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Assessment of the Symmetric and Asymmetric Effects of Exchange Rate Volatility on the Flow of Iran-China Industrial Trade

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Abstract

The exchange rate is always interacting with internal and external variables of economy. So the relationship between the exchange rate volatility and the trade flows is one of the considerable issues in international economics. The increase and decrease of the exchange rate volatility create different effects on trade flows. The main objective of this paper is to study the symmetric and asymmetric effects of exchange rate volatility on industrial trade flows in Iran. In this paper, the symmetric and asymmetric effects of exchange rate volatility on Iran's export and import industries (i.e. 9 industries exporting to China and 12 industries importing from China) are estimated over the period 1992-2016. Linear ARDL is used to evaluate the symmetric effects, and nonlinear ARDL approach is used to study the asymmetric effects. Results show that out of the 21 industries, almost half of the import and export industries have asymmetric effects of exchange rate volatility. Also, based on the results, the asymmetric effects vary by industry. Most of the investigated industries in this study use the exchange rate volatility as a factor for profitability and, despite volatility in exchange rates, increase their business. Therefore, this study is confirmed in most of the approved surveyed industries, where the risk theory is a portfolio.
Keywords: Exchange Rate Volatility, Symmetric Effect, Asymmetric Effect, Trade Flows, Autoregressive Distributed Lag.
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1. Introduction

The relation between exchange rate volatility and trade flows constitutes a large share of the literature in international finance. Since

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the emerge of floating exchange rates in 1973, the literature on the impact of exchange rate uncertainty on the trade flows has been growing theoretically and empirically. Both groups support the notion that exchange rate uncertainty measured by a measure of exchange rate volatility could have negative or positive effects on the trade flows. Bahmani-Oskooee and Hegerty (2007) described different theoretical models and their implications, in which trade flows, could respond to exchange rate uncertainty in either direction. The more frequent fluctuations in exchange rate leads to uncertain environment for international trade and, thus, a reduced international transactions, economic growth, and welfare (Hall et al., 2010). However, traders may increase trade in order to maximize their revenue, so that they can account any future loss, hence positive response. Indeed the empirical literature supports both effects (Bahmani-Oskooee et al., 2016).

Empirical literature on the effects of exchange rate uncertainty on trade flows has followed three distinct paths. Some have used trade flows between one country, and the rest of the world and some have used aggregate trade flows between two countries. Suspecting that they suffer from aggregation bias, some have adhered to trade flows between two countries at the commodity level. These studies can be classified into three categories. 1) There studies used either cross-sectional data or panel data, and included Pakistan in their samples (i.e. Bahmani-Oskooee and Ltaifa 1992; Sauer and Bohara, 2001; Hall et al., 2010; Khan et al., 2014). 2) Some used aggregate trade flows of Pakistan with the rest of the world (i.e. Bahmani-Oskooee and Payesteh, 1993; Bahmani-Oskooee, 1996; Doganlar, 2002; Arize et al., 2003; Javed and Farooq, 2009; Alam and Ahmad, 2010; Shaikh and Hongbing, 2015). 3) Few studies used bilateral trade flows of Pakistan with a few major trading partners (i.e. Kumar and Dhawan, 1991; Mustafa and Nishat, 2005; Alam and Ahmad, 2011; Saqib and Sana, 2012; Hassan, 2013). Bahmani-Oskooee and Hegerty (2007) concluded that studies which employed disaggregated trade flows at commodity level between two countries provided more support for both positive and negative impact of exchange rate volatility on commodity trade flows than those who either use aggregate trade flows between one country and rest of the world or aggregate trade flows between two countries. Following their suggestion, we employ commodity trade flows between Iran and China. China has traditionally been Iran's biggest trading partner. The Joint Comprehensive Plan of Action (JCPA), the official name of the nuclear deal, sign with world powers, including China, in 2015, gave a further boost to bilateral economic relations. The two countries' bilateral trade in 2015 was reportedly above $33.8 billion. Trade between Iran and China slipped down to $31.2 billion in 2016. In recent years, China has ranked first among the export resources and import destinations of Iran, and has been one of the main trading partners of Iran. Hence, it is an interesting case to study the effect of exchange rate fluctuations on commodity trade flows between Iran and China. The remainder of this paper is organized as follows. Section 2 provides a review of the literature. Section 3 presents the models, and describes the estimation methods. Section 4 discusses the results obtained from the tests, and Section 5 the paper.

