real exports, x_t, of country i to j and employ a dynamic distributed lag model to capture the effects of exchange rate volatility σ_s along with income volatility σ_y and the interaction of income and exchange rate volatility, $\sigma_s \times \sigma_y$, on sectoral trade flows.[12] In total we investigate 258 models and focus on the significance of coefficients associated with exchange rate and income volatilities as well as the interaction between the two. Each model includes the standard variables such as the change (Δ) in log importing country real income, y_t and Δ log real exchange rate, s_t, as well as the lagged dependent variable. Our model takes the following form:

$$\begin{aligned} x_{k,t}^{i\to j} &= \alpha_0 + \beta_0 \textstyle\sum_{n=1}^{N} \delta^n x_{k,t-n}^{i\to j} + \beta_1 \sum_{n=1}^{N} \delta^n y_{t-n} + \\ &\beta_2 \textstyle\sum_{n=1}^{N} \delta^n s_{t-n} + \beta_3 \sum_{n=1}^{N} \delta^n \left[\sigma_s\right]_{t-n} + \\ &\beta_4 \textstyle\sum_{n=1}^{N} \delta^n \left[\sigma_y\right]_{t-n} + \beta_5 \sum_{n=1}^{N} \delta^n \left[\sigma_s \times \sigma_y\right]_{t-n} + \epsilon_t \end{aligned} \tag{4}$$

where k denotes sector and $k \in [1, 10]$ and δ is a fixed coefficient. The two additional terms in our model—the impact of foreign income volatility on trade flows and the interaction between foreign income and exchange rate volatility—have been suggested by Baum et al. (2004) to capture the impact of the expansion or the retention of the trade flows as foreign income and the exchange rate fluctuates. Such an approach, according to Baum

[12]Sectoral trade series are seasonally adjusted using seasonal dummies.

et al. (2004), requires a simultaneous consideration of the behavior of the exchange rate, foreign income and the risks which can be captured through income and exchange rate volatility. Although they find mixed results on the effect of income volatility on trade flows, a subsequent analysis by Grier and Smallwood (2007) shows that income volatility plays an important role.[13]

In general, seeking new opportunities to expand, establish, retain or shut down the business in a market requires suppliers not to react instantaneously to changes in market conditions when faced with high short term profits or losses. This seems reasonable as any change in a business model requires substantial resource allocation problems. This implies that exporters' reactions to exchange rate or income volatility should be modeled with a lag. Earlier research suggests that empirical models which embody 6 to 12 lags successfully capture the potential effects regarding the agent's decision to purchase and complete their transactions. To that end, we allow up to 6 lags in our model.[14] We also set the lag parameter δ to a specific value to ensure stability of the dynamic relationship. Particularly, we report our results for $\delta = 0.3$ for stability reasons. We should note that we also experimented with linear weights giving higher weights to more recent observations. This modification did not lead to any significant change in the results.

Given the vast number of models that we consider, in discussing our results we will summarize our discussion on the significant parameters of interest (namely at the 5% and 10% significance levels) and we provide all relevant coefficient estimates with their corresponding standard errors in the appendix. We present our results in two separate tables. While one of our summary tables presents the results of the sectoral exports of 13 countries to the US, the other table concentrates on the sectoral exports of the US to the same set of countries. Furthermore, each table presents results for

[13]Koren and Szeidl (2003) suggest that exchange rate volatility should affect trade volumes through the covariances of the exchange rate with the other key variables.

[14]Results, obtained when we allow up to 12 lags, which are available upon request from the authors, do not differ from those that we present here.

developing countries only so that we can observe if there are any significant differences across developing versus developed countries.

2.4 Data

We utilize deseasonalized monthly data on sectoral bilateral real exports, in each direction, over the period of January 1996 and September 2007 between the US and her top thirteen trading countries. While eight of the countries in our dataset including the US, Japan, Germany, UK, France, Italy, Netherlands, Ireland and Canada, are highly developed, the remaining five countries, namely South Korea, Singapore, Malaysia, China, and Brazil, are developing countries. Given the earlier findings that exchange rate volatility has a significant impact on the trade flows of developing rather than developed countries, our data can help us find out if this observation holds true for sectoral data. Furthermore, the use of sectoral data can help us determine if the significant effects of exchange rate volatility on developing country trade flows is an artifact of data aggregation. In particular, our dataset includes trade flows gathered from 10 sectors which is available from the *Foreign Trade Division* (FTD) in the US *Census Bureau*. The sectors are: 1) food and live animals; 2) beverages and tobacco; 3) crude materials; 4) mineral fuels, lubricants and related materials; 5) animal and vegetable oils, fats and waxes; 6) chemicals and related products; 7) manufactured goods; 8) machinery and transport equipment; 9) miscellaneous manufactured articles; 10) commodities and transactions.

The sectoral trade data are in current US dollars, which are then converted into local currency units using the spot exchange rate *vis-à-vis* the US dollar. Then, we deflate the trade data by the export price index for both developed and developing countries. As we discussed earlier, the real exchange rate data are constructed using the spot rate and the local and US consumer price indices. Spot daily exchange rates are obtained from the *Pacific Exchange Rate Service*. Consumer price indices for the US and the remaining countries are obtained from the *Main Economic Indicators* published by the OECD. Export price indices are extracted from the IMF's *International Financial Statistics*. Finally, deseasonalized industrial production series, which we proxy for the income of a country, are extracted from the *Main Economic Indicators* published by the OECD.

3 Empirical Findings

3.1 Descriptive Statistics

Given that we will be investigating the linkages between sectoral trade flows and real exchange rate and real income variations, we first provide some statistics on the common features, as well as the dissimilarities, of these series. Table 1 presents the real exchange rate volatility correlations among those countries that we have in our dataset. These correlations show that similar real exchange volatility patterns are experienced by many of the developed countries, except for Japan, perhaps reflecting these countries' sizable exports to the US. High correlations between these countries may also reflect the agreements between the European countries which eventually led to the launch of the Euro. When we turn our attention to the correlations between the real exchange rate volatility measures of the developing countries, we observe some similarities but the correlations are not as strong as that between the European countries. Table 1 indicates that the real exchange rate volatility measures across developed and developing countries are very different from one another. This observation is perhaps *prima facia* evidence that the impact of exchange rate uncertainty on trade flows would differ across developed and developing countries.

