Economic Issues, Vol. 12, Part 1, 2007

The Impact of Exchange Rate Volatility on Commodity Trade between the U.S. and China

Mohsen Bahmani-Oskooee and Yongqing Wang[1]

ABSTRACT

Exchange rate uncertainty is said to have negative or positive effects on the trade flows. A Large body of the empirical research that tries to address the issue has used aggregate trade data between one country and rest of the world, or bilateral total trade data between two countries. The support for a significant relation between a measure of exchange rate volatility and trade flows is negligible from these studies. In this paper, when we use disaggregated data between the U.S. and China at commodity level (88 industries) and a bounds testing approach to cointegration, we find that almost half of the industries are sensitive to a measure of exchange rate uncertainty.

1. INTRODUCTION

ALTHOUGH MOST ECONOMISTS believe that the price of any commodity should be determined by market forces the exchange rate, i.e. the price of one currency in terms of another currency, introduces a problem into trade between two countries when left to the forces of demand and supply. The problem is that any fluctuation in the exchange rate introduces uncertainty which could have a detrimental effect on trade flows. What are the channels through which trade could adversely be affected? First, some traders are risk averse and try to avoid any risk associated with exchange rate fluctuations, so that they can avoid losses. The second channel is through making the price and profit outlook more uncertain, which will have a direct impact on the volume of trade. The third channel is through the impact of exchange rate uncertainty on the volume of imported inputs. Because of exchange rate fluctuations, some domestic producers may substitute domestically produced inputs for imported inputs.

Although the common notion in the literature is that exchange rate uncertainty lowers the volume of trade, neither theoretical nor empirical studies are conclusive on this issue. Indeed, some empirical studies find that exchange rate uncertainty could have a positive effect on the trade volume (e.g., Bailey *et al* 1986, 1987). Based on such findings, De Grauwe (1988) introduced a model in which he showed that in a risky environment traders may trade more in order to avoid substantial decline in their revenue.

The empirical literature examining the impact of exchange rate uncertainty on trade volumes is too large to be reviewed here. McKenzie (1999) and Bahmani-Oskooee and Hegerty (2007) provide a comprehensive review of related empirical studies and classify them into three categories. First, there are studies that have employed aggregate trade data (the imports and exports of one country with the rest of the world). Most studies fall within this category and the list includes, but is not limited to, Hooper and Kohlhagen (1978), Gotur (1985), Kenen and Rodrik (1986), Bailey *et al* (1986, 1987), Peree and Steinherr (1989), Caballero and Corbo (1989), Kroner and Lastrapes (1990), Medhora (1990), Asseery and Peel (1991), Akhtar and Spence-Hilton (1984), Chowdhury (1993), Bahmani-Oskooee (1996), Bahmani-Oskooee and Payesteh (1993), Qian and Varangis (1994), and Dell'Ariccia (1999). Because of the aggregation bias problem, the second group of studies has concentrated on using trade data at the bilateral level, i.e., import and export data between two countries. The studies include Thursby and Thursby (1987), Cushman (1983, 1986, 1988), De Grauwe (1988), Koray and Lastrapes (1989), Kumar and Dhawan (1991), Pozo (1992), Caporale and Doroodian (1994), McKenzie and Brooks (1997), and De Vita and Abbot (2004a). Finally, the last category includes only a few studies that have disaggregated the trade data between two countries and have looked at the impact of exchange rate volatility on sectoral data. Klein (1990), Bini-Smaghi (1991), Belanger *et al* (1992), McKenzie (1998), Doyle (2001), and De Vita and Abbot (2004b) are studies in this group.

As can be seen, studies in the third group are few. Furthermore, there is room to expand this part of the literature by considering commodity trade between two countries rather than sectoral trade. Indeed, disaggregating data by commodities has an advantage in that it allows us to pay special attention to commodity attributes. In this paper we investigate the impact of exchange rate volatility on commodity trade between the U.S. and one of her growing trading partners, China, using annual data over the period 1978-2002, for 88 industries. To this end, we outline the model and the method in section 2. The results are reported in section 3 with a summary in section 4. Data definitions and sources appear in an appendix.

2. The models and the method

In assessing the impact of exchange rate volatility on trade flows, the common practice is to express the volume of imports and exports as a function of exchange rate volatility, in addition to other determinants. Since no price data are available at commodity level, the best model that will suit commodity trade is that of Kenen and Rodrik (1986), who identified the income level and the real exchange rate to be other determinants of imports. Adopting their specification at the commodity level between the U.S. and China yields the following model:

$$LnM_{it} = \alpha_0 + \alpha_1 LnY_{US,t} + \alpha_2 LnRE_t + \alpha_3 LnVAR_t + \varepsilon_t \tag{1}$$

where M_i is the import volume of commodity i by the U.S. from China, Y_{US} is a measure of US income, *RE* is the real bilateral exchange rate between the US dollar and Chinese yuan, defined such that a decrease in *RE* reflects a real depreciation of the dollar. *VAR* is a volatility measure of *RE* and $\boldsymbol{\varepsilon}$ is an error term.

What are the expected signs of the estimated coefficients in (1)? Since an increase in economic activity results in increased imports by the US, we expect the estimate of α_1 to be positive. Given the definition of *RE* in the appendix, a decrease reflects a real depreciation of the dollar and if real depreciation is to discourage US imports of commodity *i*, we expect the estimate of α_2 to be positive. Finally, if exchange rate volatility is to have an adverse effect on imports, the estimate of α_3 should be negative.

Equations such as (1), where variables enter at their level and there is no lagged variable, are usually referred to as long-run relationships. Thus, any estimate obtained for α's are long-run estimates. In obtaining these long-run estimates, recent developments in time series analysis require incorporating the short-run adjustment process into the estimation procedure and making sure that when the adjustment takes place, the equilibrating error term (e) decreases over time. The procedure to account for short-run dynamics is one of expressing (1) in an error-correction modeling format. Indeed, the Engle-Granger (1987) error-correction representation theorem requires (1) to be expressed as:

$$\Delta LnM_{it} = c_0 + \sum_{k=1}^{n1} c_{1k} \Delta LnM_{it-k} + \sum_{k=0}^{n2} c_{2k} \Delta LnY_{US,t-k} + \sum_{k=0}^{n3} c_{3k} \Delta LnRE_{t-k} + \\ + \sum_{k=0}^{n4} c_{4k} \Delta LnVAR_{t-k} + \alpha\varepsilon_{t-1} + \mu_t \tag{2}$$

Without a lagged error-correction term, equation (2) is no more than a vector autoregressive specification that was usually used to test Granger causality, a short-run concept. The addition of ε_{t-1} is designed to test whether, in the long run, the equilibrating error shrinks. If it does, the estimate of α must be negative and significant. Note that a negative and significant α will also indicate that the dependent and independent variables in (1) are converging or, alternatively, they are cointegrated. The only requirement is that all variables must be non-stationary in levels or stationary when first differenced.