2. Literature Review

2.1 Theoretical Literature

The expected impact of exchange rate volatility on international trade activities can be positive or negative depending on the assumptions made on issues like the presence or absence of forward markets and other hedging instruments, the modeling of traders' risk preferences, the structure of production such as the prevalence of small firms, and the economic integration degree (Auboin and Ruta, 2013; Oskooee and Hegerty, 2007). Most theoretical studies, however, support the idea that the increase of exchange rate volatility leads to the decrease of international trade. According to the models, if economic agents are risk averse, increased volatility in exchange rate increases uncertainty in the market and raises the cost of conducting international trade (Dimitrios Asteriou et al., 2016).

The initial theoretical research suggesting that exchange rate volatility is negative for international trade was based on quite important assumptions, e.g. perfect competition, a high degree of risk aversion, the invoicing currency used, the non-existence of imported inputs, and the absence of exchange rate hedging instruments.

In spite of a large number on the studies indicating negative relationship, there are also a number of theoretical studies which point out to different directions by predicting a positive effect, or no significant effect of exchange rate volatility on trade flows.

Franke (1991), Sercu (1992), and Sercu and Vanhulle (1992) theoretically indicated that under some conditions, exchange rate volatility might benefit an exporting firm and thus encourage the volume of its exports. Broll and Eckwert (1999) demonstrated the theoretical possibility of the positive relationship between exchange rate volatility and exports. This possibility is because as exchange rate volatility increases, the real option to export to the world market increases as well. As such, higher volatility can increase the prospective gains from international trade, which applies only for firms that are able to react flexibly to the exchange rates changes, and re-allocate their products accordingly. In addition, De Grauwe (1988) emphasized there were income and substitution effects of volatility. If firms are risk averse, a rise in the exchange rate volatility will increase the expected marginal utility of exports, and can lead to more exports; this is the income effect. But if firms are not risk averse enough, they will export less, because exporting is less preferable, which is the substitution effect. Consequently, depending on the relative strengths of the income and substitution effects, the net effect of the exchange rate volatility may be positive or negative.

Finally, some other studies, for example Willett (1986), concluded that exchange rate volatility had no significant impact on the volume of international trade. Sercu and Uppal (2003) developed a model of a stochastic general_equilibrium economy with international commodity markets, and endogenously determined the exchange rate in a complete financial market. Their simple model shows ambiguous results that it is possible to have either a negative or a positive relation between exchange rate volatility and the volume of international trade, due to the source underlying the increase in exchange rate volatility.

2.2 Empirical Literature

Some economists claim that exchange rate volatility, in addition to the volume of trade flows, affects the variability of trade flows. Baum and Çağlayan (2010) examined the effect of exchange rate uncertainty both on volume and variability of trade flows. They focused on bilateral trade flows between 13 developed countries over the period

1980–1998. Results showed that there was no significant relationship between the exchange rate uncertainty and the volume of trade. Yet, they suggested that exchange rate volatility exhibited a positive impact on the volatility of international trade flows.

Haile and Pugh (2013) applied meta-regression analysis to the existing empirical literature on the impact of exchange rate volatility on international trade, and found some evidence of publication bias. They showed that their results were significantly influenced both by authors' modeling strategies and by the contexts of their investigations. Also, researchers were most likely to find an adverse impact of exchange rate volatility on international trade, when using low frequency real exchange variability and focusing on trade between less developed economies, which had less hedging opportunities. In addition, they found that studies using nominal exchange rate volatility were less likely to report a negative impact on trade than those which use real exchange rate volatility. This is because it is only over long periods that real variability diverges from its nominal value. They also report that studies employing gravity, error correction, and long-run cointegration modeling techniques are more likely to report a negative trade impact of exchange rate volatility.