We next focus on descriptive measures of foreign income volatility and the interaction term that we introduce in our model. The correlations of foreign income volatility measures and that of the interaction term—the product of the exchange rate volatility and foreign income volatility—for our exporting countries are presented in Tables 2 and 3, respectively. Inspecting Table 2, we do not detect much comovement of income volatility between the countries in our dataset. As Table 3 shows there is no systematic relationship across the interaction terms, either.

To evaluate how the exchange rate and income volatility measures can affect the sectoral bilateral trade of developing and developed countries, in Tables 4 and 5, we present sectoral export flow correlations for Germany and China. Table 4, which gives the correlation matrix for Germany does not reveal any significant sector specific trade flow correlations. This is perhaps due to the fact that Germany has a well developed economy whose sectoral exports to the US are not much affected by movements in the export volume of one sector or other. However, Table 5, which provides information on Chinese sectoral exports to the US, shows high correlations between most sectoral trade flows. This finding can be explained by the acceleration of sectoral trade flows from China to US over the last 10 years.

Given the information presented in the correlation tables, it seems reasonable to conjecture that the intensity of development could be important with respect to the role exchange rate uncertainty has on trade flows. In developing countries where international trade is consistently improving and where trading partners or exportable products are not diverse, significant effects of exchange rate volatility on trade flows should not be too surprising. Whereas, for countries whose economies are well developed and have established trade links, the impact of exchange rate volatility may be insignificant. We finally check if there are any sector specific correlations across countries, but find no systematic correlations.[15]

Next we investigate the role of exchange rate and income volatilities, and the interaction between the two, on trade flows. Given that we are working with dozens of models to understand sectoral bilateral trade flows between

[15]Sector specific correlation tables are not provided for space considerations but are available upon request.

the US and her 13 trading partners, we provide coefficient estimates and their standard deviations for the variables of interest in the appendix. Using the information presented in these tables, we provide summary statistics on the significance of those coefficients broken down into sectors and the destination of exports (exports to and from the US) for the full sample and the developing countries in Tables 6 to 11. In total we investigate 229 models.[16]

3.2 Results

In what follows, we first discuss the impact of exchange rate volatility on sectoral trade flows. Next, we examine the effect of income volatility and the interaction term on trade flows.

3.2.1 The role of exchange rate volatility

We first focus on the sign and the significance of the coefficient associated with exchange rate volatility, β_3. The number of significant effects detected for sectoral exports to the US are reported in Table 6 and that of from the US are reported in Table 7. When we concentrate on sectoral exports to the US, Table 6, we see that for each sector there are 2 to 6 (3 to 7) cases where β_3 is significantly different from zero, totaling 43 (47) out of 112 possible models at the 5% (10%) level. The tally when we concentrate on the significance of β_3 for the exports of the US, see Table 7, is similar in nature; 3 to 5 (4 to 6) cases per sector totalling 41 out of 119 models at the the 5% significance level. If we consider the impact of exchange rate uncertainty for exports to the US (see Table 6), we observe that 23 of those 43 significant coefficients are positive. When we turn to examine how exports of the US are affected by exchange rate uncertainty (see Table 7), we find that in 20 cases out of 43 the effect is positive at the 5% level.[17] When we scrutinize

[16] Trade flows of 2 sectors for Ireland are not available, and 29 models violate the dynamic stability condition.

[17] Please see Tables 12 and 13 in the Appendix for details.

Tables 6 and 7 together, we find that exchange rate uncertainty has a slight negative effect at the median. In total, there are 84 cases where exchange rate uncertainty has a significant effect on trade flows out of 229 possible models, which corresponds to about 36% of the cases. This percentage is quite low and comparable to findings reported in other studies including Baum et al. (2004).

Given the earlier findings that exchange rate volatility has a significant negative impact on the trade flows of developing countries, it is tempting to look at the set of developing countries we have in our dataset closely. When we concentrate on bilateral trade between the US and her developing country partners, we see that the number of cases where exchange rate uncertainty has a significant impact on trade flows increases. For instance exports from developing countries to the US are affected by exchange rate volatility in 26 (27) cases, of which 15 (16) are positive out of 45 possible models at the 5% (10%) level. Notably Singapore registers 8 negative, whereas China records 8 positive cases out of ten possible models. At the median, the effect of exchange rate uncertainty on exports to the US is positive, yet small. In contrast, US exports to developing countries are negatively affected by exchange rate volatility at the median. We observe that US exports are affected significantly in 19 cases out of 47 cases, 9 of which are positive, at the 5% significance level. Notably, US exporters are negatively affected by real exchange rate volatility in most sectors when they trade with China. The effect is generally positive for trade flows from US to Brazil. In total, exchange rate uncertainty is significant in 45 out of 100 models, which corresponds to 45% of all cases.

Overall, the idea that exchange rate uncertainty might have an impact on bilateral sectoral trade flows between the US and her top trading partners does not receive much support from the data. While this effect is more pronounced for developing countries, there is almost an equal number of positive and negative impacts are observed. The median effect for the full data is small and positive.

3.2.2 The role of income volatility

In this section we discuss the observed effect of industrial production volatility, captured by β_4 in our model, on exporters' behavior. Tables 8 and 9 provide the number of significant coefficients for exports to and from the US.[18] When we consider the impact of income volatility on exports to the US, we observe that β_4 is significantly different from zero in only 11 (21) cases out of 112 models at the 5% (10%) significance level. Perhaps the low significance of US income volatility on trade flows reflects the fact that the US economy over the period of our investigation did not experience excessive turmoil. However, when we turn to understanding trade flows from the US, we see that the effect of income uncertainty becomes somewhat more noticeable; we record 38 significant cases out of 117 possible models. This difference can be explained by the fact that the trade partners of the US have experienced a much more volatile period than the US. Hence, we find that US exporters are affected by the ups and downs of her trade partners' income.

3.2.3 The role of the interaction term between income and exchange rate volatility

We finally explore whether the interaction term (captured by β_5) between the real exchange rate and IP volatility has any effect on sectoral trade flows. As in the previous two cases, we report the coefficient estimates and their standard errors in Tables 16 and 17 in the Appendix, while we provide summary information on the statistically significant cases for exports to and from the US in Tables 10 and 11.