When an error-correction approach is applied to this part of the literature, we face a problem. In most models, the volatility measure of the exchange rate is already stationary in levels. The majority of the studies cited earlier are older and did not engage in cointegration analysis nor in unit root testing. Indeed recent studies that have applied cointegration analysis, point out that the volatility measure is stationary. For example Doyle (2001, p. 254), after showing that the volatility measure is stationary, concludes that 'volatility plays no role in the long-run export demand function' and concentrates on a short-run analysis. Given more recent advances in cointegration analysis, this need not to be the case. Indeed, the new technique introduced by Pesaran *et al* (2001) does not require pre-unit root testing and variables could be integrated of order one I(1) or order zero I(0) or any combination of the two. As illuminated by Bahmani-Oskooee and Ardalani (2006) and Bahmani-Oskooee and Gelan (2006), Pesaran *et al* (2001) solve equation (1) for ε_t and substitute the linear combination of the lagged level of variables for ε_{t-1} in equation (2). This yields error-correction model (3):

$$\Delta LnM_{it} = c_0 + \sum_{k=1}^{n1} c_{1k}\Delta LnM_{it-k} + \sum_{k=0}^{n2} c_{2k}\Delta LnY_{US,t-k} + \sum_{k=0}^{n3} c_{3k}\Delta LnRE_{t-k} + \sum_{k=0}^{n4} c_{4k}\Delta LnVAR_{t-k}$$
$$+ \delta_0 LnM_{it-1} + \delta_1 LnY_{US,t-1} + \delta_2 LnRE_{t-1} + \delta_3 LnVAR_{t-1} + \mu_t \qquad (3)$$

They then propose applying a standard *F*-test for joint significance of the lagged level variables. The *F*-test, however, has new critical values that they tabulate, through Monte Carlo experiment. By assuming all variables are I(1), they tabulate an upper bound critical value and, by assuming they are all I(0), a lower bound critical value is tabulated. For joint significance of all lagged level variables that support cointegration among them, the calculated F statistics should be higher than the upper bound critical value. Once cointegration is established, the short-run effects of exchange rate volatility on imports is inferred by the sign, size and significance of estimated c_{4k}'s and its long-run effects by the estimate of δ_3 that is normalized on δ_0.[2]

In an effort to discover the sensitivity of US commodity exports to exchange rate volatility, we formulate US exports of commodity i (X_i) to China as a function of Chinese income (Y_C), the real bilateral exchange rate (RE), and the variability measure of the exchange rate (VAR) as in equation (4) below:

$$LnX_{it} = \beta_0 + \beta_1 LnY_{C,t} + \beta_2 LnRE_t + \beta_3 LnVAR_t + \varepsilon_t \qquad (4)$$

In (4), if an increase in Chinese income is to increase the US export of commodity i to China, the estimate of β_1 is expected to be positive. The estimate of β_2 is expected to be negative if a real depreciation of the dollar (i.e., a decrease in RE) is to stimulate US export of commodity i. Finally, if exchange rate volatility is to have detrimental effect on the exports, the estimate of β_3 should be negative.

Just like the import demand model, here too if we attempt to distinguish the short-run effects of exchange rate volatility from its long-run effects, we should express (4) in an error-correction modeling format as in (5) below:

$$\Delta LnX_{it} = d_0 + \sum_{k=1}^{n1} d_{1k}\Delta LnX_{it-k} + \sum_{k=0}^{n2} d_{2k}\Delta LnY_{C,t-k} + \sum_{k=0}^{n3} d_{3k}\Delta LnRE_{t-k} + \sum_{k=0}^{n4} d_{4k}\Delta LnVA$$

$$+ \lambda_0 LnX_{it-1} + \lambda_1 LnY_{C,t-1} + \lambda_2 LnRE_{t-1} + \lambda_3 LnVAR_{t-1} + \xi_t \tag{5}$$

As before, the F-test is applied to test the joint significance of the lagged level variables for cointegration. Furthermore, the short-run effects are inferred from the estimates of d_{4K}'s and the long-run effects from the estimate of λ_3 normalized on λ_0.

3. The results

In this section, error-correction models (3) and (5) are subjected to empirical testing. Annual data on trade in 88 two-digit and three-digit commodity groupings between the US and China are considered. The list of industries is provided in Table 1, with the data sources and definition of variables provided in the appendix.

As outlined in the previous section, the first step in estimating error-correction models (3) and (5) is to carry out the F-test for joint significance of the lagged level variables or for their cointegration. A problem arises in this step that is related to the choice of lag length. Although Pesaran et al. (2001) propose imposing a fixed number of lags on each first differenced variable, Bahmani-Oskooee and Ardalani (2006) have demonstrated that the F test result is sensitive to the lag length. Thus, we follow Bahmani-Oskooee and Gelan (2006) and impose a maximum of two lags and use Akaike's Information Criterion (AIC) to select the optimum lags on each variable. We then carry out the F test on these optimum lags. The results of the F-test, as well as other results from optimum import models for each industry, are reported in Table 1.

Concentrating on the F-test results at optimum lags reported under the diagnostics, we see that only in 25 out of 88 cases is the calculated F statistic less than the upper bound critical value of 3.77. Thus, in the majority of cases there is evidence of cointegration among the variables of the import demand model. Even in the 25 cases in which the F-statistic is less than critical value, we shall proceed by assuming cointegration, because of stronger results in support of cointegration to be discussed later.

Table 1. Coefficient Estimates of US Import Demand Models for Each Industry

Industry	Short-run coefficient estimates of volatility		Long-run Coefficient estimates				Diagnostics	
	$\Delta LnVAR_t$	$\Delta LnVAR_{t-1}$	Constant	Ln Y US	Ln RE	Ln VAR	F	ECM_{t-1}
04 Cereals and cereal preparations	-0.11(2.29)*	0.19 (3.77)*	-13.29 (5.82)*	3.95 (5.72)*	0.52(1.53)	-0.41(4.76)*	4.86	-0.76 (4.14)*
05 Vegetables and fruit	-0.01 (0.35)	0.09 (1.94)**	-2.00 (0.81)	1.73 (2.35)*	0.90 (2.49)*	-0.28 (3.00)*	6.73	-0.70 (4.62)*
057 Fruit & nuts(not includ. oil nuts),	0.03 (0.39)	0.21 (2.99)*	-9.42 (4.77)*	3.27 (5.35)*	0.15 (0.46)	-0.17 (2.41)*	27.42	-1.47 (9.39)*
21 Hides,skins and furskins,raw	0.17 (0.74)		28.92 (3.46)*	-6.95 (2.80)*	1.15 (0.95)	0.17 (0.74)	3.89	-1.09 (4.28)*
26 Textile fibres (except wool tops) a	-0.02 (0.19)	0.17 (2.04)*	-8.23 (2.70)*	3.83 (4.13)*	-1.51 (3.09)*	-0.05 (0.41)	5.23	-1.03 (5.04)*
27 Crude fertilizers and crude materia	-0.04 (0.46)		-10.40 (2.32)*	4.26 (3.10)*	-0.48 (0.66)	-0.29 (1.99)*	7.39	-0.62 (3.73)*
278 Other crude minerals	-0.03 (0.35)		-9.85 (2.11)*	4.14 (2.89)*	-0.51 (0.67)	-0.29 (1.89)**	7.23	-0.61 (3.62)*
28 Metalliferous ores and metal scrap	0.13 (1.83)**	-0.11(1.27)	- 1.05 (0.26)	2.33 (1.86)*	-1.23 (1.94)**	0.42 (3.16)*	7.98	-0.90 (5.70)*
29 Crude animal and vegetable material	-0.03 (0.82)		-13.71 (8.36)*	5.18 (10.57)*	-0.52 (2.18)*	-0.04 (0.90)	6.21	-0.76 (4.45)*
291 Crude animal materials,n.e.s.	0.09 (1.63)		-15.53 (7.03)*	5.80 (8.98)*	-1.18 (3.99)*	0.09 (1.63)	6.34	-1.07 (5.51)*
292 Crude vegetable materials, n.e.s.	-0.04 (0.44)		31.68 (0.36)	-8.13 (0.33)	5.47 (0.55)	-0.33 (0.51)	1.01	-0.12 (0.59)
33 Petroleum,petroleum products and re	0.06 (0.51)		13.89 (1.82)**	-1.16 (0.50)	-0.19 (0.16)	0.09 (0.52)	3.42	-0.62 (3.16)*
51 Organic chemicals	-0.08 (1.75)**		-17.01 (4.99)*	5.44 (5.21)*	0.41 (0.75)	-0.42 (3.55)*	5.01	-0.45 (2.79)*