Bahmani-Oskooee and Aftab (2017) demonstrate the asymmetric effects of exchange rate volatility by using monthly data from 54 Malaysian industries that export to the U.S. and from 63 Malaysian industries that import from the U.S. The application of the nonlinear Autoregressive Distributed Lag (ARDL) approach of Shin et al. (2014) supports short-run as well as long-run asymmetric effects in almost 1/3rd of the industries. The approach identifies industries that are affected when volatility increases versus those that are affected when volatility declines.

Bahmani-Oskooee and Kanitpong (2017), using the nonlinear ARDL method, examined the asymmetric effects of exchange rate changes on the trade balance of Seven Asian economies and in this study Quarterly data are used to carry out the empirical exercise. The list of countries and data period for each country is as follows: Indonesia 1997Q1–2016Q1, Japan 1980Q1–2016Q1, Korea 1994Q1–2016Q1, Malaysia 1975Q1–2016Q1, Philippines 1981Q1–2016Q1, Singapore 1975Q1–2016Q1, and Thailand 1994Q1–2014Q4. Results of this study provided evidence of both short and long-run asymmetric effects of exchange rate changes on trade balance. Furthermore, significant long-run asymmetric effects were established in the results for Indonesia, Japan, and Korea _while short-run significant cumulative or impact asymmetry was established in the results for Korea, Malaysia, Singapore, and Thailand.

Benli (2018) used monthly data over the period from 2000:1 to 2016:12 to study the exchange rate nonlinearities in Turkey's exports to the USA. The purpose of this study was to identify whether exports responded to exchange rates in either a linear or a nonlinear way in the long-run. Moreover, using the nonlinear ARDL model recently advanced by Shin et al. (2011), he investigated the presence of a nonlinear model between the changes in US Dollar/Turkish Lira (USD/TRY) exchange rate and bilateral exports from Turkey to the US. The estimated nonlinear ARDL model affirmed the nonlinear effect of exchange rate changes on the exports. In particular, it was found that Turkish exporters seemed to benefit more from Turkish Lira depreciation than from Turkish Lira appreciation in the long run. In other words, exports respond positively to an increase in USD/TRY exchange rate but they don't respond to declines in the exchange rate.

Simakova (2018) examined the asymmetric effects of exchange rate Changes on the Foreign Trade of the Czech Republic. The aim of this paper was to evaluate the asymmetric effects of the CZK/EUR exchange rate on the most important segment of the Czech Republic foreign trade. The period from 1999 to 2014 was analyzed, and the data was disaggregated according to trading partner and product category. Based on the results, exchange rate comovement with partial trade balances was mostly confirmed by employing both applied approaches. Yet, the asymmetry cointegration approach, which introduces nonlinearity into the model, reveals a more significant impact of the exchange rate on commodity trade between the Czech Republic and its most important trading partners than a more standard model which imposes symmetry. Furthermore, distinguishing between depreciation and appreciation showed that the effects on the industry level were, in fact, asymmetrical in most industries, when assessing Czechia's bilateral trade and its most important trading partners.

Kwasiobeng (2018), using the partial sum process to create two variables and replace exchange rate volatility (Positive and negative variables), and utilized the Linear ARDL and Nonlinear ARDL techniques to investigate asymmetric effects of exchange rate volatility on export diversification in Ghana for the period 1983 to 2015. Results indicated that the exchange rate volatility had an asymmetric relationship with export diversification in Ghana. The paper recommended that the Central Bank strengthen its efforts to stabilize the exchange value of the Ghanaian cedi.

The present study differs from other studies in two ways. First, we concentrate on commodity trade flows between Iran and its major trading partner, the China. We investigate not only the impact of exchange rate volatility on Iranian exports to China, but also its imports from the China. Secondly, this paper explores and contrasts the effect of symmetric and asymmetric exchange rate volatility on industrial trade flows in Iran and China. Therefore, determining the direction and size of the link between the exchange rate volatility and foreign trade flows is ultimately an empirical issue, so that theoretical analysis cannot provide clear-cut conclusions in terms of the sign of this relationship. In fact, most theoretical results depend on the attitudes towards risk, functional forms, and type of trader, adjustment costs, market structure and availability of hedging opportunities.