On the whole, we see that the effect can either be positive or negative. Tables 10 and 11 report that there are 18 and 38 significant coefficients,

[18]The coefficient estimates and standard errors are correspondingly given in Tables 14 and 15 in the Appendix.

respectively, at the 5% significance level. This corresponds to less than 25% of the total cases. The interaction term is not significant for any sectoral exports from Germany, UK, Italy and Malaysia to the US. The remaining countries have at least one and a maximum of eight sectors (China) where the interaction term is significant. When we focus on the US exporters, we observe that the interaction term does not play a significant role on US exports to UK and Ireland at the 5% level.

Given these observations, one may conclude that the interaction term has a minor role in the determination of trade flows. However, a comparison of Tables 16 and 17 with Tables 12 and 13, reveals that the interaction term is generally significant if the corresponding coefficient for exchange rate volatility is significant. Moreover, the sign of the interaction term is the opposite of that of exchange rate volatility negating the impact of exchange rate uncertainty on trade flows in the opposite direction. This is an interesting finding which is not reported in the earlier literature. This finding implies that, depending on the relative size of exchange rate volatility and income volatility, the impact of exchange rate volatility can be nullified or amplified. Models that do not incorporate this interaction term are clearly misspecified and these models will yield a biased effect of exchange rate uncertainty.

4 Conclusion

In this paper we investigate the impact of exchange rate volatility on sectoral bilateral trade flows between the US and her 13 top trading countries over the period between 1996-2007. Our monthly dataset includes both developing and developed countries allowing us to avoid the narrow focus on the US or the developed country data which has characterized much of the literature. Furthermore, concentrating on the behavior of sectoral trade flows we avoid potential biases that may arise due to the use of aggregate data. Overall, we investigate dozens of sector-country pairs separately to shed a broader view on the linkages between the variables of interest. In our investigation, we also entertain an idea suggested by Baum et al. (2004) that income volatility and its interaction with exchange rate volatility may have an impact on trade flows.

Our results are similar to earlier research that used aggregate bilateral trade data. We find that the impact of real exchange rate volatility on trade flows is significant in about 36% of the models (84 out of 229) at the 5% significance level. For the developing countries, the percentage of significant models rises to 45% (45 out of 100) and falls to 30% (39 out of 129) for the developed nations that our dataset includes.[19] The effect of exchange rate volatility on trade flows is slightly negative for the developing countries at the median while it is slightly positive for the developed nations. These results are similar to findings reported in earlier research which used bilateral trade data.

Next, we turn to the impact of income volatility and the interaction term between exchange rate volatility and income volatility. Naturally, to understand the overall impact of exchange rate volatility on trade flows, we should consider the impact of the interaction term. It turns out that this term is significant in almost all cases when exchange rate volatility plays a significant role in the model. Furthermore, it takes an opposite sign to that of exchange rate volatility, reversing the impact of exchange rate volatility on trade flows in the opposite direction. From this perspective, omitting the interaction term from the analysis would lead to the wrong conclusion and inappropriate policy prescriptions. Finally, we turn to the impact of income volatility on trade flows. We observe that overall income uncertainty has a significant effect in 21% of the models. The sign of this coefficient is negative at the median. However, this variable seems to play a more important role when we concentrate on the exports of the US to her trading partners as

[19]When we consider the full data, the impact of exchange rate volatility on trade flows is significant for 98 cases at the 10% level. The same figure is 48 for the developing countries and 40 for the developed nations.

the ratio of significant income volatility increases to 33%. This is reasonable as the income of the trading partners over the period of investigation was much more volatile than that of the US.

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Table 1: Exchange rate uncertainty correlations across countries

	JPY	DEM	GBP	FRF	ITL	NLG	IEP	CAD	SGD	KRW	MYR	CNY	BRL
JPY	1.0000												
DEM	0.1064	1.0000											
GBP	-0.0937	0.8468	1.0000										
FRF	0.0782	0.9985	0.8553	1.0000									
ITL	-0.0479	0.9761	0.8817	0.9853	1.0000								
NLG	-0.0323	0.9760	0.8409	0.9847	0.9944	1.0000							
IEP	-0.2181	0.9111	0.8489	0.9283	0.9734	0.9691	1.0000						
CAD	-0.2581	0.7248	0.7254	0.7444	0.7999	0.7795	0.8541	1.0000					
SGD	0.6604	0.5051	0.2487	0.4651	0.3249	0.3259	0.1701	0.1045	1.0000				
KRW	0.1081	0.5373	0.3538	0.5386	0.5428	0.5569	0.5774	0.6524	0.3550	1.0000			
MYR	0.5363	0.4232	0.0778	0.3898	0.2771	0.3021	0.1917	0.1487	0.8784	0.5891	1.0000		
CNY	0.7466	0.2023	-0.0755	0.1571	-0.0043	0.0118	-0.1814	-0.2892	0.8915	0.0239	0.7465	1.0000	
BRL	0.2805	0.5262	0.4353	0.4971	0.4051	0.3720	0.2866	0.4023	0.7497	0.2827	0.5448	0.5602	1.0000

Notes: The countries are ordered as Japan, Germany, UK, France, Italy, Netherlands, Ireland, Canada, Singapore, South Korea, Malaysia, China and Brazil.