513 Carboxylic acids,& their anhydrides	0.07 (1.00)	0.08 (1.18)	-20.72 (4.48)*	6.04 (4.19)*	0.36 (0.45)	-0.25 (1.53)	18.67	-0.53 (6.14)*
514 Nitrogen-function compounds	-0.12 (1.11)		-20.36 (4.69)*	5.80 (4.27)*	0.72 (0.97)	-0.36 (2.39)*	38.74	-0.84 10.79)
515 Organo-inorganic and heterocyclic c	-0.22 (4.15)*		12.79 (0.16)	3.54 (0.23)	-8.54 (0.15)	-3.78 (0.27)	6.76	-0.02 (0.22)
516 Other organic chemicals	-0.13 (1.06)	0.14 (1.29)	-12.33 (1.65)**	3.20 (1.41)	1.71 (1.41)	-0.88 (3.09)*	2.48	-0.50 (2.84)*
52 Inorganic chemicals	0.13 (1.57)		-13.79 (2.79)*	4.63 (3.07)*	0.82 (1.01)	-0.16 (0.96)	8.57	-0.48 (2.51)*
522 Inorganic chemical elements,oxides	0.06 (1.00)		-16.47 (7.43)*	5.14 (7.61)*	0.48 (1.36)	-0.11 (1.46)	3.24	-0.69 (3.64)*
523 Other inorganic chemicals	0.05 (0.39)		-11.65 (1.18)	3.84 (1.25)	0.85 (0.48)	-0.40 (1.17)	1.12	-0.37 (1.67)**
53 Dyeing,tanning and colouring materi	-0.03 (0.28)		-24.01 (4.81)*	6.94 (4.27)*	0.43 (0.39)	-0.05 (0.29)	25.17	-0.54 (5.34)*
533 Pigments,paints,varnishes & related	0.12 (1.24)		-153.82(0.17)	72.27 (0.15)	-63.65 (0.13)	4.68 (0.13)	5.72	-0.03 (0.14)
54 Medicinal and pharmaceutical produc	-0.18 (2.63)*	0.18 (2.30)*	-14.45 (4.60)*	4.39 (4.53)*	1.13 (2.13)*	-0.46 (4.20)*	2.79	-0.70 (2.75)*
55 Essential oils & perfume mat.;toile	0.02 (0.32)	0.08 (1.17)	-28.12 (2.44)*	8.44 (2.59)*	-0.78 (0.68)	-0.41 (1.92)**	4.46	-0.38 (1.65)**
551 Essential oils,perfume and flavour	-0.01 (0.30)	0.08 (1.64)	2.27 (2.20)*	0.54 (1.73)**	0.39 (2.60)*	-0.08 (2.11)*	8.54	-1.70 (5.73)*
554 Soap,cleansing and polishing prepar	0.00(0.004)		-35.97 (4.57*)	9.68 (4.17)*	-0.63 (0.65)	0.00 (0.004)	3.83	-0.48 (2.95)*
59 Chemical materials and products,n.e	-0.19 (3.42)*		151.74 (0.09)	-60.35 (0.09)	55.26 (0.10)	-11.16 (0.11)	2.58	-0.02 (0.11)

598 Miscellaneous chemical products,n.e	-0.45 (3.55)*	0.47 (3.17)*	-23.04 (9.66)*	6.24 (8.53)*	0.46 (1.17)	-0.84 (9.20)*	6.60	-1.46 (4.94)*
61 Leather,leather manuf.,n.e.s.and dr	0.15 (2.51)*	-0.24 (4.77)*	-23.92 (2.54)*	8.17 (2.68)*	-0.79 (0.40)	1.40 (2.05)*	7.99	-0.20 (2.89)*
611 Leather	0.65 (2.04)*		14.13 (1.99)*	-4.13 (1.98)**	3.78 (3.83)*	0.52 (2.82)*	4.52	-1.26 (4.17)*
62 Rubber manufactures,n.e.s.	-0.01 (0.05)	-0.12 (1.17)	-35.07 (5.27)*	7.60 (3.71)*	3.95 (3.53)*	-0.63 (2.73)*	4.79	-0.56 (4.75)*
64 Paper,paperboard,artic.of	0.07 (2.24)*		-23.21 (3.42)*	6.72 (3.66)*	1.57 (1.98)*	0.35 (1.59)	7.02	-0.20 (3.36)*
641 Paper and paperboard	-0.09 (0.58)	0.40 (2.49)*	-26.36 (2.04)*	6.81 (1.75)*	0.32 (0.16)	-1.04 (1.82)**	2.87	-0.47 (2.72)*
642 Paper and paperboard, cut to size or	0.10 (1.65)**	-0.09 (1.60)	-35.07 (4.79)*	9.54 (4.31)*	1.37 (1.16)	0.69 (1.66)**	7.13	-0.26 (3.99)*
65 Textile yarn,fabrics,made-part.,re	0.09 (3.54)*		-5.04 (3.72)*	3.09 (7.44)*	0.56 (2.69)*	0.005 (0.14)	15.47	-0.86 (6.21)*
651 Textile yarn	0.15 (1.01)		-16.62 (1.95)**	4.85 (1.91)*	0.74 (0.60)	0.65 (3.01)**	2.42	-0.72 (3.06)*
652 Cotton fabrics,woven	0.07 (1.38)		7.95 (4.20)*	-0.53 (0.94)	0.90 (3.28)*	0.07 (1.38)	9.02	-1.26 (5.50)*
653 Fabrics,woven,of man-made fibres	0.03 (0.33)		-1.43 (0.24)	0.82 (0.46)	1.90 (2.01)*	-0.22 (0.96)	5.38	-0.61 (3.23)*
656 Tulle,lace,embroidery,ribbons,& oth	0.11 (0.57)		3.80 (0.22)	-2.38 (0.48)	6.11 (3.05)*	0.21 (0.58)	2.91	-0.50 (2.47)*
657 Special textile fabrics and related	-0.02 (0.19)	0.23 (2.01)*	-13.64 (4.27)*	4.34 (4.47)*	0.21 (0.43)	-0.32 (2.92)*	7.72	-1.24 (5.34)*
658 Made-up articles,wholly/chiefly of	0.06 (2.05)*		-8.66 (4.31)*	3.45 (5.71)*	1.29 (4.00)*	-0.04 (0.59)	10.25	-0.51 (6.07)*
66 Non-metallic mineral manufactures,n	-0.09 (2.05)*		-19.77 (5.47)*	5.90 (5.60)*	1.44 (2.82)*	-0.45 (4.15)*	5.77	-0.46 (3.75)*

661 Lime,cement,and fabricated construc	-0.14 (1.41)		-41.20 (11.22)	10.75 (9.50)*	0.26 (0.43)	-0.38 (3.17)*	4.44	-0.99 (4.25)*
663 Mineral manufac-tures,n.e.s	-0.08 (0.55)		-29.17 (1.34)	7.11 (1.17)	3.38 (1.28)	-0.30 (0.64)	1.93	-0.27 (2.13)*
68 Non-ferrous metals	-0.06 (0.79)	0.17 (2.21)*	-14.34 (5.26)*	5.40 (6.53)*	-0.77 (1.82) **	-0.04 (0.35)	9.95	-1.05 (6.87)*
689 Miscell.non-ferrous base metals emp	-0.07 (0.41)	-0.29 (1.62)	-5.35 (0.78)	2.43 (1.17)	0.63 (0.62)	-0.02 (0.10)	3.74	-1.01 (3.58)*
69 Manufactures of metal,n.e.s.	-0.03 (0.65)		-21.71 (5.99)*	6.50 (5.62)*	1.50 (2.27)*	-0.28 (2.48)*	3.50	-0.36 (3.47)*
692 Metal containers for storage and tr	0.01 (0.07)	0.12 (1.78)**	-23.81 (6.45)*	5.76 (5.11)*	1.77 (3.00)*	-0.37 (2.56)*	3.61	-0.62 (3.56)*
694 Nails,screws,nuts,bolts	-0.05 (0.81)		-23.06 (2.33)*	7.97 (2.57)*	-1.95 (1.19)	-0.14 (0.73)	2.47	-0.35 (1.90)**
695 Tools for use in hand or in machine	0.01 (0.12)		-16.84 (4.59)*	5.51 (4.89)*	0.55 (0.90)	-0.20 (1.94)**	81.08	-0.43 (10.38)
699 Manufactures of base metal,n.e.s.	-0.04 (0.64)		-21.77 (5.34)*	6.01 (4.90)*	2.08 (3.18)*	-0.25 (2.39)*	16.31	-0.62 (5.95)*
71 Power generating machinery and equi	0.35 (2.80)*		-39.84 (3.29)*	11.63 (2.89)*	-0.11 (0.04)	1.09 (1.62)	4.33	-0.32 (2.59)*
713 Internal combus-tion piston engines	0.20 (1.40)		-62.90 (2.17)*	19.77 (1.78)*	-5.89 (0.80)	1.06 (0.70)	2.42	-0.18 (1.17)
72 Machinery special-ized for particula	-0.09 (0.60)		-16.26 (1.96)*	3.34 (1.41)	4.06 (3.98)*	-0.15 (0.54)	1.50	-0.61 (3.13)*
724 Textile & leather machinery and par	0.50 (3.36)*		-19.39 (0.85)	4.06 (0.63)	5.03 (1.71)**	1.93 (1.91)**	6.39	-0.26 (2.76)*
728 Mach.& equipment specialized for pa	-0.20 (0.77)		-25.70 (3.49)*	5.42 (2.50)*	3.51 (3.39)*	-0.15 (0.72)	4.81	-1.30 (4.21)*
73 Metalworking machinery	0.07 (0.72)		-17.93 (2.10)*	5.48 (2.19)*	0.69 (0.56)	0.17 (0.64)	4.27	-0.38 (3.02)*