3. Models and Methodology

Previous studies, which have assessed the impact of exchange rate volatility on trade flows, have basically included a measure variable such as real income, a relative price term measured by the real exchange rate and a measure of exchange rate uncertainty constructed as volatility of the real exchange rate. Following the above empirical background, this paper is to distinctively examine both the short and long-run effects of exchange rate volatility on disaggregated Iran-China bilateral trade flows in an error correction model framework. Standard import and export demand functions are employed by including a scale variable and a relative price term. In addition, a measure of exchange rate volatility is added to these models in assessing the impact of the exchange rate risk on the trade flows.

Since our focus is on the short and the long-run in order to capture the effects of volatility both before and after adjustment occurs and since our dataset may contain a mixture of stationary and nonstationary variables, we use the ARDL approach of Pesaran et al. (2001) which is commonly applied in this branch of literature.

In this analysis, we use the most common reduced-form model for trade flows. The trade flow models are to be introduced from ran's perspective. Therefore, following the literature (e.g., Thursby and Thursby, 1987; Lastrapes and Koray, 1990; Assery and Peel, 1991; Quin and Varangis, 1994; Bahmani-Oskooee and Hegerty, 2009; Bahmani-Oskooee and Harvey, 2011; Bahmani-Oskooee and Aftab, 2017) first, the Iranian export demand model in log-linear form is given by the Equations 1 and 2:

$$X_{i,t}^{ir}= f\ (IP_t^{ch}, EX_t, V_t) \tag{1}$$

$$LN\ X_{i,t}^{ir}=\alpha_0+\alpha_1 LN\ IP_t^{ch}+\alpha_2 LN\ EX_t+\alpha_3 LN\ V_t +\varepsilon_t \tag{2}$$

Second, the Iranian import demand model in log-linear form is given by the Equations 3 and 4:

$$M_{i,t}^{ir}= f\ (IP_t^{ir}, EX_t, V_t) \tag{3}$$

$$LN\ M_{i.t}^{ir}=\beta_0+\beta_1 LN\ IP_t^{ir}+\beta_2 LN\ EX_t+\beta_3 LN\ V_t+ \mu_t \tag{4}$$

Where X_{it}^{ir} and M_{it}^{i} are Iranian real exports of the commodity i to the Chinese and its real imports of the commodity i from the Chinese, respectively. IP_t^{ir} and IP_t^{ch} are the value added of the industries of Iran and China, respectively. EX_t is the real bilateral exchange rate (RBER). Finally, V_t is a measure of real exchange rate volatility which is based on Generalized Autoregressive Conditional Heteroskedasticity (GARCH) approach. Theoretically, estimates of α_1 and β_1 are expected to be positive, that is increased economic activity in both countries should promote trade. We also expect an estimate of α_2 to be positive, and that of β_2 to be negative. Finally, as discussed before, since exchange rate volatility could have positive or negative effects on trade, estimates of α_3 and β_3 could be positive or negative.

The next step is to introduce the dynamic adjustment mechanism into (2) and (4), so that we can distinguish the short-run effects of exchange rate volatility on trade flows from its long-run effects. Again, following the literature, we rely upon ARDL bounds testing approach (Pesaran et al., 2001), and specify the models (2) and (4) as error-correction models as in the models (5) and (6):

$$\Delta LnX_{i,t}^{ir} = \alpha_1 + \sum_{j=1}^{n1} \alpha_{2j}\Delta LnX_{t-j}^{ir} + \sum_{j=0}^{n2} \alpha_{3j}\Delta LnIP_{t-j}^{ch} + \sum_{j=0}^{n3} \alpha_{4j}\Delta LnEX_{t-j} + \sum_{j=0}^{n4} \alpha_{5j}\Delta LnV_{t-j} + \theta_1 LnX_{t-1}^{ir} + \theta_2 LnIP_{t-1}^{ch} + \theta_3 LnEX_{t-1} + \theta_4 LnV_{t-1} + \varepsilon_t \quad (5)$$

$$\Delta LnM_{i,t}^{ir} = b_1 + \sum_{j=1}^{n5} b_{2j}\Delta LnM_{t-j}^{ir} + \sum_{j=0}^{n6} b_{3j}\Delta LnIP_{t-j}^{ir} + \sum_{j=0}^{n7} b_{4j}\Delta LnEX_{t-j} + \sum_{j=0}^{n8} b_{5j}\Delta LnV_{t-j} + \rho_1 LnM_{i,t-1}^{ir} + \rho_2 LnIP_{t-1}^{ir} + \rho_3 LnEX_{t-1} + \rho_4 LnV_{t-1} + \varepsilon_t \quad (6)$$