Table 2: Income volatility correlations across countries

	U.S.	JP	GE	UK	FR	IT	NL	IE	CAN	SG	KR	ML	CN	BR
US	1.0000													
JP	-0.0706	1.0000												
GE	-0.1263	0.6271	1.0000											
UK	-0.2816	0.4538	0.3979	1.0000										
FR	0.2812	0.1368	0.2023	0.2334	1.0000									
IT	0.2951	0.1442	0.2086	0.2687	0.9686	1.0000								
NL	-0.4920	0.3470	0.6116	0.5979	0.0588	0.0890	1.0000							
IE	-0.1477	0.2359	0.8126	0.1669	0.0129	0.0133	0.6339	1.0000						
CAN	-0.1308	0.2400	0.7488	0.3371	0.0681	0.0922	0.6498	0.8866	1.0000					
SG	-0.2071	-0.0045	-0.0228	0.0002	-0.1867	-0.1929	0.0111	-0.0045	0.0191	1.0000				
KR	-0.2115	0.0638	0.0758	0.0894	-0.0827	-0.0989	0.0787	0.0702	0.1008	0.5972	1.0000			
ML	0.2546	-0.1144	-0.2948	-0.2777	-0.1639	-0.1686	-0.3506	-0.2458	-0.2378	0.0352	0.0212	1.0000		
CN	-0.1692	0.3295	0.1468	0.2909	-0.1520	-0.1347	0.2656	0.0683	0.1379	0.0815	0.2119	-0.0226	1.0000	
BR	-0.2265	-0.2429	-0.1329	-0.1918	-0.1937	-0.2018	0.0185	-0.0255	-0.0808	0.2127	0.2805	0.0662	-0.0430	1.0000

Notes: The countries are ordered as US Japan, Germany, UK, France, Italy, Netherlands, Ireland, Canada, Singapore, South Korea, Malaysia, China and Brazil.

Table 3: Interaction terms correlations across countries

	JP	GE	UK	FR	IT	NL	IE	CAN	SG	KR	ML	CN	BR
JP	1.0000												
GE	0.1466	1.0000											
UK	0.1931	0.7495	1.0000										
FR	0.2938	0.9378	0.8096	1.0000									
IT	0.2109	0.9697	0.7417	0.9510	1.0000								
NL	0.3033	0.8813	0.8187	0.9144	0.8881	1.0000							
IE	-0.0555	0.7681	0.4495	0.6242	0.7616	0.5196	1.0000						
CAN	-0.1155	0.1566	0.1059	0.2115	0.1887	-0.0159	0.2045	1.0000					
SG	0.2602	0.0514	0.0398	0.0860	0.0555	-0.0213	-0.1049	0.2038	1.0000				
KR	0.0201	-0.0371	-0.0916	-0.0916	-0.0401	-0.1088	-0.0526	-0.0275	0.3807	1.0000			
ML	0.2847	-0.0587	0.0280	-0.0269	-0.0466	0.0167	-0.2206	0.0048	0.3114	0.2457	1.0000		
CN	0.1804	-0.2374	-0.0228	-0.1802	-0.2264	-0.1476	-0.2358	-0.0037	0.4431	0.2365	0.3475	1.0000	
BR	0.1667	-0.1360	-0.2362	-0.1777	-0.0719	-0.2254	0.0233	-0.0262	0.1858	0.3226	0.3643	0.0756	1.0000

Notes: See notes to Table 1.

Table 4: Correlations of German sectoral exports to the US

	1	2	3	4	5	6	7	8	9	10
1	1.0000									
2	-0.0110	1.0000								
3	0.1844	0.0837	1.0000							
4	0.2883	0.2522	0.2306	1.0000						
5	0.2070	0.0245	-0.0198	0.1274	1.0000					
6	0.4710	-0.0356	0.2515	0.2348	-0.0111	1.0000				
7	0.4567	0.1890	0.3502	0.2888	0.0696	0.8028	1.0000			
8	0.3392	0.2891	0.2323	0.2047	0.0853	0.6720	0.8732	1.0000		
9	0.4199	0.2923	0.2759	0.2507	0.0590	0.7241	0.9034	0.8958	1.0000	
10	0.3350	0.2999	0.2738	0.1751	0.1480	0.4826	0.7320	0.7519	0.7284	1.0000

Notes: Numbers 1 to 10 denote sectors, namely 1) food and live animals; 2) beverages and tobacco; 3) crude materials; 4) mineral fuels, lubricants and related materials; 5) animal and vegetable oils, fats and waxes; 6) chemicals and related products; 7) manufactured goods; 8) machinery and transport equipment; 9) miscellaneous manufactured articles; 10) commodities and transactions.

Table 5: Correlations of Chinese sectoral exports to the US

	1	2	3	4	5	6	7	8	9	10
1	1.0000									
2	0.6077	1.0000								
3	0.8411	0.5932	1.0000							
4	0.4425	0.3647	0.4488	1.0000						
5	0.0131	0.0258	-0.0979	0.1517	1.0000					
6	0.7979	0.6743	0.9014	0.4671	0.0031	1.0000				
7	0.8167	0.6961	0.9311	0.4348	-0.0571	0.9246	1.0000			
8	0.7964	0.6781	0.9065	0.4496	-0.0170	0.8978	0.9309	1.0000		
9	0.8282	0.6765	0.9369	0.4585	-0.1051	0.9260	0.9566	0.9456	1.0000	
10	0.7660	0.6663	0.8642	0.4353	-0.0208	0.9054	0.9157	0.8993	0.9075	1.0000

Notes: See notes to Table 4.

Table 6: Number of significant σ_{s_i} effects: Sectoral exports to the US

	10%		5%		1%	
Sector	All	LDCs	All	LDCs	All	LDCs
1	6	3	5	3	5	3
2	5	4	5	4	3	2
3	5	3	4	2	1	1
4	3	2	3	2	2	1
5	3	0	2	0	1	0
6	7	4	6	4	5	3
7	6	3	6	3	3	2
8	4	3	4	3	2	2
9	3	2	3	2	2	1
10	5	3	5	3	4	2
Total:	47	27	43	26	28	17

Notes: *All* (*LDCs*) depicts the number of significant real exchange rate volatility coefficients obtained for the full (developing countries only) data. Sector names are provided in the Table 4 notes.

Table 7: Number of significant $\sigma_{s_i'}$ effects: Sectoral exports of the US

	10 %		5%		1 %	
Sector	All	LDCs	All	LDCs	All	LDCs
1	5	1	4	1	2	0
2	5	1	4	0	1	0
3	6	2	4	2	1	0
4	5	2	4	1	3	1
5	5	2	5	2	1	0
6	5	1	3	1	2	0
7	6	3	5	3	0	0
8	5	3	4	3	2	2
9	5	3	4	3	2	1
10	4	3	4	3	1	0
Total:	51	21	41	19	15	4

Notes: See notes to Table 6.