From the short-run results, for brevity we only report the short-run coefficient estimates for the exchange rate volatility measure (*VAR*). As can be seen, there is at least one coefficient that is significant at the 10% level in 38 cases. Moreover, there are positive as well as negative coefficients indicating that the short-run effects of exchange rate volatility could be positive or negative, a result that is in line with most previous research.

Are these short-run effects extended into the long run? The long-run results reveal that the variability measure of the real bilateral rate (Ln VAR) carries a significant coefficient either at the 10 per cent or 5 per cent level in 36 out of 88 industries. Furthermore, in almost half of the cases the estimated coefficient is negative and in half it is positive. Further inspection reveals that the cases in which exchange rate volatility has a significantly negative effect on imports are mostly for non-durable commodities. This finding contradicts Lee (1999), who used aggregate durable and non-durable trade data and showed that exchange rate volatility lowers the volume of durables but not non-durables. He considered durables as asset-like goods and argued that risk-averse consumers may pay a lower price for durable goods to be compensated for the risk. Our finding show that consumers treat non-durables in the same way as durables, perhaps over a shorter horizon.[3]

Clearly the results reveal that once durables and non-durables are disaggregated by commodity, there are commodities in each group that respond negatively to a measure of exchange rate uncertainty. On the other hand, many durable commodities seem to be affected positively by exchange rate volatility. Furthermore, it appears that the size of an industry does not matter. More than 70 per cent of U.S. imports from China are from seven large industries, i.e., Manufactures of metal (4.2 per cent), Office Machines (11.8 per cent), Telecommunications (11 per cent), Telecommunications Equipment (4.9%), Electrical Machinery (8.6 per cent), Miscellaneous manufactured articles (18.9 per cent) and Baby Carriages (11.9 per cent). From Table 1 we gather that while the first of these seven industries is negatively affected, the next two are positively affected by exchange rate uncertainty. The remaining four are not affected significantly.[4]

As for the long-run effects of a change in the real exchange rate, there are 29 industries in which a real depreciation of the dollar against the yuan lowers the import volume. Further inspection reveals that there are more durable imports (18 commodities) than non-durable imports (11 commodities) sensitive to the real depreciation of the dollar. This supports Burda and Gerlach (1992) who argued that durables should be more sensitive to the exchange rate than non durables, even though they used aggregate trade data in their analysis. Finally, US income carries its expected positive and significant coefficient in most cases, signifying the importance of economic growth in the U.S. as a key source of the trade deficit with China.

Following Bahmani-Oskooee and Brooks (1999), we use the long-run coefficient estimates and form an error-correction term denoted by *ECM*. We then replace the linear combination of the lagged level variables by ECM_{t-1} and estimate the new error-correction model using the same optimum number of lags on each first differenced variable. A significantly negative coefficient obtained for ECM_{t-1} is an alternative way of supporting cointegration among the variables. Table1 reveals that ECM_{t-1} carries a significantly negative coefficient in almost all cases.

We now turn to the estimates of the export demand model outlined by equation (5). The results from the optimum lag models are reported in Table 2.

First, cointegration among the variables in the export demand model is supported by the *F*-test in 65 out of 88 cases and by the ECM_{t-1} in 84 out of 88 cases. Second, from the short-run coefficient estimates there are 38 industries in which there is at least one coefficient obtained for exchange rate volatility that carries a significant coefficient. Thus, as with imports, little less than half of the export industries are sensitive to exchange rate volatility. The long-run estimates reveal that the short-run effects are extended into the long run in 33 cases. Note that the coefficient estimate is negative only in five industries. Thus, in contrast to imports, it appears that exchange rate volatility has a positive effect on many industries in the export sector.

Included among these industries are small and large industries. Large industries, which export almost 56 per cent of U.S. goods to China are Metal ores (4.4 per cent), Machinery Specialized (5 per cent), Machine and Equipment (3.1 per cent), General Industrial Machinery (5.9 per cent), Office Machines (4.4 per cent), Telecommunications (4.4 per cent), Telecommunications Equipment (4.2 per cent), Electrical Machinery (10.6 per cent), Thermionic (6.2 per cent), Professional and Scientific Items (4.3 per cent), and Measuring Instruments (3.6 per cent). While five of these industries are positively and significant affected by exchange rate uncertainty, six are not affected. As for the long-run effect of the real depreciation of the dollar, the real bilateral exchange rate takes its negative and significant sign in only 17 industries.[5] Finally, Chinese income carries its expected positive and significant coefficient in most industries, supporting the view that economic growth in China should help boost US exports to China.

Finally, before closing we report some additional diagnostics in Table 3. First, to test for stability of the short-run and the long-run coefficients, we follow Bahmani-Oskooee *et al.* (2005) and apply the CUSUM and CUSUMSQ tests to the residuals of each optimum error-correction model. Stable coefficients are identified by an 'S' and unstable coefficients by a 'U'. As can be seen from Table 3, in the majority of models, import and export, there is evidence of stability. Second, to test for autocorrelation in the presence of a lagged dependent variable, we report the Lagrange Multiplier (LM) statistic. As indicated at the bottom of the table, this statistic is distributed as χ^2 with one degree of freedom. Given the 5% critical value of 3.84, the residuals seem to be autocorrelation-free in almost all models. Third, to test for functional

