US Export Earnings from and Import Payments to German Industries: Role of the Real Exchange Rate and Asymmetry

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ABSTRACT

We add to the new literature findings on the asymmetric effects of exchange rate changes on a country's export and import values by considering nearly 20 industries that trade between the US and Germany. These industries contribute more than 90 per cent of the trade between the two countries. We find short-run asymmetric effects of exchange rate changes on export and import values in nearly all industries. However, short-run asymmetric effects translate into long-run asymmetric effects in four US exporting industries with a total trade share of 21.62 per cent and six US importing industries with a total trade share of 34.53 per cent. These findings were absent when we first estimated a traditional symmetric or linear model. The approach helped us to identify industries whose exports earning (imports value) could benefit from dollar depreciation (appreciation) and vice versa.

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1. INTRODUCTION

The exchange rate is one of the major macro variables that links any domestic economy to the rest of the world. Much of the literature on exchange rates has been devoted to their effects on a country's trade flows, and there are a number of approaches to assess the impact of exchange rate changes on those trade flows. The traditional approach estimated import and export price elasticities and checked for the validity of the so-called Marshall-Lerner condition. This condition asserts that if the sum of the import and export demand elasticities add up to one, a devaluation can improve the trade balance. In estimating the import and export demand elasticities, real exports and imports are typically regressed on a scale variable and relative import and export prices. The import and export prices for each country come in the form of indexes that are associated with aggregate trade flows of each country with the rest of the world.[4]

However, the elasticities estimated using relative prices against the rest of the world are said to suffer from aggregation bias in that a country's significant trade elasticities with one partner could be offset by insignificant elasticities with another partner, yielding insignificant outcomes. To reduce this bias, trade flows are disaggregated by trading partner. However, since no import and export prices are available at the partner level to deflate nominal imports and exports and obtain them in real terms, a strand of the literature has used nominal imports and exports and the real bilateral exchange rate to assess the effects of a real devaluation on a country's nominal exports and imports.

Concentrating on the experience of the US with its partners, Haynes *et al* (1986) investigated the responsiveness of nominal exports and imports of manufactured goods between the US and Japan and found no significant link. The same was reported by Bergstrand (1987), but not by Cushman (1987). However, when Bahmani-Oskooee and Ratha (2008) accounted for the integrating properties of variables and expanded the list of US partners to 19, they found that dollar depreciation increases US export earnings from Austria, Denmark, Finland, Germany, Greece, Japan, New Zealand, Sweden, and Switzerland in the long run. However, they also found that dollar depreciation lowers US import values from Denmark, Germany, Greece, Ireland, and Sweden.

The above studies were recently criticised by Bahmani-Oskooee and Fariditavana (2019) on the ground that they assumed the effects of exchange rate changes on export and import values to be symmetric. The authors argued subsequently for asymmetric effects of exchange rate changes to be accounted for. As they pointed out, since traded goods' prices respond to exchange rate changes in an asymmetric manner, a country's export and import values should follow suit, since values are the product of price and quantity.

Furthermore, the asymmetry could emanate from the standard J-curve effects of a devaluation. In this case we would initially expect a rise in import payments to be greater than a rise in export receipts, as import prices rise faster than export volumes following a devaluation. In the medium to long run, if the devaluation is successful at improving the balance of trade, then export receipts will exceed import payments. This theory of the J-curve is of course dependent on a number of implicit assumptions: perfect competition in goods markets (i.e., no pricing-to-market by suppliers), infinite supply elasticities, trade credit, and a lack of tariffs. If any of the assumptions are violated, asymmetric effects will come to existence.

To demonstrate their conjecture, Bahmani-Oskooee and Fariditavana (2019) considered US trade with 15 trading partners and applied the nonlinear ARDL approach of Shin *et al* (2014) to US export and import values with each partner. The authors found evidence of short-run as well as long-run asymmetric effects in more than half of the models, though they recognised that their findings are partner-specific. However, they also recognised that their findings could suffer from aggregation bias; hence, they recommended that 'future research should concentrate on disaggregating US trade flows by commodity in order to identify industries that could benefit from dollar depreciations.' (Bahmani-Oskooee and Fariditavana 2019 p 629).

Following Bahmani-Oskooee and Fariditavana (2019), we consider trade flows between the US and its largest partner from European Union (Germany) and disaggregate their trade flows by industry. A total of 22 US exporting industries and 20 US importing industries that trade between the US and Germany are included in our analysis. Together, these groups represent more than 90 per cent of the trade between the two countries.[5] Our goal is to assess the symmetric and asymmetric effects of changes in the value of the dollar on each US industry's export earnings from and import payments to Germany. To that end, in Section 2 we introduce the models and methods, followed by Section 3 where we report our results. A summary is provided in Section 4 and sources of the data and definition of variables are cited in an Appendix.

2. The Models and the Methods

The export and import schedules or specifications in this paper are similar to those in the literature. Specifically, we modify the models by Bahmani-Oskooee and Fariditavana (2019) so that they conform to industry level data as follows:

$$LnVX_{i,t}^{US} = a + b\,LnY_t^{GER} + c\,LnREX_t + \varepsilon_t \qquad (1)$$

and

$$LnVM_{i,t}^{US} = e + f\,LnY_t^{US} + g\,LnREX_t + \xi_t \qquad (2)$$

Where in Equation (1), VX_i^{US} is the nominal value of US exports to Germany by industry *i* and is assumed to depend on the level of economic activity or income in Germany (Y^{GER}) and the real dollar-euro exchange rate denoted by *REX*. Similarly, in Equation (2), VM_i^{US} is the nominal value of US imports of industry *i* from Germany, which is assumed to depend on the level of economic activity or income in the US (Y^{US}) and the real exchange rate, *REX*. Since an increase in economic activity stimulates trade, we expect estimates of *b* in Equation (1) and *f* in Equation (2) to be positive. As for the estimates of c and g, they will depend on how we define the real dollar-euro rate. From the Appendix we gather that the REX variable is defined in a manner such that an increase reflects dollar depreciation.[6] If dollar depreciation is to boost industry *i*'s exports and reduce the same industry's imports, we expect an estimate of *c* in Equation (1) to be positive and that of *g* in Equation (2) to be negative.

The estimates discussed above are long-run coefficient estimates. In order to infer short-run effects we convert both models to error-correction specifications. The ARDL bounds testing approach of Pesaran *et al* (2001) offers a unique advantage in that both short-run and long-run effects are estimated simultaneously by applying the OLS method to the following models:

$$\Delta LnVX_{i,t}^{US} = \alpha_0 + \sum_{j=1}^{n1}\alpha_{1j}\Delta LnVX_{i,t-j}^{US} + \sum_{j=0}^{n2}\alpha_{2j}\Delta LnY_{t-j}^{GER} + \sum_{j=0}^{n3}\alpha_{3j}\Delta LnREX_{t-j} + \lambda_1 LnVX_{i,t-j}^{US} + \lambda_2 LnY_{t-1}^{GER} + \lambda_3 LnREX_{t-1} + \mu_t \quad (3)$$

and

$$\Delta LnVM_{i,t}^{US} = \beta + \sum_{j=1}^{n4}\beta_{1j}\Delta LnVM_{i,t-j}^{US} + \sum_{j=0}^{n5}\beta_{2j}\Delta LnY_{t-j}^{US} + \sum_{j=0}^{n6}\beta_{3j}\Delta LnREX_{t-j} + \delta_1 LnVM_{i,t-1}^{US} + \delta_2 LnY_{t-1}^{US} + \delta_3 LnREX_{t-1} + \psi_t \quad (4)$$