In error-correction models (5) and (6), short-run effects are reflected in the estimates of coefficients assigned to first-differenced variables, and long-run effects are revealed in the estimates of θ_2_θ_4 normalized on θ_1 in (5) and $\rho_2 - \rho_4$ normalized on ρ_1 in (6).

To test for the asymmetry effects of exchange rate volatility we decompose changes in our volatility measure to its positive and negative changes. We do this first by forming ΔLnV which includes positive changes, $\Delta LnV+$, and negative changes, $\Delta LnV-$. We then create two new time-series variables, one representing only increased volatility as a partial sum of positive changes, denoted by POS and the second one measuring decreased volatility as a partial sum of negative changes denoted by NEG:

$$POS_t = \sum_{j=1}^{t} \Delta LnV_j^{+} = \sum_{j=1}^{t} \max(\Delta LnV_j, 0) \quad (7)$$

$$NEG_t = \sum_{j=1}^{t} \Delta LnV_j^{-} = \sum_{j=1}^{t} \min(\Delta LnV_j, 0) \quad (8)$$

The next step is to go back to specifications (5) and (6), and replace the volatility variable, LnV_t , with POS_t and NEG_t variables. So,We have:

$$\Delta LnX_{i,t}^{ir} = c_1 + \sum_{j=1}^{n1} c_{2j}\Delta LnX_{t-j}^{ir} + \sum_{j=0}^{n2} c_{3j}\Delta LnIP_{t-j}^{ch} + \sum_{j=0}^{n3} c_{4j}\Delta LnEX_{t-j} + \sum_{j=0}^{n4} c_{5j}\Delta LPOS_{t-j} + \sum_{j=0}^{n5} c_{6j}\Delta NEG_{t-j} + \lambda_1 LNX_{t-1}^{ir} + \lambda_2 LnIP_{t-1}^{ch} + \lambda_3 LnEX_{t-1} + \lambda_4 POS_{t-1} + \lambda_5 NEG_{t-1} + \varepsilon_t \quad (9)$$

$$\Delta LnM_{i,t}^{ir}=d_{1}+\sum_{j=1}^{n6} d_{2j}\Delta LnM_{t-j}^{ir}+\sum_{h=0}^{n7} d_{3j}\Delta LnIP_{t-j}^{ir}+\sum_{j=0}^{n8} d_{4j}\Delta LnEX_{t-j}+\sum_{j=0}^{n9} d_{5j}\Delta POS_{t-j}+\sum_{j=0}^{n10} d_{6j}\Delta NEG_{t-j}+\text{л}_1 LnM_{int-1}^{ir}+\text{л}_2 LnIP_{t-1}^{ir}+\text{л}_3 LnEX_{t-1}+\text{л}_4 POS_{t-1}+\text{л}_5 NEG_{t-1}+\varepsilon_t \quad (10)$$

Specifications (9) and (10) are two error-correction models that Shin et al. (2014) call them nonlinear ARDL models whereas, (5) and (6) are called linear ARDL models. Nonlinearity in (9) and (10) are introduced by the way of constructing POS and NEG variables using partial sum concept.

3. Empirical Results

As mentioned in the introductory section, our goal is to assess the impact of exchange rate volatility on Iran's trade flows with its trading partner China at commodity or industry level. Continuous annual data over the 1992–2016 periods were available for 9 Iranian exporting selected industries to China and 12 Iranian importing selected industries from China.

We first concentrate on the results from the linear models, specifically the Iranian export demand model (5). To save space, we do not report the short-run estimates, but there was at least one significant coefficient attached to the measure of volatility in 9 Iranian exporting industries, which indicates the short-run effects of real exchange rate fluctuations on export.

In order to determine that in which industry the short-run effects lasted into the long- run, we report the long-run normalized estimates for all variables in Table 1.