Table 8: Number of significant σ_y effects: Sectoral exports to the US

	10 %		5%		1 %	
Sector	All	LDCs	All	LDCs	All	LDCs
1	0	0	0	0	0	0
2	2	2	2	2	2	2
3	3	1	2	1	0	0
4	1	1	0	0	0	0
5	0	0	0	0	0	0
6	4	1	1	0	1	0
7	4	0	3	0	1	0
8	2	0	1	0	1	0
9	2	1	1	1	0	0
10	3	2	1	0	0	0
Total:	21	8	11	4	5	2

See notes to Table 6.

Table 9: Number of significant σ_{y_i} effects: Sectoral exports of the US

	10 %		5%		1 %	
Sector	All	LDCs	All	LDCs	All	LDCs
1	3	1	3	1	3	1
2	5	1	4	1	3	0
3	5	1	5	1	3	1
4	7	2	3	1	2	1
5	4	1	3	0	3	0
6	6	2	5	2	3	1
7	5	2	4	1	3	1
8	5	2	4	1	4	1
9	3	1	3	1	2	1
10	4	2	4	2	3	1
Total:	47	15	38	11	29	8

See notes to Table 6.

Table 10: Number of significant $\sigma_{s_i} \times \sigma_y$ effects: Sectoral exports to the US

	10 %		5%		1 %	
Sector	All	LDCs	All	LDCs	All	LDCs
1	1	1	0	0	0	0
2	2	2	2	2	2	2
3	4	2	3	2	0	0
4	2	2	2	2	0	0
5	0	0	0	0	0	0
6	2	1	2	1	1	0
7	5	2	4	2	1	0
8	2	1	2	1	0	0
9	3	3	2	2	0	0
10	2	1	1	1	1	1
Total:	23	15	18	13	5	3

See notes to Table 6.

Table 11: Number of significant $\sigma_{s_i'} \times \sigma_{y_i}$ soefficients: Sectoral exports of the the US

	10 %		5%		1 %	
Sector	All	LDCs	All	LDCs	All	LDCs
1	4	1	3	1	3	1
2	5	1	3	0	1	0
3	6	2	5	2	2	1
4	7	3	4	1	3	1
5	5	2	5	2	2	1
6	3	1	3	1	3	1
7	6	3	5	3	2	1
8	5	3	4	3	2	2
9	5	3	4	3	3	2
10	4	3	2	1	2	1
Total:	50	22	38	17	23	11

See notes to Table 6.

Appendices

Table 12: Parameter estimates of exchange rate volatility for sectoral exports to the US

Cntry→U.S.	1	2	3	4	5	6	7	8	9	10
JP	−0.10***	0.29***	0.00	0.05	*NA*	−0.43***	−0.16**	−0.03	−0.15***	−0.25***
	(0.035)	(0.096)	(0.081)	(0.117)		(0.081)	(0.070)	(0.052)	(0.048)	(0.079)
GE	−0.12	0.27	−0.34**	−0.53	−0.20	−0.44*	−0.12	−0.04	0.08	*NA*
	(0.151)	(0.265)	(0.146)	(0.582)	(0.495)	(0.223)	(0.130)	(0.142)	(0.137)	
UK	0.09	0.23	−0.09	0.40	*NA*	0.00	0.00	−0.09	−0.05	−0.31
	(0.111)	(0.199)	(0.155)	(0.507)		(0.260)	(0.133)	(0.130)	(0.141)	(0.277)
FR	−0.16	0.02	−0.03	*NA*	−0.94*	0.11	−0.09	0.04	0.14	−0.01
	(0.118)	(0.392)	(0.136)		(0.505)	(0.212)	(0.152)	(0.148)	(0.138)	(0.096)
IT	*NA*	−0.32	−0.05	*NA*	*NA*	*NA*	−0.42**	0.17	0.03	−0.23
		(0.413)	(0.129)				(0.180)	(0.151)	(0.150)	(0.140)
NL	*NA*	0.53	−0.52**	−0.67	−0.96**	−0.16	−0.33***	0.30**	0.04	0.14
		(0.336)	(0.225)	(0.465)	(0.434)	(0.213)	(0.119)	(0.128)	(0.160)	(0.124)
IE	0.54*	*NA*	−0.03	*NA*	*NA*	0.13	−0.16	0.21	0.04	0.49***
	(0.296)		(0.190)			(0.223)	(0.141)	(0.206)	(0.252)	(0.155)
CAN	0.28***	*NA*	*NA*	1.25***	0.51***	0.33***	0.12	−0.07	*NA*	0.17
	(0.086)			(0.257)	(0.130)	(0.087)	(0.074)	(0.056)		(0.102)
SG	−0.23***	0.61**	−0.24*	−1.84***	*NA*	−0.38***	−0.18**	−0.22**	−0.11**	−0.23**
	(0.072)	(0.250)	(0.122)	(0.334)		(0.127)	(0.076)	(0.091)	(0.057)	(0.099)
KR	−0.01	0.23**	0.05**	0.20**	−0.06	0.00	0.03	−0.01	0.03	0.01
	(0.031)	(0.106)	(0.023)	(0.081)	(0.115)	(0.042)	(0.021)	(0.028)	(0.034)	(0.028
ML	−0.17***	0.18	*NA*	*NA*	*NA*	−0.09**	0.11***	0.01	0.04	−0.02
	(0.059)	(0.127)				(0.036)	(0.036)	(0.046)	(0.044)	(0.041)
CN	8.15***	20.85***	13.87***	4.04	−1.80	8.50***	8.75***	8.31***	7.69***	7.31***
	(2.445)	(4.306)	(3.804)	(4.321	(6.409	(2.169	(2.216	(2.091	(2.202	(1.673
BR	0.06	−0.24***	0.01	0.08	*NA*	0.12***	0.03	0.11***	0.04	0.11***
	(0.056)	(0.093)	(0.045)	(0.065)		(0.043)	(0.020)	(0.035)	(0.027)	(0.042)

Notes: Numbers 1 to 10 denote sectors, namely 1) food and live animals; 2) beverages and tobacco; 3) crude materials; 4) mineral fuels, lubricants and related materials; 5) animal and vegetable oils, fats and waxes; 6) chemicals and related products; 7) manufactured goods; 8) machinery and transport equipment; 9) miscellaneous manufactured articles; 10) commodities and transactions. NA stands for not available. Standard errors are given in brackets.
$*$ stands for 10% significant level, $**$ stands for 5% significant level, $***$ stands for 1% significant level.