In both models short-run effects are reflected in the estimates of coefficients attached to the first-differenced variables. For example, the short-run effect of dollar depreciation on nominal exports (nominal imports) of industry i is embodied in the estimate of α_{3j} (β_{3j}). The long-run effects are judged by the estimates of $\lambda_2$and λ_3 normalised on $-\lambda_1$ in Equation (3) and by the estimates of δ_2 and δ_3 normalised on $-\delta_1$ in Equation (4). For the long-run estimates to be valid, Pesaran *et al* (2001) propose two cointegration tests: the F test to establish joint significance of the lagged level variables and the t-test to establish significance of λ_1 in Equation (3) and δ_1 in Equation (4).[7] Since the distribution of both tests are non-standard, the authors tabulate new critical values that also account for the degree of integration of the variables. Under this approach, variables could be a combination of I(0) and I(1), which are the properties of most macro variables.

Models such as those in Equation (3) or Equation (4) are modified by Shin *et al* (2014) so that they could be used to assess the possibility of asymmetric effects of exchange rate changes on the dependent variables. The modification essentially involves decomposing the real exchange rate variable into two new time-series variables, following Bahmani-Oskooee and Fariditavana (2019). For this purpose, we first form $\Delta LnREX$ which includes positive changes signifying dollar depreciation and negative changes signifying dollar appreciation. The two new time series are then generated using the partial sum concept as follows:

$$DDEP_t = \textstyle\sum_{j=1}^{t}\max(\Delta LnREX_j, 0), \text{ and } DAPR_t = \textstyle\sum_{j=1}^{t}\min(\Delta LnREX_j, 0) \quad (5)$$

We then replace the *LnREX* variable in Equation (3) and Equation (4) with the two partial sum variables and arrive at the following models:

$$\Delta LnVX_{i,t}^{US} = \pi_1 + \sum_{j=1}^{n1}\pi_{2j}\Delta LnVX_{t-j}^{US} + \sum_{j=0}^{n2}\pi_{3j}\Delta LnY_{t-j}^{GER} + \sum_{j=0}^{n3}\pi_{4j}\Delta DDEP_{t-j} + \sum_{j=0}^{n4}\pi_{5j}\Delta DAPR_{t-j} + \theta_1 LnVX_{t-1}^{US} + \theta_2 LnY_{t-1}^{GER} + \theta_3 DDEP_{t-1} + \theta_4 DAPR_{t-1} + \gamma_t \quad (6)$$

$$\Delta LnVM_{i,t}^{US} = \sigma_1 + \sum_{j=1}^{n5}\sigma_{2j}\Delta LnVM_{t-j}^{US} + \sum_{j=0}^{n6}\sigma_{3j}\Delta LnY_{t-j}^{US} + \sum_{j=0}^{n7}\sigma_{4j}\Delta DDEP_{t-j} + \sum_{j=0}^{n8}\sigma_{5j}\Delta DAPR_{t-j} + \chi_1 LnVM_{t-j}^{US} + \chi_2 LnY_{t-1}^{US} + \chi_3 DDEP_{t-1} + \chi_4 DAPR_{t-1} + \phi_t \quad (7)$$

Models such as those in Equation (6) and Equation (7) are commonly referred to as nonlinear ARDL models, where the nonlinearity stems from the way in which the partial sum variables are constructed. On the other hand, models such as those in Equation (3) and Equation (4) are called linear ARDL models. Shin *et al* (2014) demonstrate that both the linear and nonlinear ARDL models are subject to the same tests and the same diagnostics.[8]

Once Equation (6) and Equation (7) are estimated, a number of asymmetric hypotheses can be tested. First, if at a given lag order *j*, the estimate of $\pi_{4j} \neq \pi_{5j}$ in Equation (6) and the estimate of $\sigma_{4j} \neq \sigma_{5j}$ in Equation (7), short-run effects of exchange rate on industry *i*'s nominal exports and nominal imports are confirmed to be asymmetric. Second, exchange rate changes have short-run cumulative asymmetric effects if we can reject the null hypothesis of $\Sigma\pi_{4j} = \Sigma\pi_{5j}$ in Equation (6) and $\Sigma\sigma_{4j} = \Sigma\sigma_{5j}$ in Equation (7), by applying the Wald test. Third, the short-run adjustment of exports and imports to exchange rate changes is asymmetric if $n3 \neq n4$ in Equation (6) and $n7 \neq n8$ in Equation (7). Finally, exchange rate changes have long-run asymmetric effects on industry i's exports and imports if the Wald test rejects the null of $\theta_3/-\theta_1 = \theta_4/-\theta_1$ in Equation (6) and $\chi_3/-\chi_1 = \chi_4/-\chi_1$ in Equation (7).[9]

3. Empirical Results

In this section, we estimate two linear models, Equation (3) and Equation (4), and two nonlinear models, Equation (6) and Equation (7), for each of the two-digit industries whose trade share is more than one per cent. These industries, along with their trade shares, are reported in each table and the aggregate share of each group adds up to more than 90 per cent of total trade. Since the data are monthly, we impose a maximum of 10 lags on each first-differenced variable and use Akaike's Information Criterion (AIC) to select an optimum model. Furthermore, since our study period (January 1999 to December 2019) includes the global financial crisis of 2008, we include a dummy in every model to account for it. Additionally, since different estimates and diagnostics are subject to different critical values, we provide the required critical values in the notes to each table and use them to identify significant estimates and/or diagnostic statistics.

We begin with the estimates of the linear US export value model, Equation (3), for each industry. The short-run results (not reported but available upon request) reveal that the real exchange rate carries at least one significant coefficient in all industries except 54, 59, and 76, supporting short-run effects of exchange rate changes on these industries' export earnings from Germany. Most of the significant coefficient estimates are negative. However, as Table 1 reveals, short-run effects survive into long run significant and meaningful effects only in industry 72 (Machinery Specialised, with a 2.41 per cent export share). Only in this industry is cointegration supported by the t-test. Furthermore, since the long-run coefficient is positive, dollar depreciation increases export earnings of this industry. It appears that the level of economic activity in Germany plays a more significant role than the exchange rate. The LnY^{GER} variable carries its expected positive sign in nine industries and a negative sign in five industries. These five industries are likely those in which, as the German economy grows, it produces more import-substitute goods (Bahmani-Oskooee 1986).

In Table 1, in addition to the cointegration tests, we have also reported supplementary diagnostics. To check for serial correlation, we have reported the Lagrange-Multiplier statistic, LM. As can be seen, it is insignificant in most models, supporting autocorrelation-free residuals. We have also reported Ramsey's RESET statistic to determine if any optimum model is mis-specified. Most models are not since the RESET test is insignificant. Following the literature, particularly Bahmani-Oskooee and Fariditavana (2019), next we try to establish the stability of all coefficient estimates by applying the CUSUM and CUSUMSQ tests to the residuals of each optimum model. Stable estimates are indicated by 'S' and unstable ones by 'UnS'. Clearly, most estimates are stable. Finally, the size of adjusted R^2 is reported to judge the goodness of fit.