Table1: Long-Run Coefficient Estimates of Linear ARDL Export Demand Model and its Diagnostic Statistics

Industry	C	LNIPTCH	LNEX	LNV	F	ECM (-1)	CUSUM
03-Fish, crustaceans and molluscs, and preparations thereof	-38.933	1.826*	-1.150	0.298	3.555	-0.165*	S
26-Textile fibers (other than wool tops) n.e.s.	-53.032	1.524	0.650	0.770*	7.570	-0.108*	S
28-Metalliferous ores and metal scrap	-78.430*	3.260*	-0.391	0.041	4.798	-0.163*	S
33-Petroleum, petroleum products and related materials	-26.520	2.125*	-1.941	-0.140	3.264	-0.051*	S

Industry	C	LNIPTCH	LNEX	LNV	F	ECM (-1)	CUSUM
57-Plastics in primary forms	-89.647*	3.597*	-0.121	0.088*	7.881	-0.389*	S
59-Chemical materials and products,n.e.s.	108.588*	2.833*	3.852*	0.303	4.702	-0.171*	S
65-Textile yarn, fabrics, made-up aricles, n.e.s.	-78.122*	2.385*	1.955	0.085	3.420	-0.123*	S
67-Iron and steel	-49.462	2.001	-2.359	1.013*	3.247	-0.222*	S
76-Telecommunications and sound recording n.e.s.	50.232	0.342	-4.806	0.818	6.840	-0.178*	S

Source: Research Findings.
* indicate significance at 5% levels, respectively.

It is clear from Table 1 that the short-run effects of exchange rate volatility last into the long-run in 4 industries, because the LnV variable carries a significant coefficient. In industries coded 03, 26, 57, and 67, the coefficient estimate is significantly positive. These industries benefit from increased fluctuations. This means that, in the long-run, the increase in exchange rate fluctuations will be considered as a factor in profitability, and will increase exports in these industries. As for the effects of China economic activity, results reveal that it carries its expected positive significant coefficient in 6 industries coded 03, 28, 33, 57, 59, and 65. This means that China’s growing economy will help these 6 Iranian industries export more to China. Finally, the real exchange rate carries its expected positive significant coefficient in industry coded 59, that is as the Rial depreciates, Iran exports more of these goods to the China.

In order to validate the above long-run estimates, we must establish cointegration. As can be seen, in all models, the calculated F-statistic is significant, supporting cointegration. Therefore, an error correction model (ECM) can be used. After replacing the linear combination of lagged level variables in (3) by ECM_{t-1}, and imposing the same optimum lags as before, the new specification is estimated one more time. A significantly negative estimate attached to ECM_{t-1} will support cointegration. It appears that this test provides additional support for cointegration in all the models. Finally, following the literature the CUSUM test was also applied to establish the stability of all estimates. It is indicated by CUS, and supports the stability of all estimates, indicated by “S”.

Next, we turn to the estimates of the linear ARDL import demand model (6). The short-run estimates not reported, but available upon request, show that there are all industries, in which the measure of exchange rate volatility carries at least one significant coefficient. It indicates the short-run effects of real exchange rate fluctuations on import.

In order to see that in how many of these industries the short-run effects are translated into the long-run, the long-run normalized estimates are reported in Table 2.

Table 2: Long-Run Coefficient Estimates of Linear ARDL Import Demand Model and it Diagnostic Statistics Associated