Table 2. Coefficient Estimates for US Export Demand Model for Each Industry

Industry	*Short-run coefficient estimates of volatility*		*Long-run coefficient estimates*				*Diagnostics*	
	$\Delta Ln\ VAR_t$	$\Delta Ln\ VAR_{t-1}$	*Constant*	$Ln\ Y_C$	$Ln\ RE$	$Ln\ VAR$	F	ECM_{t-1}
04 Cereals and cereal preparations	0.22 (0.56)		16.74 (6.15)*	-0.95 (0.52)	-2.03 (0.62)	0.33 (0.55)	3.25	-0.67 (3.54)*
05 Vegetables and fruit	-0.48 (2.67)*		-8.88 (12.25)*	2.18 (2.67)*	2.11 (1.32)	-0.92 (2.90)*	6.50	-0.98 (4.45)*
057 Fruit & nuts(not includ. oil nuts),	-0.41 (1.49)		-7.95 (7.16)*	1.03 (0.82)	3.49 (1.43)	-1.08 (2.21)*	5.06	-0.89 (4.11)*
21 Hides,skins and furskins,raw	0.28 (1.30)		-3.58 (2.91)*	5.85 (5.38)*	-6.98 (3.54)*	0.38 (1.22)	7.96	-0.74 (5.07)*
26 Textile fibres (except wool tops) a	0.54 (1.89)**		9.15 (2.63)*	2.75 (1.03)	-5.04 (1.06)	1.57 (1.11)	1.65	-0.35 (1.73)**
27 Crude fertilizers and crude materia	-0.09 (0.21)		-7.43 (4.26)*	0.58 (0.47)	4.79 (2.17)*	-0.09 (0.21)	3.72	-0.98 (4.14)*
278 Other crude minerals	-0.08 (0.48)	0.33 (1.73)**	-7.25 (7.01)*	1.37 (1.15)	3.24 (1.47)	-0.03 (0.05)	4.26	-0.68 (3.21)*
28 Metalliferous ores and metal scrap	1.25 (5.73)*	-1.09 (4.56)*	-4.16 (7.61)*	4.17 (4.94)*	-1.93 (1.13)	1.78 (5.22)*	34.57	-1.75 (8.22)*
29 Crude animal and vegetable material	0.01 (0.11)		-3.36 (3.11)*	1.93 (2.43)*	0.61 (0.43)	0.03 (0.11)	2.25	-0.42 (2.54)*
291 Crude animal materials,n.e.s.	0.05 (0.42)	-0.23 (2.28)*	-2.96 (2.22)*	2.52 (2.75)*	-0.44 (0.22)	0.74 (1.85)**	9.34	-0.60 (3.77)*
292 Crude vegetable materials, n.e.s.	-0.11 (0.60)		-5.79 (1.59)	2.94 (1.48)	-0.70 (0.20)	-0.40 (0.47)	0.86	-0.28 (1.23)
33 Petroleum,petroleum products and re	-0.01 (0.03)	-0.61 (0.43)	-3.99 (2.16)*	3.72 (1.95)**	-2.20 (0.57)	1.41 (1.60)	4.28	-0.67 (4.02)*
51 Organic chemicals	0.32 (3.49)*	-0.16 (1.81)**	5.36 (7.59)*	1.70 (3.35)*	-1.61 (1.63)	0.80 (3.56)*	5.10	-0.68 (4.08)*
512 Alcohols,phenols,phenol-alcohols,&	0.23 (1.33)		1.86 (2.76)*	3.50 (4.60)*	-4.64 (3.13)*	0.70 (2.38)*	18.43	-1.08 (9.32)*

514 Nitrogen-function compounds	0.11 (0.80)		0.65 (0.61)	2.47 (3.07)*	-1.71 (1.08)	0.65 (2.15)*	3.93	-0.64 (3.96)*
515 Organo-inorganic and heterocyclic c	0.02 (0.14)		-1.10 (1.04)	1.75 (2.23)*	-0.15 (0.11)	0.04 (0.14)	2.07	-0.55 (2.63)*
516 Other organic chemicals	0.24 (1.90)**		1.50 (3.06)*	1.46 (3.67)*	-0.39 (0.54)	0.24 (1.90)**	4.92	-0.89 (4.73)*
52 Inorganic chemicals	0.01 (0.06)		3.98 (6.01)*	-0.03 (0.05)	1.44 (1.40)	0.01 (0.06)	3.46	-1.10 (3.46)*
522 Inorganic chemical elements,oxides	0.12 (0.54)		2.40 (2.36)*	1.35 (1.90)**	-1.12 (0.92)	0.12 (0.54)	3.40	-0.89 (4.00)*
523 Other inorganic chemicals	0.08 (0.41)	-0.23 (1.42)	3.62 (4.99)*	-0.61 (0.76)	2.57 (1.60)	0.08 (0.24)	3.92	-1.05 (3.55)*
53 Dyeing,tanning and colouring materi	0.51 (3.37)*	-0.46 (3.26)*	-1.03 (0.39)	3.73 (2.61)*	-2.89 (1.00)	1.69 (2.14)*	3.30	-0.38 (2.47)*
533 Pigments,paints,varnishes & related	0.72 (2.86)*	-0.62 (2.52)*	-0.75 (0.27)	7.78 (2.52)*	-11.01 (1.71)**	3.01 (2.26)*	9.04	-0.55 (3.51)*
54 Medicinal and pharmaceutical produc	0.02 (0.22)		-2.50 (5.47)*	0.80 (2.38)*	2.71 (4.43)*	0.02 (0.22)	8.45	-1.09 (6.22)*
55 Essential oils & perfume mat.;toile	0.39 (2.43)*	-0.40 (2.32)*	-3.25 (4.27)*	3.16 (4.69)*	-1.50 (1.23)	0.94 (3.28)*	8.27	-0.95 (6.29)*
551 Essential oils,perfume and flavour	0.62 (2.52)*		-5.17 (5.04)*	1.68 (2.29)*	1.57 (1.21)	0.62 (2.52)*	3.77	-0.88 (4.08)*
554 Soap,cleansing and polishing prepar	0.59 (2.48)*	-0.72 (3.20)*	-2.89 (2.15)*	5.03 (2.72)*	-5.42 (1.56)	1.66 (2.11)*	10.43	-0.76 (3.92)*
59 Chemical materials and products,n.e	0.04 (0.59)	-0.17 (2.26)*	2.49 (6.32)*	2.75 (4.11)*	-3.09 (2.54)*	0.05 (0.20)	11.14	-0.69 (4.70)*
598 Miscellaneous chemical products,n.e	-0.03 (0.29)		0.52 (1.31)	2.91 (6.74)*	-2.57 (3.13)*	0.11 (0.71)	8.15	-0.98 (6.29)*
61 Leather,leather manuf.,n.e.s.and dr	0.14 (1.28)		1.79 (2.15)*	5.21 (6.55)*	-8.86 (6.02)*	0.25 (1.24)	24.98	-0.54 (7.15)*
611 Leather	0.26 (2.56)*		1.70 (0.69)	6.56 (2.83)*	-11.93 (2.85)*	1.14 (1.95)**	3.48	-0.23 (3.18)*
62 Rubber manufactures,n.e.s.	0.48 (3.63)*	-0.42 (2.80)*	-1.06 (3.04)*	3.32 (8.82)*	-3.62 (5.30)*	0.72 (4.90)*	15.57	-1.72 (8.14)*