Next, we consider the estimates of the linear US import value model in Equation (4) for each industry that imports from Germany and we report the long-run estimate results in Tables 2. The short-run estimates (available upon request) reveal that the real exchange rate has significant short-run effects on imports from all 20 industries. However, as can be seen from Table 2, the short-run effects survive into long-run significant and meaningful effects only in industry 67 (Iron and Steel, with a 1.12 per cent import share). Again, only in this industry is cointegration supported by either the F or t-test for cointegration. Other diagnostics are similar to those in Table 1 and need not be repeated here.

How do the outcomes change if we shift consideration to the estimates of the nonlinear models? Again, we first consider the estimates of the US nonlinear export value model in Equation (6). The short-run estimates reveal that either $\Delta DDEP$ (dollar depreciation) or $\Delta DAPR$ (dollar appreciation) carry at least one significant coefficient in 20 of 22 industries, the exceptions being industries 33 and 69. However, the long-run estimates reported in Table 3 show that the short-run effects survive into long-run, meaningful effects in industries 51 (Organic Chemicals, with a 1.77 per cent export share), 66 (Nonmetallic Minerals, with a 1.82 export share), 69 (Manufactures of Metals, with a 1.5 per cent of export share), and 79 (Transportation Equipment, with a 16.53 per cent export share).

This increase in the number of industries from one linear model to four nonlinear models must be attributed to the nonlinear adjustment of the real exchange rate. Furthermore, in the first three industries the two variables representing dollar depreciation (*DDEP*) and dollar appreciation (*DAPR*) carry positive coefficients, implying that while dollar depreciation increases the export earnings of all four industries, dollar appreciation hurts them. However, in the fourth industry (Transportation Equipment), while dollar depreciation increases export earnings of this large industry, dollar appreciation has no effect, a clear sign of long-run asymmetric effects of exchange rate changes that is also supported by the Wald test reported as Wald-L in Table 3. Indeed, long-run asymmetric effects are supported in 11 other industries.

Finally, we consider the estimates of the US nonlinear import value model in Equation (7). The short-run estimates revealed that either $\Delta DDEP$ or $\Delta DAPR$ have significant short-run effects in all industries except 69 (Manufactures of Metals, with a 2.07 per cent import share). The short-run effects were asymmetric in only four industries, identified in Table 4 by a significant Wald-S test. Table 4, which also reports the long-run estimates, reveals that the short-run effects survive into significant and meaningful long-run effects in industries 54 (Medical and Pharmaceutical Products, with a 12.07 per cent import share), 57 (Plastics in Primary Form, with a 1.15 per cent import share), 67 (Iron and Steel, with a 1.12 per cent import share), 74 (General Industry Machinery, with an 8.37 per cent import share), 87 (Professional Scientific Instruments, with a 6.47 per cent import share), and 93 (Special Transactions, with a 5.35 per cent import share).

Note that only in industry 93 did both the *DDEP* and *DAPR* variables carry negative coefficients, implying that while dollar depreciation reduces import values of this industry, dollar appreciation increases it, in line with our expectations. However, in the other five industries, both variables carry positive coefficients, implying that while dollar depreciation raises US import costs of these industries from Germany, dollar appreciation reduces them. These are industries in which US import demand must be inelastic. Once again, the increase in the number of industries from one (Iron and Steel) using estimates of the linear model in Table 2, to six in Table 4 (nonlinear models) must be attributed to the nonlinear adjustment of the real exchange rate which brings about asymmetric cointegration. The aggregate share of the six US importing industries (34.53 per cent) is high enough to adhere to the estimates of the nonlinear models.[10]

As an additional exercise, we replaced the real exchange rate with the nominal rate and carried out the estimation for the nonlinear models. The results are reported in Tables 5 (US export values) and 6 (US import values). From the first table we gather that two industries (51 and 79) are no longer on the list of affected industries. However, from the second table, one more industry (69) is added to the list. In sum, nominal depreciation of the dollar against the euro increases US export earnings from Germany in two industries 66 (Nonmetallic Minerals, with a 1.82 per cent export share) and 69 (Manufactures of Metals, with a 1.5 per cent of export share); and nominal appreciation of the dollar reduces US import costs in the same two industries. On the other hand, nominal depreciation of the dollar increases US import values from Germany in industries 54 (Medical and Pharmaceutical Products, with a 12.07 per cent import share), 57 (Plastics in Primary Form, with a 1.15 per cent import share), 67 (Iron and Steel, with a 1.12 per cent import share), 69 (Manufactures of

Table 1: Long-Run Coefficient Estimates of the Linear US Export Value Model (3) and Diagnostics

		Long-Run Estimates			Diagnostics Tests					
Industry i	***T. Share in %***	***Constant***	***Ln Y^GER^***	***Ln REX~t~***	***F test^c^***	**$_1$(t-test)^d^**	***LM^e^***	***RESET^f^***	***QS (QS^2^)***	***Adj. R^2^***
05 Vegetables and Fruit	1.64	-0.60(0.79)[b]	0.94(1.18)	4.38(5.67)**	1.46	-0.20(1.98)	0.05	7.39**	S(S)	0.44
33 Petroleum, Petroleum Products	2.49	-5.87(1.58)	1.44(0.55)	8.66(3.12)**	1.86	-0.23(2.29)	0.28	1.41	S(UnS)	0.38
51 Organic Chemicals#[A]	1.77	2.16(2.37)**	1.63(3.18)**	2.50(3.93)**	2.36	-0.34(2.36)	0.50	0.98	S(S)	0.42
54 Medicinal & Pharmaceutical Products	8.38	0.003(0.00)	1.57(1.05)	4.08(2.74)**	1.65	-0.11(2.33)	6.86**	3.25*	S(S)	0.31
59 Chemical Materials	3.15	0.35(0.95)	3.44(0.74)	2.13(0.79)	1.51	-0.04(0.62)	0.32	4.67**	UnS(UnS)	0.38
66 Nonmetallic Minerals	1.82	0.62(1.52)	3.84(0.62)	0.22(0.03)	2.13	-0.03(0.64)	1.31	6.20**	S(S)	0.45
68 Nonferrous Metals	1.24	1.87(2.32)**	2.13(2.50)**	1.94(1.87)*	2.93	-0.21(2.10)	0.05	1.44	S(S)	0.39
69 Manufactures of Metals	1.50	0.63(1.64)*	0.81(2.17)**	3.05(9.18)**	2.92	-0.17(2.73)	0.35	0.19	S(S)	0.43
71 Power Generating Machinery	2.63	1.73(1.80)*	-2.51(2.58)**	0.64(0.61)	1.76	-0.10(2.56)	0.49	4.07**	S(S)	0.26
72 Machinery Specialised	2.41	3.84(3.43)**	0.67(1.77)*	0.71(1.77)*	3.08	-0.25(3.26)*	1.79	1.25	S(S)	0.37
74 General Industrial Machinery	4.29	0.51(1.28)	0.96(0.84)	2.73(4.07)**	1.80	-0.08(1.24)	2.37	1.42	S(S)	0.46
75 Office Machines and ADP Equipment	2.09	-0.25(0.18)	-3.63(0.76)	5.81(0.47)	2.04	-0.02(0.71)	1.38	3.20*	S(S)	0.58
76 Telecommunications Equipment	2,26	3.46(2.55)**	-0.06(0.19)	1.66(5.52)**	2.38	-0.32(2.81)	0.14	2.90*	S(S)	0.47
77 Electrical Machry, Apparatus, Appliance	8.16	1.74(1.98)**	-0.35(0.70)	0.78(1.67)*	1.36	-0.10(1.97)	0.38	1.50	S(S)	0.36
78 Motor Vehicles	13.52	1.66(2.53)	0.90(1.21)	2.03(2.27)**	3.99	-0.15(2.12)	7.08**	0.38	S(S)	0.47
79 Transport Equipment	16.53	-0.22(0.27)	1.94(2.46)**	4.39(6.45)**	3.70	-0.27(3.17)	0.01	1.45	S(S)	0.33
87 Professional Scientific Instruments	7.11	1.86(2.98)**	0.78(2.88)**	2.05(8.07)**	2.83	-0.19(2.77)	0.72	0.18	S(S)	0.53
88 Photo Appt, Equipment & Optical Goods	1.11	1.04(1.77)*	1.03(0.99)	1.50(1.69)*	1.30	-0.10(1.60)	0.09	2.56	S(S)	0.28
89 Miscellaneous Manufactured Articles	4.67	1.07(1.47)	0.76(1.06)	2.87(5.52)**	1.93	-0.19(1.90)	0.20	0.46	S(S)	0.46
93 Special Transactions	1.06	2.37(1.86)*	-1.99(3.59)**	2.06(3.54)**	2.58	-0.29(2.97)	0.71	4.28**	S(S)	0.47
95 Coin Including Gold#	1.27	-13.45(2.11)**	16.06(2.18)**	22.17(3.65)**	3.10	-0.15(2.71)	0.40	3.57*	S(S)	0.36
99 Low Value Shipments	2.14	1.00(2.34)**	0.80(1.52)	1.59(2.84)**	1.50	-0.09(2.27)	0.77	3.88**	S(S)	0.33