Table 13: Parameter estimates of exchange rate volatility for US's sectoral exports

U.S.→Cntry	1	2	3	4	5	6	7	8	9	10
JP	−0.15	*NA*	−2.06**	−4.95**	0.55	0.27	−0.72**	−0.23	0.92***	−0.48
	(0.572)		(0.939)	(2.280)	(0.687)	(0.469)	(0.361)	(0.298)	(0.340)	(0.688)
GE	−2.15*	−4.81**	−5.95*	−9.14	*NA*	−5.91***	−3.10*	−2.08	*NA*	−2.46
	(1.260)	(2.069)	(3.314)	(6.767)		(2.015)	(1.630)	(1.588)		(1.508)
UK	0.15	−0.45	−0.71	−3.00	1.27	−0.74	−0.31	0.31	*NA*	−0.88
	(0.608)	(0.787)	(1.260)	(2.182)	(1.204)	(1.304)	(0.563)	(0.341)		(0.818)
FR	−1.48	−2.54**	−0.87	*NA*	−10.37***	−2.73	0.16	0.34	0.01	1.13
	(1.213)	(1.220)	(1.265)		(3.805)	(1.877)	(0.629)	(0.900)	(1.117)	(1.082)
IT	−4.41***	−6.36**	−8.27***	7.77	−6.17**	−3.92*	−2.05	−3.62**	−0.06	−2.16
	(1.478)	(2.482)	(1.871)	(7.696)	(2.501)	(2.273)	(1.380)	(1.396)	(0.656)	(2.549)
NL	1.55***	*NA*	1.46*	10.82***	3.95**	3.47***	1.54**	1.04*	1.90*	2.48***
	(0.503)		(0.750)	(3.303)	(1.761)	(0.894)	(0.590)	(0.530	(0.972)	(0.902)
IE	1.31	1.69	2.11	*NA*	*NA*	2.82	1.89	3.68	0.94	1.32
	(6.021)	(6.083)	(5.752)			(6.575)	(5.522)	(5.692)	(6.938)	(6.061)
CAN	2.88**	1.77***	0.14	10.41***	−0.62	3.39*	1.48	0.17	1.43	0.79
	(1.347)	(0.576)	(0.819)	(3.299)	(1.295)	(1.797)	(1.095)	(0.771)	(0.969)	(1.111)
SG	−0.11	1.49	*NA*	−4.63	8.43**	−0.45	1.30	0.73	−1.10**	−1.78**
	(0.831)	(4.194)		(3.323)	(3.909)	(2.537)	(0.915)	(0.740)	(0.480)	(0.823)
KR	0.00	−0.02	0.63	2.57	0.16	0.97	0.82**	0.03	0.11	0.54
	(0.377)	(1.124)	(0.513)	(2.056)	(3.351)	(0.649	(0.415)	(0.465)	(0.282)	(0.523)
ML	0.25	−1.50	0.80**	−2.05*	*NA*	−0.03	*NA*	−0.41***	−0.02	−0.81**
	(0.481)	(7.325)	(0.314)	(1.098)		(0.280)		(0.143)	(0.085)	(0.368)
CN	−7.20**	−5.01	−5.06**	−7.76	−9.21**	−5.85**	−7.31**	−7.17**	−4.71**	−5.93**
	(3.050)	(3.114)	(2.393)	(5.124)	(4.328)	(2.846)	(2.952)	(3.485)	(1.868)	(2.760)
BR	0.53	1.46*	0.53)	4.24***	−0.27	0.98	1.11**	1.48***	0.57***	0.49
	(0.321)	(0.834)	(0.377)	(1.292)	(0.540)	(0.616)	(0.521)	(0.396)	(0.152)	(0.434)

Notes: See notes to Table 12.

Table 14: Parameter estimates of industrial production volatility for sectoral exports to the US

Cntry→U.S.	1	2	3	4	5	6	7	8	9	10
JP	−45.62	402.89	452.25	106.02	*NA*	−1111.79***	−207.57	−174.13	−279.10	−791.03**
	(160.045)	(437.491)	(369.888)	(534.631)		(366.129)	(313.142)	(238.345)	(218.001)	(361.085)
GE	63.21	331.76	−930.21	204.70	−2485.80	−1975.87*	−1130.80*	−1055.44	−590.43	*NA*
	(711.497)	(1263.403)	(696.062)	(2765.872)	(2353.585)	(1058.293)	(616.258)	(674.151)	(648.408)	
UK	275.48	344.08	−826.79	1202.70	*NA*	−1034.72	−253.87	−630.67	−892.81	219.91
	(436.613)	(783.334)	(609.780)	(1995.395)		(1027.013)	(526.046)	(511.051)	(554.512)	(1095.412)
FR	−305.59	−629.58	−432.46	*NA*	−3160.11	−1110.55	−1492.23**	−1099.60	−715.43	−675.31
	(544.981)	(1809.625)	(627.330)		(2329.665)	(976.404)	(703.720)	(684.094)	(636.526)	(444.546)
IT	*NA*	1549.04	−168.82	*NA*	*NA*	*NA*	−1502.13	−580.14	−339.30	−763.18
		(2123.277)	(657.031)				(918.095)	(772.896)	(765.879)	(716.354)
NL	*NA*	−39.66	−1962.07*	121.87	−1856.37	−401.55	−1163.44**	−407.05	−69.28	357.99
		(1606.214)	(1059.927)	(2197.262)	(2045.122)	(1002.090)	(558.731)	(606.330)	(751.238)	(585.264)
IE	−315.03	*NA*	−1939.83**	*NA*	*NA*	−1657.99*	−1916.90***	−1664.22*	−1859.92*	−420.82
	(1232.848)		(795.158)			(925.797)	(585.835)	(853.787)	(1044.747)	(645.895)
CAN	−155.94	*NA*	*NA*	654.50	200.31	−171.54	−336.76	−459.11***	*NA*	99.29
	(243.193)			(729.946)	(369.845)	(247.281)	(210.457)	(159.002)		(288.242)
SG	−165.46	1083.52	−593.20	−1748.32*	*NA*	−426.62	−225.16	−386.75	−268.67	−505.08*
	(222.676)	(770.795)	(375.124)	(1019.407)		(388.671)	(230.113)	(281.768)	(176.174)	(304.222)
KR	185.86	2390.38***	347.61**	780.43	−1006.37	−61.03	231.26	−41.05	180.30	66.96
	(231.549)	(792.583)	(170.832)	(599.732)	(852.748)	(309.718)	(154.722)	(211.413)	(251.497)	(208.651)
ML	−152.37	241.89	*NA*	*NA*	*NA*	−217.49	−169.76	−202.07	−256.11	−139.66
	(257.226)	(562.313)				(156.623)	(161.168)	(203.448)	(194.444)	(181.882)
CN	962.38	3702.84***	1435.28	−281.79	−714.02	824.47	608.28	941.65	694.19	701.12
	(723.320)	(1293.470)	(1131.067)	(1286.043)	(1898.981)	(646.891)	(659.505)	(622.870)	(650.996)	(497.782)
BR	53.64	61.48	−367.30	−100.20	*NA*	−563.13*	−199.15	−375.57	−376.75**	−474.56*
	(383.777)	(635.680)	(306.341)	(446.839)		(294.773)	(137.697)	(238.598)	(182.604)	(284.567)