64 Paper, paperboard, artic.of paper,pap	-0.08 (0.74)	-0.30 (2.81)*	3.22 (8.05)*	2.09 (3.88)*	-1.75 (1.63)	0.26 (1.22)	56.18	-1.24 (11.75)*
641 Paper and paper-board	-0.19 (2.03)*		3.16 (11.41)*	1.00 (4.53)*	0.25 (0.60)	-0.14 (2.07)*	46.40	-1.38 (13.78)*
642 Paper and paper-board,cut to size or	-0.02 (0.12)	-0.39 (2.54)*	-7.22 (11.4)*	3.81 (4.92)*	-1.31 (0.90)	0.39 (1.24)	11.68	-1.13 (7.49)*
65 Textile yarn, fabrics, made-up art, re	0.60 (3.42)*		6.71 (6.47)*	3.26 (1.84)*	-6.09 ((1.84)**	1.08 (1.73)**	4.81	-0.55 (2.76)*
651 Textile yarn	0.49 (2.04)*		6.46 (5.89)*	2.76 (3.34)*	-5.65 (4.08)*	0.49 (2.04)*	5.58	-1.00 (5.17)*
652 Cotton fabrics,woven	1.73 (3.62)*	-2.06 (4.11)	6.00 (1.56)	17.01 (2.78)*	-32.10 (2.58)*	7.73 (2.85)*	14.09	-0.63 (4.12)*
653 Fabrics,woven,of man-made fibres	0.31 (1.17)		6.45 (4.26)*	1.89 (1.53)	-4.31 (1.93)**	0.47 (1.14)	3.65	-0.67 (4.14)*
656 Tulle,lace,embroi-dery,ribbons,& oth	0.07 (0.41)		-7.00 (10.17)	2.27 (4.61)*	0.27 (0.31)	0.07 (0.41)	12.66	-1.37 (6.53)*
657 Special textile fabrics and related	0.66 (2.22)*		-1.22 (0.34)	3.70 (1.51)	-2.42 (0.50)	1.35 (1.28)	0.71	-0.49 (1.83)**
658 Made-up articles, wholly/chiefly of	0.19 (0.66)		-2.16 (1.84)**	2.64 (3.14)*	-2.44 (1.64)	0.19 (0.66)	4.05	-0.77 (3.43)*
66 Non-metallic mineral manufactures, n	-0.23 (1.52)		-2.99 (2.69)*	1.36 (2.18)*	2.03 (1.76)**	-0.32 (1.53)	3.40	-0.70 (3.09)*
661 Lime, cement, and fabricated construction	-0.80 (2.76)*		-15.05 (18.48)*	4.86 (7.73)*	-1.29 (1.17)	-0.55 (2.92)*	17.28	-1.45 (8.51)*
663 Mineral manufac-tures,n.e.s	0.30 (2.61)*	-0.13 (1.25)	-4.48 (8.30)*	2.96 (7.58)*	-0.82 (1.12)	0.64 (3.68)*	4.53	-1.13 (4.67)*
68 Non-ferrous metals	-0.34 (1.82)**	0.56 (2.50)*	1.20 (2.83)*	1.14 (2.59)*	0.23 (0.26)	-0.30 (1.57)	3.93	-1.81 (4.42)*
689 Miscell. non-ferrous base metals emp	0.54 (1.07)		1.26 (0.60)	2.53 (1.69)**	-3.50 (1.32)	0.54 (1.07)	2.90	-0.83 (3.29)*
69 Manufactures of metal, n.e.s.	0.10 (0.77)	0.29 (2.13)*	2.15 (3.91)*	2.67 (3.94)*	-3.20 (2.49)*	0.17 (0.60)	7.16	-0.99 (5.94)*
692 Metal containers for storage and tr	0.19 (0.20)	-0.23 (1.28)	-1.89 (2.84)*	4.69 (5.76)*	-5.61 (3.57)*	1.14 (3.30)*	7.33	-1.00 (6.01)*
694 Nails, screws, nuts, bolts etc.of iron	-0.04 (0.24)		-4.62 (7.44)*	1.64 (3.57)*	1.15 (1.38)	-0.04 (0.24)	4.15	-0.79 (4.44)*
Tools for use in hand or in machine	0.34 (1.88)**		3.37 (7.15)*	2.70 (5.01)*	-4.50 (4.36)*	0.48 (2.44)*	11.60	-1.51 (6.43)*

699 Manufactures of base metal,n.e.s.	-0.23 (1.58)		-2.79 (6.18)*	2.38 (6.99)*	-0.80 (1.34)	-0.17 (1.57)	21.01	-1.37 (8.69)*
71 Power generating machinery and equi	-0.09 (0.66)		2.71 (4.45)*	0.07 (0.14)	2.57 (2.69)*	0.12 (0.63)	4.82	-1.04 (4.71)*
713 Internal combustion piston engines	0.15 (1.40)		-0.34 (0.76)	1.21 (3.70)*	0.69 (1.19)	0.15 (1.40)	5.99	-0.82 (5.22)*
72 Machinery specialized for particula	0.25 (3.15)*		4.95 (18.27)*	0.79 (2.71)*	0.25 (0.44)	0.33 (3.20)*	8.34	-1.24 (5.76)*
724 Textile & leather machinery and par	0.26 (2.10)*		2.99 (5.41)*	-0.57 (1.36)	2.78 (3.98)*	0.26 (2.10)*	4.53	-0.97 (4.68)*
728 Mach.& equipment specialized for pa	0.25 (2.00)*	-0.23 (1.36)	2.70 (9.90)*	0.36 (1.04)	2.04 (3.16)*	0.43 (2.99)*	7.21	-1.60 (5.11)*
73 Metalworking machinery	0.14 (0.80)		2.15 (4.54)*	0.54 (0.96)	1.58 (1.49)	0.41 (2.03)*	8.47	-1.37 (5.35)*
736 Mach.tools for working metal or met	0.02 (0.15)		1.48 (2.40)*	-0.23 (0.49)	3.01 (3.62)*	0.02 (0.15)	6.18	-1.02 (5.43)*
74 General industrial machinery & equi	0.10 (1.83)**		2.58 (11.54)*	1.56 (6.51)*	-0.03 (0.06)	0.32 (3.54)*	10.74	-1.03 (7.26)*
745 Other non-electrical mach.tools,app	-0.10 (0.92)		-2.14 (5.05)*	1.55 (4.51)*	0.72 (1.14)	-0.10 (0.92)	4.61	-1.01 (4.68)*
749 Non-electric parts and accessories	0.10 (0.93)		-0.22 (0.31)	0.57 (1.03)	2.59 (2.54)*	0.16 (0.90)	3.82	-0.60 (3.23)*
75 Office machines & automatic data pr	0.18 (1.56)		2.96 (1.95)**	3.34 (1.75)**	-4.05 (1.02)	0.59 (1.23)	9.89	-0.31 (1.69)**
751 Office machines	-0.16 (0.93)		0.25 (0.31)	1.04 (1.84)**	-0.44 (0.46)	-0.16 (0.93)	14.55	-0.88 (8.28)*
76 Telecommunications & sound recordin	0.00 (0.05)	-0.14 (1.91)**	0.02 (0.01)	1.67 (1.66)**	0.39 (0.19)	0.29 (0.65)	2.39	-0.39 (2.18)*
764 Telecommunications equipment & pa	-0.03 (0.40)	-0.12 (1.84)**	-0.38 (0.36)	0.91 (0.90)	1.93 (1.05)	0.08 (0.22)	3.55	-0.37 (2.45)*
77 Electrical machinery,apparatus & ap	0.02 (0.27)	0.11 (1.92)**	-0.35 (0.59)	2.77 (5.80)*	-1.06 (1.19)	-0.06 (0.28)	4.14	-0.51 (3.18)*
772 Elect.app.such as switches,relays,f	0.20 (2.12)*		-3.02 (9.29)*	2.75 (10.52)*	-0.58 (1.18)	0.35(3.55)*	9.12	-1.32 (5.85)*
774 Electric apparatus for medical purp	-0.08 (0.80)		0.87 (1.09)	0.98 (1.53)	0.59 (0.50)	-0.18 (0.67)	14.59	-0.46 (2.13)*
775 Household type,elect.& non-electric	0.10 (0.67)		-3.45 (2.24)*	2.55 (3.09)*	-1.12 (0.67)	0.16 (0.65)	6.15	-0.63 (3.58)*
776 Thermionic, cold & photocathode valves	0.10 (0.83)		-5.77 (9.55)*	6.06 (8.16)*	-5.08 (3.62)*	0.56 (2.05)*	9.10	-0.79 (5.75)*