Notes:
a. # next to an industry's code indicates that the Global Financial Crisis dummy was significant.
b. Numbers inside the parentheses are absolute value of t-ratios.
c. At the 5% (10%) significance level when there are two exogenous variables (k=2). the upper bound critical value of the F test is 4.85(4.14). These come from Pesaran *et al* (2001. Table CI-Case III. p 300).
d. Number inside the parenthesis next $_1$is the absolute value of the t-ratio. Its upper bound critical value at the 5%(10%) significance level is -3.53(-3.21) when k=2 and these come from Pesaran *et al* (2001. Table CII-Case III. p 303).
e. LM is Lagrange Multiplier test of residual serial correlation. It is distributed as χ^2 with one degree of freedom (first order). Its critical value at 5% (10%) significance level is 3.84(2.71).
f. RESET is Ramsey's test for misspecification. It is distributed as χ^2 with one degree of freedom.
g. * and ** indicate significance at 10% levels and 5% level respectively.

Table 2: Long-Run Coefficient Estimates of the Linear US Import Value Model (4) and Diagnostics.

Industry I	Trade Share(%)	Long-Run Coefficient Estimates			Diagnostics					
		Constant	*Ln* Y^{US}	*Ln* REX_t	F^c	$_1$(t-test)[d]	LM^e	*RESET*[f]	*QS* (QS^2)	*Adj.* R^2
51 Organic Chemicals	2.24	3.76(2.90)**[g]	0.73(1.54)[b]	0.80(0.67)	2.18	-0.24(2.23)	0.61	1.82	S(S)	0.40
54 Medicinal & Pharmaceutical Products	12.07	-2.10(1.36)	2.71(1.34)	10.71(2.79)**	0.82	-0.07(168)	1.24	1.68	S(S)	0.44
57 Plastics in Primary Form	1.15	1.35(2.66)**	-2.67(0.46)	19.70(0.92)	2.39	-0.01(0.66)	1.92	2.24	S(S)	0.45
59 Chemical Materials	1.76	1.21(1.81)*	5.05(0.27)	35.65(0.30)	1.15	-0.008(0.26)	1.19	0.10	S(S)	0.33
67 Iron and Steel#[A]	1.12	2.83(2.48)**	2.09(4.12)**	1.87(1.97)*	6.61**	-0.29(4.09)**	1.01	2.48	UnS(S)	0.39
68 Nonferrous Metals	2.60	-0.28(0.32)	0.96(1.26)	4.50(2.99)**	1.61	-0.12(2.34)	1.03	0.09	S(S)	0.25
69 Manufactures of Metals	2.07	0.88(1.62)	-102.52(0.02)	243.78(0.02)	1.31	-0.007(0.02)	3.76*	2.56	S(S)	0.49
71 Power Generating Machinery	5.35	0.44(0.66)	1.11(2.39)**	3.75(4.89)**	2.92	-0.18(2.90)	2.26	2.00	S(S)	0.44
72 Machinery Specialised	6.49	0.61(1.03)	1.02(1.38)	3.36(3.43)**	2.28	-0.15(1.59)	2.10	0.57	S(S)	0.42
73 Metalworking Machinery	1.46	-1.18(1.29)	0.03(0.07)	5.05(6.55)**	2.41	-0.23(2.97)	2.49	2.65	S(S)	0.45
74 General Industrial Machinery	8.37	0.55(1.38)	3.02(1.24)	0.13(0.02)	1.65	-0.02(1.03)	2.41	1.91	S(S)	0.63
75 Office Machines and ADP Equipment	1.24	-0.83(0.60)	-2.23(0.65)	7.15(0.74)	1.71	-0.05(0.69)	0.43	2.61	S(UnS)	0.38
76 Telecommunications Equipment	1.08	-0.03(0.04)	0.58(0.57)	4.00(1.98)**	1.33	-0.09(2.09)	0.00	4.09**	S(S)	0.29
77 Electrical Machry, Apparatus, Appliance	6.16	0.82(2.32)**	0.58(0.38)	-2.47(0.28)	1.50	-0.02(0.76)	0.31	0.97	S(S)	0.51
78 Motor Vehicles	1.81	3.10(3.14)**	1.20(1.09)	-2.56(0.57)	2.48	-0.09(1.44)	5.14**	2.39	S(S)	0.59
79 Transport Equipment	3.12	-0.84(0.26)	0.15(0.07)	4.90(1.40)	1.73	-0.20(1.71)	1.48	0.88	S(S)	0.41
87 Professional Scientific Instruments	6.47	0.29(0.73)	1.38(1.10)	2.46(0.83)	0.89	-0.03(1.41)	1.39	3.63*	S(S)	0.70
89 Miscellaneous Manufactured Articles	2.29	0.47(0.56)	1.87(0.98)	2.46(0.67)	0.67	-0.06(1.01)	2.41	0.05	S(S)	0.53
93 Special Transactions	5.35	-1.82(1.54)	6.47(0.23)	29.41(0.35)	3.13	-0.01(0.28)	0.96	4.59**	S(UnS)	0.39
99 Low Value Shipments	1.07	0.49(0.65)	0.004(0.01)	2.85(1.90)*	1.69	-0.09(2.21)	6.76**	1.09	S(S)	0.33

Notes:
a. # next to an industry's code indicates that the Global Financial Crisis dummy was significant.
b. Numbers inside the parentheses are absolute value of t-ratios.
c. At the 5% (10%) significance level when there are two exogenous variables (k=2). the upper bound critical value of the F test is 4.85(4.14). These come from Pesaran *et al* (2001. Table CI-Case III. p 300).
d. Number inside the parenthesis next $_1$is the absolute value of the t-ratio. Its upper bound critical value at the 5%(10%) significance level is -3.53(-3.21) when k=2 and these come from Pesaran *et al* (2001. Table CII-Case III. p 303).
e. LM is Lagrange Multiplier test of residual serial correlation. It is distributed as χ^2 with one degree of freedom (first order). Its critical value at 5% (10%) significance level is 3.84(2.71).
f. RESET is Ramsey's test for misspecification. It is distributed as χ^2 with one degree of freedom.
g. * and ** indicate significance at 10% levels and 5% level respectively.