INDUSTRY	C	LNIPTIR	LNEX	LNV	F	ECM (-1)	CUSUM
07-Coffee, tea, cocoa, spices, and manufactures thereof	-148.404	4.894*	-0.829	-0.146	5.617*	-0.100*	S
27-Crude fertilizers and crude minerals n.e.s.	-157.459*	5.143*	-1.102	0.035	1.992	-0.107*	S
33-Petroleum, petroleum products and related materials	-113.907	3.936	-1.036	0.052	2.919	-0.188*	S
51-Organic chemicals	-874.231*	7.136*	-0.358	0.048	4.654*	-0.036*	S
53-Dyeing, tanning and colouring materials	-386.962*	10.248*	3.548	0.911	4.227*	-0.016*	S
54-Medicinal and pharmaceutical products	-423.312*	12.094*	0.630	0.527	2.301	-0.026*	S
58-Plastics in non-primary forms	-513.979*	14.737*	0.451	0.453*	3.943*	-0.026*	S
66-Non-metallic mineral manufactures n.e.s.	-520.965*	14.885*	0. 520	0.615*	3.709*	-0.031*	S
71-Power generating machinery and equipment	-161.728	5.548*	-1.694	-0.098	2.248	-0.040*	S
72-Machinery specialized for particular industries	-198.753*	6.416*	-0.701	-0.196	4.332*	-0.047*	S
77-Electrical machinery, apparatus and appliances, n.e.s.	-303.810*	9.110*	-0.097	0.120	1.405	-0.026*	S
78-Road vehicles (including air-cushion vehicles	-428.218*	12.425*	0.340	0.357	2.250	-0.049*	S

Source: Research findings.

* indicate significance at 5% levels, respectively

By results, it can be seen that among the 12 imported industries, imports of two industries (58, 66) are significantly and positively affected by exchange rate volatility. As the exchange rate fluctuates, investment in these industries is associated with a high risk and, as a result, production in these industries decreases, and leads to an increase in imports of these industries. Exchange rate volatility in other industries does not have a significant effect on Imports in the long-run.

The index of industrial production in Iran as a measure of economic activity carries a positive significant coefficient in all industries except industry coded 33. As a result, the increase of Iranian economic activity is because of the increase of imports.

Finally, the real bilateral exchange rate does not have a significant coefficient in any of the imported industries in the long-run.

In order to determine cointegration, we turn to Table 2 and the results of the F test as well as other diagnostics. Clearly, in any industry that there was at least one significant long-run coefficient estimate, cointegration is supported either by the F test or by ECMt-1. As can be seen, clearly in half of the industries our calculated F statistic is significant and clearly in all models our calculated ECMt-1 statistic is significant. Finally, in all import demand models, coefficient estimates are stable, which is indicated by CUSUM test.

To summarize the long-run findings thus far, we can say that exchange rate volatility has significant long-run effects on exports of 4 out of 9 Iranian exporting industries to the China and on imports of 2 out of 12 Iranian importing industries.

We now consider the main contribution of the paper that is the estimates of nonlinear models to establish asymmetric effects of exchange rate volatility. First, we concern the estimates of the nonlinear ARDL export model (9). Short-run coefficient estimates obtained for positive changes in the volatility measure (ΔPOS) are reported in Table 3, and those obtained for negative changes in volatility (ΔNEG) are provided in Table 4.

Table 3: Short-Run Coefficient Estimates of ΔPOS Variables in Nonlinear ARDL export Model

industry	Δpos_t	Δpos_{t-1}	Δpos_{t-2}	Δpos_{t-3}	Δpos_{t-4}	Δpos_{t-5}	Δpos_{t-6}	Δpos_{t-7}	Δpos_{t-8}
03	-0.006	-0.007	-0.066	-0.130	0.620*	-0.409*			
26	-0.017	0.187	-0.279	0.056	0.544*	-0.391*			
28	0.011	-0.021	0.010	-0.081	0.169*	-0.092	-0.053	0.015	0.040
33	0.106	-0/033	-0/100	-0/004					

industry	Δpos_t	Δpos_{t-1}	Δpos_{t-2}	Δpos_{t-3}	Δpos_{t-4}	Δpos_{t-5}	Δpos_{t-6}	Δpos_{t-7}	Δpos_{t-8}
57	0/448*	-0/550*	0/233*						
59	0/336*	-0/106	-0/072	-0/249	0/830*	-0/184	-0/159	0/057	-0/191*
65	0/485*	-0/272	-0/075	-0/272	0/341	0/141	-0/234	0/123	-0/264*
67	-0/096								
76	-0/055								