778 Electrical machinery and apparatus,	0.10 (1.58)		0.08 (0.32)	1.75 (9.37)*	-0.10 (0.31)	0.10 (1.58)	5.64	-0.53 (5.08)*
81 Sanitary, plumbing, heating and light	0.33 (2.15)*	-0.28 (1.93)**	-3.81 (5.60)*	2.89 (6.50)*	-1.30 (1.49)	0.64 (3.23)*	20.67	-1.20 (7.64)*
87 Professional,scientific & controlin	-0.11 (1.22)	0.18 (2.28)*	3.21 (2.05)*	-1.40 (0.70)	4.64 (1.20)	-1.25 (0.99)	2.58	-0.31 (1.21)
872 Medical instruments and appliances	-0.04 (0.35)		-2.09 (1.48)	2.56 (2.24)*	-1.29 (0.54)	-0.10 (0.33)	7.76	-0.42 (1.60)
874 Measuring, checking, analysing instru	-0.11 (1.18)	0.20 (0.49)	3.24 (1.61)	-1.86 (0.75)	5.33 (1.11)	-1.49 (0.92)	2.69	-0.27 (1.09)
88 Photographic apparatus,optical good	0.04 (0.29)		-3.15 (2.16)*	4.87 (2.25)*	-5.05 (1.29)	0.60 (0.86)	3.67	-0.45 (2.52)*
881 Photographic apparatus and equi.	0.22 (1.22)		-1.58 (1.27)	3.86 (2.86)*	-4.06 (1.70)**	0.76 (1.68)**	3.80	-0.66 (3.40)*
882 Photographic & cinematographic supp	-0.19 (1.14)		-9.10 (3.22)*	1.55 (1.05)	3.44 (1.13)	-0.47 (0.92)	2.52	-0.39 (2.28)*
885 Watches and clocks	-0.15 (0.53)		-3.21(2.70)*	4.26 (4.58)*	-5.61 (3.44)*	-0.15 (0.53)	9.00	-1.11 (6.33)*
89 Miscellaneous manufactured articles	-0.15 (1.71)**		-0.64 (1.13)	1.64 (3.49)*	0.55 (0.64)	-0.25 (1.49)	1.90	-0.59 (3.03)*
892 Printed matter	-0.06 (0.33)		1.36 (1.21)	1.23 (1.32)	-0.59 (0.34)	-0.10 (0.33)	2.97	-0.56 (2.77)*
893 Articles of materials described in	0.07 (0.77)	-0.28 (3.36)*	-4.78 (13.16)*	4.00 (9.12)*	-2.36 (2.78)*	0.48 (2.64)*	45.71	-1.04 (14.79)*
894 Baby arriages, toys, games and sport	-0.17 (0.77)		-3.40 (1.08)	0.93 (0.47)	2.01 (0.53)	-0.57 (0.81)	1.51	-0.30 (2.52)*
895 Office and stationery supplies,n.e.	0.20 (1.12)		-8.89 (19.67)*	3.39 (9.77)*	-0.70 (1.12)	0.12 (1.13)	16.26	-1.59 (7.90)*
897 Jewellery,goldsmiths and other art.	0.79 (1.94)**		-3.54 (0.78)	4.13 (1.28)	-3.81 (0.61)	1.78 (1.32)	2.58	-0.44 (2.36)*
898 Musical instruments,parts and acces	0.00 (0.00)		-3.30 (8.65)*	1.83 (6.51)*	0.98 (1.91)**	0.00 (0.001)	9.34	-1.27 (7.43)*
899 Other miscellaneous manufactured articles	-0.15 (1.21)		-4.63 (8.63)*	0.89 (1.51)	2.67 (2.36)*	-0.55 (2.45)*	4.97	-0.85 (4.90)*

misspecification, we report Ramsey's RESET statistic, which is also distributed as χ^2 with one degree of freedom. Again, in the majority of the models, this statistic is less than its critical value of 3.84, indicating that the error-corrections models are correctly specified. Finally, we report the size of adjusted R^2 to measure the goodness of fit. Again, in most models the size of the adjusted R^2 is reasonable.

4. Summary and conclusion

One area in international economics that has its own literature is the impact of exchange rate uncertainty on trade flows. The topic has received a great deal of attention since the advent of current float in 1971. Indeed, under the Smithsonian Agreement those who favoured fixed rates argued against floating exchange rates mostly because of concerns that floating rates introduce uncertainty that could hurt trade flows among the countries.

In testing the impact of exchange rate uncertainty on trade flows, almost all studies have employed aggregate trade data. When such data are used, a significant relation between a measure of exchange rate volatility and the imports of one industry could be offset by an insignificant relation between the same two variables of another industry, with the net outcome being an insignificant relation between aggregate imports and exchange rate volatility. In trade between two countries, in order to identify which industries are affected by exchange rate uncertainty, we should disaggregate the data.

In this paper we disaggregate total trade between the US and China using import and export data from 88 industries, to identify those that are affected by a measure of exchange rate volatility. By relying on a relatively new cointegration technique that does not require pre-unit root testing, the bounds testing approach, we show that the imports and exports of little less that half of the industries are affected by exchange rate volatility. An important discovery is that while most US imports from China are negatively affected by exchange rate uncertainty, the majority of its exports to China are positively affected.

Accepted for publication: 15 December 2006

Appendix

Data definitions and sources

Annual data over the period 1978-2002 are used d to carry out the empirical analysis. They come from the following sources:

a. World Bank.
b. International Financial Statistics of IMF (CD-ROM).
c. Chinese Statistical Yearbook.

Variables

M_i = Volume of imports of commodity *i*. Import value data for each commodity comes from source *a*. In the absence of a price level for each commodity, as a second best deflator following Bahmani-Oskooee and Ardalani (2006) we use the aggregate import price index for the US to deflate the nominal imports of each commodity. The aggregate import price index comes from source *b*.

X_i = Volume of exports of commodity *i*. Export value data for each commodity come from source a. In the absence of a price level for each commodity, again as a second best deflator, following Bahmani-Oskooee and Ardalani (2006) we use the aggregate export price index for the US to deflate the nominal exports of each commodity. The aggregate export price index comes from source *b*.

Y_{US} = Measure of United States income. It is proxied by real *GDP*. The data come from source *b*.

Y_C = China's real *GDP*. Nominal *GDP* is deflated by *CPI*, the only price index available (1995=100). All data come from source *c*.

RE = Real bilateral exchange rate between dollar and yuan, defined as $(P_{US}.EX/P_C)$ where *EX* is the nominal exchange rate, defined as number of yuan per dollar; P_{US} is the price level in the US measured by the *CPI* and P_C, the price level in China, again measured by the *CPI*. The data for all three variables involved come from source *b*.

VAR = Variability measure of the real bilateral yuan-dollar rate (*RE*). For each year it is defined as the standard deviation of the 12 monthly real bilateral rate (*RE*) within that year. Monthly CPI data and nominal exchange rate data come from source *b*. Note that prior to the introduction of cointegration and error-correction techniques, the volatility measure was based on the standard deviation of percentage changes in the real exchange rate. For example, Lanyi and Suss (1982, p. 538) defined their volatility measure as the standard deviation of monthly percentage changes and argued that this measure 'provides the most appropriate way of removing the trend in changes in the exchange rate'. Since cointegration and error-correction techniques do not require de-trending the variables, rather than using the standard deviation of percentage change in the exchange rate we rely upon the standard deviation of the real exchange rate itself. In order to see the extent of real bilateral Yuan-dollar exchange rate volatility, we plot the measure in Figure 1.

ENDNOTES

1. Mohsen Bahmani-Oskooee and Yongqing Wang, The Center for Research on International Economics and The Department of Economics, University of Wisconsin-Milwaukee, Milwaukee, WI 53201. Phone: 414-229-4334; Fax: 414-229-2438. bahmani@uwm.edu Valuable comments of an anonymous referee are greatly appreciated. Any errors, however, belong to us.

2. As a matter of fact, the long-run effects of all three variables could be inferred by the

estimates of δ_1 - δ_3 that are normalized on δ_0 . This is usually done by dividing estimates of δ_1 - δ_3 by the estimate of δ_0 multiplied by a minus sign. More precisely, once equation (3) is estimated we set the long run component equal to zero, which amounts to $\hat{\delta}_0 LnM_{it-1} + \hat{\delta}_1 LnY_{US,t-1} + \hat{\delta}_2 LnRE_{t-1} + \hat{\delta}_3 LnVAR_{t-1} = 0$. Solving this for Ln M_{it-1} yields:

$LnM_{it-1} = -\frac{\hat{\delta}_1}{\hat{\delta}_0} LnY_{US,t-1} - \frac{\hat{\delta}_2}{\hat{\delta}_0} LnRE_{t-1} - \frac{\hat{\delta}_3}{\hat{\delta}_0} LnVAR_{t-1}$ which clearly shows the long-run effects of all three right-hand side variables in (1) on imports.