Notes: See notes to Table 12.

Table 15: Parameter estimates of industrial production volatility for U.S.'s sectoral exports

U.S.→Cntry	1	2	3	4	5	6	7	8	9	10
JP	2.62	*NA*	−65.42**	−121.94*	21.53	12.87	−12.63	6.49	39.21***	5.60
	(17.825)		(29.291)	(70.779)	(21.405)	(14.603	(11.242)	(9.313)	(10.569)	(21.475)
GE	−69.09	−203.97***	−260.08**	−480.44**	*NA*	−237.32***	−132.25**	−138.47***	*NA*	−162.18***
	(41.782)	(68.594)	(109.892)	(224.157)		(66.815)	(54.052)	(52.667)		(49.990)
UK	14.40	−8.49	−19.73	−114.38*	29.10	−19.77	15.55	16.20	*NA*	−0.66
	(17.787)	(23.043)	(36.877)	(63.946)	(35.248)	(38.208)	(16.495)	(9.952)		(23.972)
FR	−18.59	−39.41*	−7.21	*NA*	−211.76***	−54.31*	12.73	−4.09	−4.35	4.61
	(20.105)	(20.236)	(20.960)		(63.049)	(31.109)	(10.406)	(14.929)	(18.516)	(17.939)
IT	−44.58***	−69.14***	−83.32***	−43.42	−68.72***	−45.42**	−30.33***	−41.94***	−5.12	−29.08
	(11.851)	(19.898)	(14.997)	(61.684)	(20.052)	(18.230)	(11.062)	(11.187	(5.259	(20.445)
NL	51.28***	*NA*	73.51***	431.75***	74.67	142.24***	81.81***	56.16***	72.18**	113.41***
	(15.988)		(23.789)	(104.962)	(56.007)	(28.423)	(18.753)	(16.870)	(30.897)	(28.659)
IE	188.67	205.52	186.42	*NA*	*NA*	274.87	182.72	233.40	247.39	189.58
	(152.365)	(153.906)	(145.586)			(166.162)	(139.666)	(143.990)	(175.439)	(153.412)
CAN	46.66	47.57***	−19.83	176.14*	−107.02***	21.30	−2.90	−3.44	25.09	32.67
	(36.752)	(15.686)	(22.274)	(90.044)	(35.272)	(48.957)	(29.803)	(21.028)	(26.419	(30.331)
SG	−0.28	−3.30	*NA*	−46.07	49.01	−17.30	14.82*	12.27*	−13.66***	−19.17**
	(7.679)	(41.468)		(29.814)	(36.438)	(23.430)	(8.456)	(6.832)	(4.439)	(7.605
KR	9.79	16.08	27.46	119.63*	−22.16	49.23**	37.06***	10.37	−1.76	20.25
	(12.667)	(37.780)	(17.235)	(68.536)	(87.558)	(21.800)	(13.871)	(15.588)	(9.439)	(17.523)
ML	−16.98	−31.65	21.87***	−114.82***	*NA*	−37.64***	*NA*	−32.91***	−1.50	−60.91***
	(12.401)	(19.823)	(8.162)	(28.643)		(7.274)		(3.735)	(2.210)	(9.578)
CN	−20.01	−4.42	−15.01	−32.38	−30.90*	−13.11	−18.14	−19.61	−12.87	−14.88
	(12.862)	(13.144)	(10.104)	(21.638)	(18.276)	(12.026	(12.550)	(14.697)	(7.893)	(11.674)
BR	41.20***	82.03**	10.68	56.01	35.19	40.20	35.41	22.05	3.87	−18.11
	(14.780)	(38.119)	(17.222)	(59.066)	(24.651)	(28.113)	(23.784)	(18.079)	(6.939)	(19.824)

Notes: See notes to Table 12.

Table 16: Parameter estimates of $\sigma_s \times \sigma_y$ for sectoral exports to the US