Table 3: Long-Run Coefficient Estimates of the Nonlinear US Export Value Model (6) and Diagnostics.

Industry i	T. Share in %	Long-Run Estimates				Diagnostics Tests				
		Constant	Ln Y^{GER}	DDEP	DAPR	F test[c]	$_{1}$(t-test)[d]	Adj. R^2	Wald-S[e]	Wald-L
05 Vegetables And Fruit	1.64	5.20(2.68)**[f]	0.75(0.03)[b]	-0.14(0.03)	-0.08(0.01)	2.69	-0.5(3.8)**	0.33	4.85**	1.37
33 Petroleum, Petroleum Products	2.49	4.29(2.57)**	0.38(0.06)	3.32(0.45)	1.70(0.10)	1.90	-0.27(2.37)	0.43	0.19	2.63
51 Organic Chemicals#[A]	1.77	5.79(2.15)**	1.64(11.27)**	1.94(1.81)*	2.39(2.8)**	2.48	-0.33(3.53)*	0.38	3.04*	2.37
54 Medicinal & Pharmaceutical Products	8.38	2.51(2.20)**	2.25(4.71)**	-1.23(0.17)	-2.39(0.66)	1.77	-0.13(2.22)	0.41	1.50	3.31*
59 Chemical Materials	3.15	6.59(2.03)**	1.16(35.25)**	0.24(0.20)	0.07(0.01)	3.69	-0.37(3.24)	0.38	1.35	2.88*
66 Nonmetallic Minerals	1.82	8.28(4.42)**	0.39(4.65)**	1.87(14.3)**	1.85(13.8)**	7.93**	-0.50(4.4)**	0.37	1.04	0.01
68 Nonferrous Metals	1.24	3.90(2.08)**	1.14(2.92)**	1.97(1.00)	1.22(0.35)	2.29	-0.24(2.18)	0.33	2.25	2.60
69 Manufactures Of Metals#	1.50	5.49(3.69)**	0.30(3.04)**	1.88(22.4)**	1.73(19.0)**	3.94	-0.32(3.7)**	0.34	0.17	3.09*
71 Power Generating Machinery	2.63	2.19(2.53)**	-3.65(10.1)**	3.05(8.70)**	2.87(7.70)**	1.25	-0.11(2.42)	0.31	3.60*	0.70
72 Machinery Specialised	2.41	5.72(3.02)**	0.28(0.67)	3.04(9.96)**	2.53(6.16)**	2.54	-0.31(3.03)	0.4	0.47	3.33*
74 General Industrial Machinery	4.29	3.26(1.80)*	-0.35(12.1)**	2.26(69.0)**	1.96(53.1)**	1.71	-0.18(1.84)	0.4	0.05	24.96**
75 Office Machines And ADP Equipment	2.09	3.38(2.07)**	-1.07(32.4)**	1.29(5.97)**	1.07(3.95)**	1.44	-0.17(2.11)	0.41	0.91	3.29*
76 Telecommunications Equipment	2,26	4.92(2.26)**	-0.22(0.20)	3.44(4.72)**	3.00(4.53)**	2.16	-0.27(3.28)	0.39	0.009	1.07
77 Electrical Machry, Apparatus, Appliance	8.16	1.86(1.81)*	-0.13(0.10)	1.15(1.13)	0.84(0.60)	1.26	-0.09(1.80)	0.38	2.34	1.70
78 Motor Vehicles	13.52	2.99(1.97)**	1.56(12.68)**	0.87(0.52)	1.16(0.94)	3.35	-0.15(1.94)	0.46	0.38	1.25
79 Transport Equipment	16.53	5.23(2.81)**	0.95(4.23)**	2.53(5.14)**	1.34(1.40)	4.55*	-0.27(2.83)	0.46	1.60	21.17**
87 Professional Scientific Instruments	7.11	4.15(2.72)**	0.96(7.16)**	1.27(3.02)**	0.81(1.11)	2.87	-0.22(2.75)	0.41	0.97	2.99*
88 Photo Appt, Equipment & Optical Goods	1.11	2.56(2.04)**	-0.38(3.03)**	1.13(3.49)**	0.35(0.33)	1.16	-0.02(0.12)	0.45	0.57	27.05**
89 Miscellaneous Manufactured Articles#	4.67	6.65(2.40)**	-0.10(0.18)	1.85(8.08)**	156(6.13)**	2.42	-0.36(2.06)	0.37	0.87	3.82*
93 Special Transactions	1.06	7.54(3.38)**	-2.13(52.6)**	-0.18(0.05)	-0.70(0.83)	3.09	-0.45(3.49)*	0.38	0.04	10.64**
95 Coin Including Gold#	1.27	0.66(0.50)	3.37(0.40)	21.51(3.0)**	18.44(3.0)**	2.97	-0.20(1.65)	0.42	0.59	1.24
99 Low Value Shipments	2.14	2.12(2.38)**	0.75(1.36)	-1.10(0.37)	-1.57(0.69)	2.18	-0.11(2.27)	0.47	0.08	2.74*

Notes:
a. # next to an industry's code indicates that the Global Financial Crisis dummy was significant.
b. Numbers inside the parentheses are absolute value of t-ratios.
c. At the 5% (10%) significance level when there are two exogenous variables (k=2). the upper bound critical value of the F test is 4.85(4.14). These come from Pesaran *et al* (2001. Table CI-Case III. p 300).
d. Number inside the parenthesis next $_{1}$is the absolute value of the t-ratio. Its upper bound critical value at the 5%(10%) significance level is -3.53(-3.21) when k=2 and these come from Pesaran *et al* (2001. Table CII-Case III. p 303).
e. Both Wald tests are distributed as χ^2 with one degree of freedom. Its critical value at 5% (10%) significance level is 3.84(2.71).
f. * and ** indicate significance at 10% levels and 5% level respectively.