3. The fact that volatility affects non-durables more than durables could be due to hedging possibility that could be available relatively more for durables than non-durables. Trade in non-durables has to take place over shorter time period during which hedging options may not be available.

4. A table is available from the authors upon request showing the trade share of each industry in Table 1.

5. Note that in the export industries more non-durables are sensitive to the exchange rate than durables. These results are not consistent with those of Burda and Gerlach (1992).

REFERENCES

Akhtar M A and Spence-Hilton R (1984) 'Effects of exchange rate uncertainty on German and US trade', *Quarterly Review*, Federal Reserve Bank of New York, Spring, 7-16.

Asseery A and Peel D A (1991) 'The effects of exchange rate volatility on exports', *Economics Letters*, 37, 173-177.

Bahmani-Oskooee M (1996) 'Exchange rate uncertainty and trade flows of LDCs: evidence from Johansen's cointegration analysis', *Journal of Economic Development*, 21, 23-35.

Bahmani-Oskooee M and Ardalani Z (2006) 'Exchange Rate Sensitivity of U.S. Trade Flows: Evidence from Industry Data', *Southern Economic Journal*, 72, 542-559.

Bahmani-Oskooee M and Brooks T J (1999) 'Bilateral J-Curve between U.S. and her Trading Partners', *Weltwirtschaftliches Archiv*, 135, 156-165.

Bahmani-Oskooee M and Gelan A (2006) 'Black Market Exchange rate and the Productivity Bias Hypothesis', *Economics Letters*, 91, 243-249.

Bahmani-Oskooee M, Goswami G and Talukdar B (2005) 'The Bilateral J-Curve: Australia versus her 23 Trading Partners', *Australian Economic Papers*, 44, 110-120.

Bahmani-Oskooee M and Hegerty S (2007) 'Exchange Rate Volatility and Trade Flows: A Review Article', *Journal of Economic Studies*, forthcoming.

Bahmani-Oskooee M and Payesteh S (1993) 'Does exchange rate volatility deter trade volume of LDCs?', *Journal of Economics Development*, 18, 189-202.

Bailey M J, Tavlas G S and Ulan M (1986) 'Exchange rate variability and trade performance: evidence for the big seven industrial countries', *Weltwirtschaftliches Archiv*, 122, 466-477.

Bailey M J, Tavlas G S and Ulan M (1987) 'The impact of exchange rate volatility on export growth: some theoretical considerations and empirical results', *Journal of Policy Modeling*, 9, 225-243.

Belanger D, Gutierrez S, Racetter D and Raynauld J (1992) ' The impact of exchange rate variability on trade flows: further results on sectoral U.S. imports from Canada', *North American Journal of Economics and Finance*, 3, 888-892.

Bini-Smaghi L (1991) 'Exchange rate variability and trade: why is it so difficult to find any relationship', *Applied Economics*, 23, 927-936.

Brada J C and Mendez J A (1988) 'Exchange rate risk, exchange rate regime and the volume of international trade', *Kyklos*, 41, 263-280.

Burda M C and Gerlach S (1992) 'Intertemporal Prices and the US Trade Balance', *American Economic Review*, 82, 1234-1253.

Caballero R J and Corbo V (1989) 'The Effect of Real Exchange Rate Uncertainty on Exports: Empirical Evidence', *The World Bank Economic Review*, 3, 263-278.

Caporale T and Doroodian K (1994) 'Exchange Rate Variability and the Flow of International Trade', *Economics Letters*, 46, 49-54.

Chowdhury A R (1993) 'Does Exchange Rate Volatility Depress Trade Flows? Evidence from Error-Correction Models', *The Review of Economics and Statistics*, 75, 700-706.

Cushman D O (1983) 'The effects of real exchange rate risk on international trade', *Journal of International Economics*, 15, 45-63.

Cushman D O (1986) 'Has exchange risk depressed international trade: the impact of third country exchange risk', *Journal of International Money and Finance*, 5, 361-379.

Cushman D O (1988) 'U.S. bilateral trade flows and exchange risk during the floating period', *Journal of International Economics*, 24, 317-330.

De Grauwe P (1988) 'Exchange rate variability and the slowdown in the growth of international trade', *IMF Staff Papers*, 35, 63-84.

De Vita G and Abbott A (2004a) 'Real Exchange Rate Volatility and US Exports: An ARDL Bounds Testing Approach', *Economic Issues*, 9, 69-78.

De Vita G and Abbott A (2004b) 'The Impact of Exchange Rate Volatility on UK Exports to EU Countries', *Scottish Journal of Political Economy*, 51, 62-81.

Dell'Ariccia G (1999) 'Exchange rate fluctuation and trade flows: evidence from the European Union', *IMF Staff Papers*, 46, 315-334.

Doyle E (2001) 'Exchange rate volatility and Irish-UK trade, 1979-1992', *Applied Economics*, 33, 249-265.

Engle R F and Granger C W J (1987) 'Co-integration and Error Correction: Representation, Estimation, and Testing', *Econometrica*, 55, 251-276.

Gotur P (1985) 'Effects of exchange rate volatility on trade: some further evidence', *IMF Staff Papers*, 32, 475-512.

Hooper P and Kohlhagen S (1978) 'The effect of exchange rate uncertainty on the price and volume of international trade', *Journal of International Economics*, 8, 483-511.

Kenen P and Rodrik D (1986) 'Measuring and analyzing the effects of short-term volatility on real exchange rates', *Review of Economics and Statistics*, LXIII, 311-315.

Klein M W (1990) 'Sectoral Effects of Exchange Rate Volatility on United States Exports', *Journal of International Money and Finance*, 9, 299-308.

Koray F and Lastrapes W D (1989) 'Real exchange rate volatility and U.S. bilateral trade: a VAR approach', *The Review of Economics and Statistics*, 71, 708-712.

Kroner K F and Lastrapes W D (1990) 'The Impact of Exchange Rate Volatility on International Trade: Reduced form Estimates Using the GARCH-in-mean Model', *Journal of International Money and Finance*, 12, 298-318.

Kumar R and Dhawan R (1991) 'Exchange Rate Volatility and Pakistan's Exports to the Developed World, 1974-1985', *World Development*, 19, 1225-1240.

Lanyi A and Suss E C (1982) 'Exchange Rate Variability: Alternative Measures and Interpretation', *IMF Staff Papers*, 29, 527-560.

Lee J (1999) 'The effect of exchange rate volatility on trade in durables', *Review of International Economics*, 7, 189-201.

McKenzie M D (1998) 'The Impact of Exchange Rate Volatility on Australian Trade Flows', *Journal of International Financial Markets, Institutions and Money*, 8, 21-38.

McKenzie M D (1999),'The Impact of Exchange Rate Volatility on International Trade Flows', *Journal of Economic Surveys*, 13, 71-106.

McKenzie M D and Brooks R (1997) 'The Impact of Exchange Rate Volatility on German-U.S. Trade Flows', *Journal of International Financial Markets, Institutions and Money*, 7, 73-87.

Medhora R (1990) 'The Effect of Exchange Rate Variability on Trade: The Case of the West African Monetary Union's Imports', *World Development*, 18, 313-324.

Peree E and Steinherr A (1989) 'Exchange Rate Uncertainty and Foreign Trade', *European Economic Review*, 33, 1241-1264.

Pesaran M, Shin Y and Smith R (2001) 'Bound testing approaches to the analysis of level relationships' *Journal of Applied Econometrics* 16, 289-326.

Pozo S (1992) 'Conditional Exchange Rate Volatility and the Volume of International

Trade: Evidence from the Early 1900's', *The Review of Economics and Statistics*, 74, 325-329.

Qian Y and Varangis P (1994) 'Does Exchange Rate Valatility Hinder Export Growth: Additional Evidence', *Empirical Economics*, 19, 371-96.

Thursby M C and Thursby J G (1987) 'Bilateral trade flows, the Linder hypothesis and exchange risk', *The Review of Economics and Statistics*, 69, 488-495.