Cntry→U.S.	1	2	3	4	5	6	7	8	9	10
JP	41.05	−135.51	−87.56	−35.48	*NA*	320.78***	57.26	41.54	76.88	207.99*
	(48.485)	(133.142)	(111.753)	(161.826)		(111.171)	(95.285)	(72.191)	(66.034)	(109.302)
GE	−52.23	−225.37	377.39	−164.36	973.83	647.17	394.65	363.41	162.05	*NA*
	(276.876)	(491.889)	(270.725)	(1076.519)	(915.780)	(411.766)	(239.934)	(262.512)	(252.460)	
UK	−132.17	−296.21	380.27	−705.06	*NA*	396.43	100.50	323.58	374.83	−67.59
	(209.796)	(376.628)	(293.049)	(958.100)		(493.412)	(252.767)	(245.587	(266.351)	(526.704)
FR	113.05	231.29	175.49	*NA*	1264.92	308.25	505.38*	359.46	201.74	277.67
	(212.582)	(705.398)	(244.614)		(908.463)	(380.750)	(274.383)	(266.755)	(248.443)	(173.239)
IT	*NA*	−719.64	47.30	*NA*	*NA*	*NA*	478.19	204.02	50.12	241.88
		(785.966	(242.911)				(339.480)	(285.850)	(283.090)	(264.806)
NL	*NA*	−113.44	772.99*	−102.78	907.47	25.38	451.95**	54.61	−96.51	−196.70
		(611.798)	(402.155)	(833.075)	(775.785)	(380.174)	(211.957)	(230.261)	(285.248)	(222.175)
IE	76.95	*NA*	752.97**	*NA*	*NA*	512.62	755.19***	538.10	613.76	76.33
	(487.521)		(314.571)			(368.931)	(231.902)	(338.293)	(413.989)	(255.393)
CAN	19.82	*NA*	*NA*	−663.17	−254.84	8.69	108.03	233.00**	*NA*	−131.75
	(138.228)			(413.543)	(209.630)	(140.506)	(119.569)	(90.395)		(164.209)
SG	52.75	−468.79	246.81	1275.69**	*NA*	101.56	95.90	130.97	64.73	162.75
	(121.486)	(420.886)	(204.806)	(558.597		(212.066)	(126.012)	(153.812)	(96.137)	(166.518)
KR	−66.08	−1140.12***	−167.37**	−697.09**	665.41	−185.79	−181.52**	−63.64	−219.68*	13.90
	(110.246)	(377.511)	(81.266)	(285.242)	(405.130)	(147.454)	(73.638)	(100.616)	(119.683)	(99.239)
ML	40.87	−42.76	*NA*	*NA*	*NA*	20.22	14.58	−39.04	15.01	−31.83
	(81.189)	(176.241)				(49.414)	(50.600)	(63.929)	(61.152)	(57.004)
CN	−6610.94*	−24067.81***	−11939.15**	−1560.15	1215.87	−7525.38**	−6950.29**	−7558.65**	−6551.44**	−6406.92***
	(3534.191)	(6213.271)	(5484.735)	(6234.035)	(9229.408)	(3128.682)	(3191.998)	(3014.597)	(3178.566)	(2410.384)
BR	115.20	163.10	80.06	−21.99	*NA*	69.75	30.27	43.61	96.03**	56.15
	(84.622)	(139.512)	(67.482)	(98.191)		(65.576)	(30.174)	(52.280)	(40.119)	(62.392)

Notes: See notes to Table 12.

Table 17: Parameter estimates of $\sigma_s \times \sigma_y$ for US's sectoral exports

U.S.→Cntry	1	2	3	4	5	6	7	8	9	10
JP	0.42	NA	21.24**	51.76**	−7.61	−4.56	8.65**	1.59	−10.22***	3.66
	(6.430)		(10.558)	(25.601)	(7.721)	(5.270)	(4.059)	(3.354)	(3.816)	(7.730)
GE	27.08	63.04**	77.64*	121.03	NA	78.01***	40.19*	28.33	NA	31.82
	(17.627)	(28.941)	(46.366)	(94.703)		(28.187)	(22.808)	(22.217)		(21.092)
UK	0.37	7.55	14.96	51.39*	−14.43	13.17	4.96	−2.96	NA	12.72
	(8.597)	(11.134)	(17.822)	(30.878)	(17.027)	(18.457)	(7.969)	(4.815)		(11.580)
FR	8.74	15.12*	4.53	NA	67.72***	17.28	−1.85	−1.42	0.36	−5.89
	(7.797)	(7.837)	(8.127)		(24.440)	(12.059)	(4.039)	(5.785)	(7.175)	(6.952)
IT	14.29***	20.73**	27.78***	−29.52	20.29**	12.65	6.63	11.86**	0.29	6.79
	(5.190)	(8.714)	(6.568)	(27.015)	(8.781)	(7.980)	(4.845)	(4.899)	(2.303)	(8.950)
NL	−19.04***	NA	−21.36**	−149.13***	−46.49**	−48.71***	−23.54***	−13.30*	−23.52*	−34.17***
	(6.451)		(9.615)	(42.333)	(22.576)	(11.460)	(7.561)	(6.799)	(12.460)	(11.555)
IE	−63.14	−68.55	−72.63	NA	NA	−76.17	−66.12	−86.91	−58.49	−60.29
	(65.308)	(66.004)	(62.459)			(71.295)	(59.879)	(61.773)	(75.245)	(65.714)
CAN	−41.75*	−29.14***	−2.73	−160.72***	12.51	−48.58	−19.68	0.65	−18.48	−7.70
	(22.772)	(9.740)	(13.843)	(55.782)	(21.887)	(30.375)	(18.500)	(13.048)	(16.380)	(18.785)
SG	2.41	−8.20	NA	37.93	−68.99**	−2.24	−8.77	−4.82	8.47**	13.13*
	(6.751)	(33.913)		(26.996)	(32.839)	(20.613)	(7.443)	(6.015)	(3.902)	(6.688)
KR	−0.90	−2.50	−10.56	−45.03	8.12	−16.38	−13.68**	−1.78	−1.73	−9.63
	(6.043)	(18.016)	(8.226)	(32.919)	(50.580)	(10.403)	(6.650)	(7.456)	(4.520)	(8.377)
ML	−4.55	30.09	−12.66**	33.42*	NA	1.33	NA	6.08**	0.40	12.88*
	(8.497)	(153.855)	(5.536)	(19.376)		(4.935)		(2.529)	(1.497)	(6.491)
CN	205.93***	91.57	154.07***	185.51*	265.66***	178.03***	209.94***	212.68***	133.54***	173.64***
	(63.822)	(65.177)	(50.070)	(107.251)	(90.586)	(59.574)	(61.923)	(73.033)	(39.098)	(57.784)
BR	−7.24	−22.11*	−7.23	−57.84***	2.57	−13.95	−15.49**	−19.56***	−8.21***	−5.62
	(4.706)	(12.219)	(5.523)	(18.932)	(7.910)	(9.023)	(7.644)	(5.800)	(2.223)	(6.362)

Notes: See notes to Table 12.