Table 4: Long-Run Coefficient Estimates of the Nonlinear US Import Value Model (7) and Diagnostics

Industry i	T. Share in %	Constant	Long-Run Estimates: Ln Y^{US}	DDEP	DAPR	F^{C}	Diagnostics Tests: $_1$(t-test)[c]	Adj. R^2	Wald-S[e]	Wald-L
51 Organic Chemicals	2.24	7.67(3.18)**	-1.05(0.7)	0.61(3.52)**	0.48(1.16)	3.03	-0.39(3.12)	0.38	3.53*	2.01
54 Medicinal & Pharmaceutical Products	12.07	11.1(4.39)**	2.49(10.90)**	1.56(40.5)**	0.83(11.1)**	3.9	-0.57(4.3)**	0.39	0.14	127.6**
57 Plastics in Primary Form	1.15	10.65(4.2)**	1.47(18.7)**	0.63(55.8)**	0.22(6.59)**	5.89**	0.6(4.15)**	0.4	0.08	331.8**
59 Chemical Materials	1.76	7.55(3.37)**	0.17(0.08)	0.30(2.69)**	-0.16(0.71)	3.12	-0.41(3.34)	0.39	0.02	107.8**
67 Iron and Steel#[A]	1.12	5.96(4.14)**	0.58(0.16)	1.69(13.0)**	1.57(11.0)**	4.46*	-0.31(4.0)**	0.34	0.005	1.22
68 Nonferrous Metals	2.60	2.68(2.55)**	3.58(3.42)**	0.68(1.07)	0.342(0.24)	2.02	-0.15(2.66)	0.33	1.85	3.87**
69 Manufactures of Metals	2.07	7.94(3.39)**	2.04(22.99)**	0.68(28.2)**	0.37(8.34)**	3.34	-0.42(3.26)	0.34	0.17	96.21**
71 Power Generating Machinery	5.35	6.22(2.51)**	3.13(9.51)**	0.67(6.04)**	0.48(2.84)**	2.68	-0.32(2.56)	0.31	1.28	7.76**
72 Machinery Specialised	6.49	5.38(2.57)**	2.77(1.51)	0.16(0.39)	0.06(0.06)	1.5	-0.27(2.54)	0.4	1.05	2.01
73 Metalworking Machinery	1.46	5.72(2.88)**	3.57(11.52)**	-0.25(0.51)	0.34(0.89)	2.11	-0.31(2.91)	0.46	0.17	0.86
74 General Industrial Machinery	8.37	6.59(3.95)**	2.07(24.6)**	1.08(57.2)**	0.73(26.2)**	3.93	-0.33(3.9)**	0.4	0.2	105.7**
75 Office Machines and ADP Equipment	1.24	-1.60(0.82)	2.82(0.34)	1.18(0.46)	1.43(0.57)	0.85	-0.09(0.84)	0.41	2.59	0.64
76 Telecommunications Equipment	1.08	4.54(2.79)**	1.99(1.66)*	0.72(1.25)	0.34(0.67)	1.9	-0.25(2.83)	0.39	1.91	12.65**
77 Electrical Machry, Apparatus, Appliance	6.16	5.65(2.97)**	1.21(6.63)**	0.64(19.9)**	0.34(5.66)**	2.01	-0.29(2.98)	0.38	1.74	56.52**
78 Motor Vehicles	1.81	1.92(1.22)	-6.80(0.78)	0.95(0.73)	0.45(0.17)	1.34	-0.09(1.24)	0.46	0.01	1.3
79 Transport Equipment	3.12	6.22(2.51)**	3.13(9.51)**	0.67(6.04)**	0.48(2.84)**	0.52	-0.17(1.19)	0.41	0.48	0.1
87 Professional Scientific Instruments	6.47	6.19(3.74)**	1.53(13.02)**	0.79(33.7)**	0.39(8.16)**	2.9	-0.32(3.7)**	0.41	0.26	116.6**
89 Miscellaneous Manufactured Articles	2.29	13.32(2.97)**	1.17(6.44)**	0.70(20.6)**	0.35(5.42)**	3.28	-0.71(2.97)	0.37	0.43	85.05**
93 Special Transactions	5.35	13.88(4.35)**	2.05(18.21)**	-1.23(60.8)**	-1.72(11.5)**	4.48*	-0.76(4.3)**	0.33	10.95**	131.2**
99 Low Value Shipments	1.07	3.05(3.22)**	6.67(17.25)**	0.07(0.02)	0.35(0.63)	2.9	-0.17(3.23)	0.42	1.12	4.73**

Notes:
a. # next to an industry's code indicates that the Global Financial Crisis dummy was significant.
b. Numbers inside the parentheses are absolute value of t-ratios.
c. At the 5% (10%) significance level when there are two exogenous variables (k=2). the upper bound critical value of the F test is 4.85(4.14). These come from Pesaran *et al* (2001. Table CI-Case III. p 300).
d. Number inside the parenthesis next $_1$is the absolute value of the t-ratio. Its upper bound critical value at the 5%(10%) significance level is -3.53(-3.21) when k=2 and these come from Pesaran *et al* (2001. Table CII-Case III. p 303).
e. Both Wald tests are distributed as χ^2 with one degree of freedom. Its critical value at 5% (10%) significance level is 3.84(2.71).
f. * and ** indicate significance at 10% levels and 5% level respectively.

Table 5: Long-Run Coefficient Estimates of the Nonlinear US Export Value Model (6) when the Real Exchange Rate is Replaced by the Nominal Rate

		Long-Run Estimates				Diagnostics Tests				
Industry i	***T. Share in %***	***Constant***	***Ln Y^{GER}***	***DDEP***	***DAPR***	***F test*[c]**	**$_1$(t-test)[d]**	***Adj. R^2***	***Wald-S*[e]**	***Wald-L***
05 Vegetables and Fruit	1.64	8.58(3.67)**[f]	0.52(0.33)[b]	0.64(4.80)**	0.014(0.002)	3.03	-0.51(3.59)	0.33	0.41	20.88**
33 Petroleum, Petroleum Products	2.49	4.03(2.41)**	-11.05(1.23)	3.59(1.88)*	0.89(0.11)	1.99	-0.24(2.12)	0.45	0.62	3.76*
51 Organic Chemicals#[A]	1.77	5.69(2.1)	0.844(0.21)	1.59(8.55)**	1.50(6.83)**	2.23	-0.32(2.08)	0.39	0.84	0.12
54 Medicinal & Pharmaceutical Products	8.38	2.52(2.21)**	1.29(011)	1.91(2.36)**	1.87(2.02)**	1.82	-0.13(2.22)	0.43	3.57*	0.003
59 Chemical Materials	3.15	5.67(2.83)	-0.29(0.14)	1.26(24.6)**	0.73(10.35)	3.49	-0.31(2.82)	0.39	0.01	19.77**
66 Nonmetallic Minerals	1.82	8.04(4.17)**	1.71(16.68)**	0.39(7.71)**	-0.07(0.24)	6.99**	-0.48(4.2)**	0.35	3.92**	56.54**
68 Nonferrous Metals	1.24	4.11(2.11)**	0.87(0.18)	1.59(6.11)**	1.34(3.98)**	2.46	-0.25(2.20)	0.39	2.23	0.75
69 Manufactures of Metals#	1.50	5.51(3.72)**	1.29(6.72)**	0.54(8.3)**	0.27(1.89)*	4.21*	-0.32(3.7)**	0.39	0.25	12.71**
71 Power Generating Machinery	2.63	2.27(2.52)**	-1.82(0.38)	-2.38(6.8)**	-2.87(8.8)**	1.29	-0.11(2.38)	0.35	0.83	1.34
72 Machinery Specialised	2.41	5.88(3.06)**	2.18(5.88)**	0.48(2.58)**	0.68(4.86)**	2.58	-0.32(3.06)	0.46	1.61	2.46
74 General Industrial Machinery	4.29	2.87(1.56)	1.64(2.93)**	0.18(0.21)	-0.04(0.01)	1.49	-0.16(1.59)	0.47	0.1	2.56
75 Office Machines and ADP Equipment	2.09	3.87(2.23)	2.74(4.28)**	-1.29(9.6)**	-0.55(1.28)	3.66	-0.2(2.25)	0.43	2.86*	16.43**
76 Telecommunications Equipment	2,26	4.97(2.27)**	2.48(4.91)**	-0.001(0.00)	0.11(0.06)	2.04	-0.28(2.29)	0.38	0.61	0.41
77 Electrical Machry, Apparatus, Appliance	8.16	1.39(1.39)	0.96(0.23)	-0.1(0.02)	0.13(0.039)	1.02	-0.07(1.36)	0.38	5.12**	0.55
78 Motor Vehicles	13.52	2.85(1.83)*	2.22(0.95)	0.71(0.75)	0.81(1.04)	2.85	-0.14(1.79)	0.42	0.15	0.07
79 Transport Equipment	16.53	5.42(3.01)**	1.97(1.15)	2.01(6.49)**	1.95(4.89)**	3.14	-0.28(3.02)	0.44	3.11**	0.04
87 Professional Scientific Instruments	7.11	4.08(2.65)**	1.26(4.83)**	0.73(10.1)**	0.63(6.34)**	2.61	-0.21(2.67)	0.41	0.16	1.16
88 Photo Appt, Equipment & Optical Goods	1.11	2.53(2.07)**	-0.28(0.03)	0.37(0.45)	0.01(0.000)	1.21	-0.14(2.06)	0.44	0.16	2.31
89 Miscellaneous Manufactured Articles#	4.67	6.65(2.04)**	1.59(3.41)**	0.25(0.59)	0.013(0.001)	2.36	-0.36(2.05)	0.39	0.38	3.61*
93 Special Transactions	1.06	6.915(3.12)**	-0.58(0.27)	-1.87(20)**	-2.4(30.5)**	2.48	-0.41(3.14)	0.39	0.54	10.96**
95 Coin Including Gold#	1.27	0.82(0.61)	17.91(1.02)	13.35(4.82)	12.73(2.8)**	2.52	-0.19(1.49)	0.44	0.001	0.03
99 Low Value Shipments	2.14	1.81(2.01)	-2.78(1.38)	1.002(3.3)**	0.47(0.76)	3.86	-0.09(1.89)	0.48	4.78**	3.86**

Notes:
a. # next to an industry's code indicates that the Global Financial Crisis dummy was significant.
b. Numbers inside the parentheses are absolute value of t-ratios.
c. At the 5% (10%) significance level when there are two exogenous variables (k=2). the upper bound critical value of the F test is 4.85(4.14). These come from Pesaran *et al* (2001. Table CI-Case III. p 300).
d. Number inside the parenthesis next $_1$is the absolute value of the t-ratio. Its upper bound critical value at the 5%(10%) significance level is -3.53(-3.21) when k=2 and these come from Pesaran *et al* (2001. Table CII-Case III. p 303).
e. Both Wald tests are distributed as χ^2 with one degree of freedom. Its critical value at 5% (10%) significance level is 3.84(2.71).
f. * and ** indicate significance at 10% levels and 5% level respectively.

Table 6: Long-Run Coefficient Estimates of the Nonlinear US Import Value Model (7) when the Real Exchange Rate is Replaced by the Nominal Rate

		Long-Run Estimates				Diagnostics Tests				
Industry i	***T. Share in %***	***Constant***	***Ln Y^{US}***	***DDEP***	***DAPR***	***F^C***	***$_1$(t-test)[c]***	***Adj. R^2***	***Wald-S[e]***	***Wald-L***
51 Organic Chemicals	2.24	7.61(3.21)**[f]	-1.38(1.07)[b]	0.63(4.40)**	0.53(2.72)**	3.23	-0.38(3.15)	0.39	3.67*	1.31
54 Medicinal & Pharmaceutical Products	12.07	10.95(4.35)**	2.63(10.70)**	1.45(40.50)**	0.78(10.20)**	3.93	-0.57(4.3)**	0.36	0.04	108.70**
57 Plastics in Primary Form	1.15	10.88(4.28)**	1.55(19.72)**	0.60(62.06)**	0.22(7.68)**	6.02**	-0.61(4.2)**	0.44	0.01	30.10**
59 Chemical Materials	1.76	7.58(3.37)**	0.17(0.08)	0.35(4.46)**	-0.11(0.39)	3.06	-0.41(3.35)	0.38	0.01	103.70**
67 Iron and Steel#[A]	1.12	5.88(4.17)**	0.50(0.10)	1.59(13.51)**	1.57(11.54)**	4.43*	-0.31(4.1)**	0.38	0.08	0.05
68 Nonferrous Metals	2.60	2.47(2.25)**	4.31(3.67)**	0.46(0.42)	0.10(0.01)	1.83	-0.14(2.37)	0.36	1.87	3.05*
69 Manufactures of Metals	2.07	7.72(3.49)**	2.02(19.96)**	0.65(28.36)**	0.37(8.32)**	3.39	-0.41(3.46)*	0.39	0.02	75.45**
71 Power Generating Machinery	5.35	6.84(2.75)**	3.16(11.12)**	0.59(7.41)**	0.43(3.28)**	3.10	-0.35(2.82)	0.39	1.85	6.38**
72 Machinery Specialised	6.49	5.95(2.88)**	2.60(11.13)**	0.09(0.18)	0.009(0.001)	1.83	-0.30(2.83)	0.41	0.07	1.89
73 Metalworking Machinery	1.46	5.13(2.67)**	3.98(10.30)**	-0.23(0.42)	-0.32(0.74)	1.94	-0.28(2.71)	0.49	1.24	0.90
74 General Industrial Machinery	8.37	6.33(3.80)**	2.07(21.03)**	1.02(57.17)**	0.73(26.41)**	3.63	-0.32(3.8)**	0.44	0.001	70.42**
75 Office Machines and ADP Equipment	1.24	-0.70(0.41)	4.75(0.30)	2.15(0.15)	2.77(0.17)	0.93	-0.04(0.44)	0.46	2.84*	0.22
76 Telecommunications Equipment	1.08	4.66(2.97)**	2.05(2.62)**	0.68(3.52)**	0.34(0.79)	2.15	-0.26(3.00)	0.39	2.13	11.37**
77 Electrical Machry, Apparatus, Appliance	6.16	6.32(3.39)**	1.39(11.28)**	0.61(27.98)**	0.34(7.80)**	2.59	-0.32(3.42)	0.39	3.59*	52.85**
78 Motor Vehicles	1.81	1.71(1.13)	-7.33(0.72)	0.92(0.65)	0.40(0.11)	1.19	-0.08(1.17)	0.46	0.10	1.04
79 Transport Equipment	3.12	4.58(1.71)*	0.06(0.001)	-1.02(0.32)	-1.00(0.25)	0.65	-0.22(1.55)	0.44	0.52	0.001
87 Professional Scientific Instruments	6.47	6.74(3.98)**	1.59(15.86)**	0.74(43.63)**	0.39(10.64)**	3.29	-0.35(4.1)**	0.45	0.78	115.40**
89 Miscellaneous Manufactured Articles	2.29	9.73(2.29)**	0.89(1.59)	0.75(12.23)**	0.44(4.02)**	2.53	-0.52(2.29)	0.39	0.11	390.00**
93 Special Transactions	5.35	15.00(4.79)**	2.04(19.34)**	-1.04(58.2)**	-1.59(124)**	5.23*	-0.81(4.7)**	0.39	10.57**	206.50**
98 Estimate of Low Valued Import Transa	1.07	2.98(3.13)**	6.61(15.28)**	-0.05(0.01)	0.26(0.36)	2.98	-0.16(3.12)	0.48	0.63	5.60**

Notes:
a. # next to an industry's code indicates that the Global Financial Crisis dummy was significant.
b. Numbers inside the parentheses are absolute value of t-ratios.
c. At the 5% (10%) significance level when there are two exogenous variables (k=2). the upper bound critical value of the F test is 4.85(4.14). These come from Pesaran *et al* (2001. Table CI-Case III. p 300).
d. Number inside the parenthesis next $_1$is the absolute value of the t-ratio. Its upper bound critical value at the 5%(10%) significance level is -3.53(-3.21) when k=2 and these come from Pesaran *et al* (2001. Table CII-Case III. p 303).
e. Both Wald tests are distributed as χ^2 with one degree of freedom. Its critical value at 5% (10%) significance level is 3.84(2.71).
f. * and ** indicate significance at 10% levels and 5% level respectively.

Metals, with a 2.07 per cent import share), 74 (General Industry Machinery, with an 8.37 per cent import share), and 87 (Professional Scientific Instruments, with a 6.47 per cent import share); but reduces import values of industry 93 (Special Transactions, with a 5.35 per cent import share). Nominal dollar appreciation affects the same industries in the opposite direction.

4. Summary and Conclusion

In this paper, we consider US trade flows with its largest partner from the European Union, Germany. We disaggregate their trade flows by industry and assess the symmetric and asymmetric effects of changes in the real value of the dollar-euro exchange rate on the export and import values of 22 two-digit industries. To assess the symmetric effects, we use the linear ARDL approach of Pesaran *et al* (2001) to error-correction modelling and cointegration. To assess asymmetric effects, we utilisethe nonlinear ARDL approach of Shin *et al* (2014) to asymmetric error-correction modelling and asymmetric cointegration.

Our findings can best be summarised by saying that both the linear and nonlinear approaches yield significant short-run effects of exchange rate changes in nearly all industries. However, short-run effects survive into significant and meaningful long-run effects in more nonlinear models than in linear models. More precisely, the linear model predicted that dollar depreciation will increase the export earnings of industry 72 (Machinery Specialised, with a 2.41per cent export share) and dollar appreciation will reduce its import costs. However, the nonlinear model predicted that while dollar depreciation will increase the export earnings of industries 51 (Organic Chemicals, with a 1.77 per cent export share), 66 (Nonmetallic Minerals, with a 1.82 per cent export share), 69 (Manufactures of Metals, with a 1.5 per cent of export share), and 79 (Transportation Equipment, with a 16.53 per cent export share), dollar appreciation will reduce the export earnings of the first three industries but will have no effect on the export earnings of the fourth and largest industry (79), a clear sign of asymmetric effects.

As for the US imports from German industries, the linear model predicted that dollar depreciation will increase US import values of industry 67 (Iron and Steel, with a 1.12 per cent import share) and dollar appreciation will reduce it, a sign of an industry in which the US demand is inelastic. However, the nonlinear model predicted that dollar depreciation will increase US import values of industries 54 (Medical and Pharmaceutical Products, with a 12.07 per cent import share), 57 (Plastics in Primary Form, with a 1.15 per cent import share), 67 (Iron and Steel, with a 1.12 per cent import share), 74 (General Industry Machinery, with an 8.37 per cent import share), 87 (Professional Scientific Instruments, with a 6.47 per cent import share) and dollar appreciation will reduce their import values, again a clear sign of industries in which the US import demand is inelastic. Only in industry 93 (Special Transactions, with a 5.35 per cent import share) does dollar depreciation reduce import values and dollar appreciation increase it. Clearly, the increase in the number of industries from the linear models to the nonlinear models must be attributed to the nonlinear adjustment of the real exchange rate.

Our analysis reveals that if we were to rely only on the traditional approach of estimating the linear model, we would have concluded that exchange rate changes have long-run effects on exports and imports of only two industries. However, the nonlinear model reveals that when a nonlinear adjustment of the real exchange rate is introduced into the estimation procedure, a total of 10 industries are affected. Our findings are industry-specific and have different implications for different industries. For example, consider the largest US exporting industry to Germany, coded 79 (Motor Vehicles, with a 16.53 per cent export share). The linear model predicted that the exchange rate has no meaningful effect on export earnings of this industry, since cointegration was not supported. However, the nonlinear model reveals that dollar depreciation has significant positive and meaningful effects on the export earnings of this industry, but dollar appreciation does not. A similar analysis could be considered by other industries when planning their production and sales or at times of currency crisis.

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Appendix: Data Definitions and Sources

Monthly data over the period January 1999 to December 2019 are used to carry out the estimation. The data come from the following sources:
a. International Financial statistics (IFS)
b. US Census Bureau, https://usatrade.census.gov/

Variables:

VX_i^{US} Export value of commodity *i* by the US to Germany. Export value data in dollars for each commodity or industry come from source b.

VM_i^{US} Import value of commodity *i* by the US from Germany. Import value data for each commodity or industry comes from source b.

Y^{US} Measure of US economic activity. Since data are monthly, we follow Bahmani-Oskooee and Aftab (2017) and use the Industrial Production Index which is available on a monthly basis from source a.

Y^{GER} Measure of Germany's economic activity, also proxied by the industrial production index from source a.

REX Real bilateral exchange rate between the US dollar and the euro. It is defined as $(NEX*CPI^{GER})/CPI^{US}$, where *NEX* is the nominal exchange rate defined as *number of dollars per euro*, CPI^{US} is the price level in the United States and CPI^{GER} is the price level in Germany. Thus, an increase in REX reflects a real depreciation of the US dollar. All data come from Source a.

Endnotes

1. The Center for Research on International Economics and Department of Economics, the University of Wisconsin-Milwaukee, Milwaukee, WI53201. Valuable comments of two anonymous referees are greatly appreciated. Any remaining error, however, is our own. Corresponding author's e-mail: bahmani@uwm.edu

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4. See Bahmani-Oskooee *et al* (2013) for a review article.

5. The original submission did include all other small industries. In total we had 67 industries. Results for all industries are available from the corresponding author upon request.

6. Note that the definition of the real exchange rate (REX) is dominated by the definition of the nominal exchange rate which we have defined as the number of dollars per euro. Thus, an increase reflects euro appreciation or dollar depreciation.

7. Note that the t-test under this ARDL framework is the same as the t-test applied to test significance of the lagged error-correction term in the two-step approach of Engle and Granger (1987). For demonstration of this point see Bahmani-Oskooee (2020). Note that estimates of λ_1 and δ_1 must also be negative.

8. Note that Shin *et al* (2014 p 291) even argue that the two partial sum variables must be treated as a single entry into the nonlinear model so that critical values of the F test remains at high level when we move from the linear to the nonlinear model.

9. For some other applications of these methods see Halicioglu (2007), Nusair (2012, 2016), Baghestani and Kherfi (2015), Durmaz (2015), Gogas and Pragidis (2015), Al-Shayeb and Hatemi-J. (2016), Lima *et al* (2016), Aftab *et al* (2017), Gregoriou (2017), and Hajilee and Niroomand (2019).

10. All other diagnostics are similar to those in other tables and need not be repeated. Furthermore, in the nonlinear models, level of economic activity carries a significant coefficient in many more industries than the linear models.

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