Source: Research findings.
* indicate significance at 5% levels, respectively

Table 4: Short-Run Coefficient Estimates of ΔNEG Variables in Nonlinear ARDL Export Model

industry	ΔNEG_t	ΔNEG_{t-1}	ΔNEG_{t-2}	ΔNEG_{t-3}	ΔNEG_{t-4}	ΔNEG_{t-5}	ΔNEG_{t-6}	ΔNEG_{t-7}	ΔNEG_{t-8}
03	0.047								
26	-0.040	0.169							
28	-0.005	0.052	-0.058	0.039	0.012	0.008	0.009	-0.059*	
33	-0.138*	0.169*							
57	0.065	-0.047	0.123	-0.004	-0.248*	0.249*	-0.151*		
59	0.259*	0.215	-0.144						
65	0.047								
67	0.474*								
76	-0.172								

Source: Research Findings.
* indicate significance at 5% levels, respectively

From these two tables, we first gather all selected industries, in which either ΔPOS or ΔNEG carry at least one significant lag coefficient, supporting short-run effects of exchange rate volatility on Iranian export volume to the Chinese. Therefore, separating increased volatility from the decreased yields more significant short-run effects, which should be attributed to introducing nonlinear adjustment of the volatility measure.

In order to find out in which of the industries the short-run asymmetric effects last into the long-run, results of long-run coefficients are reported in Table 5, and the related diagnostics in Table 6.

Table 5: Long-Run Coefficient Estimates of Nonlinear ARDL Export Model (9)

Industry	c	LNIPTCH	LNEX	LNV-POS	LNV-NEG
03- Fish, crustaceans and molluscs, and preparations thereof	-98.389	4.027	-0.857	0.007	0.452
26- Textile fibres (other than wool tops) n.e.s.	-78.890	2.430	2.537	0.720	0.933*
28- Metalliferous ores and metal scrap	-76.787*	3.137*	-0.069	-0.007	-0.008
33- Petroleum, petroleum products and related materials	-133.178*	5.646*	-1. 223*	-0.347	0.335*

Industry	c	LNIPTCH	LNEX	LNV-POS	LNV-NEG
57- Plastics in primary forms	-51.944*	2.443*	-0.699*	0.224*	-0.023
59- Chemical materials and products,n.e.s.	-147.371*	4.040*	-4.809*	0.703*	0.802*
65- Textile yarn, fabrics, made-up aricles, n.e.s.	-102.352	3.362	-2.065*	-0.105	0.185
67- Iron and steel	-287.287*	10.806*	-1.330	-0.298	1.463*
76- Telecommunications and sound recording n.e.s.	120.737	-2.695	-4.698*	-0.293	-0.910

Source: Research Findings.
* indicate significance at 5% levels, respectively

From Table 5, we gather 5 industries either the POS or NEG variable carries a significant coefficient. Furthermore, the effects of increased volatility seem to be different from decreased volatility in most cases, supporting asymmetry long-run effects of exchange rate uncertainty on Iranian exports. For example, in industry the 57 (Plastics in primary forms), where the increased volatility has significant effects on the exports of this industry, the decreased volatility has no long-run effects.

Again, results of the Wald test applied to equality of normalized long-run coefficient estimates of the POS and NEG variables, reported as Wald in Table 6 reveal that, indeed, this statistic is significant in 5 industries coded 26, 57, 59, and 67.

Table 6: Diagnostics Associated with Estimates of Nonlinear Export Models in Table 5

INDUSTRY	F	ECM(-1)	WALD	CUSUM
03-Fish, crustaceans and molluscs, and preparations thereof	2.226	-0.104*	1.831	S
26-Textile fibers (other than wool tops) n.e.s.	5.346*	-0.137*	5.906*	S
28-Metalliferous ores and metal scrap	4.753*	-0.141*	0.008	S
33-Petroleum, petroleum products and related materials	13.576*	-0.092*	2.873	S
57-Plastics in primary forms	6.650*	-0.585*	5.520*	S
59-Chemical materials and products, n.e.s.	27.626*	-0.413*	52.638*	S
65-Textile yarn, fabrics, made-up articles, n.e.s.	4.833*	-0.256*	0.539	S
67-Iron and steel	3.983*	-0.324*	6.620*	S
76-Telecommunications and sound recording n.e.s.	5.851*	-0.189*	2.715	S

Source: Research Findings.
* indicate significance at 5% levels, respectively

In sum, significant short-run and long-run impact asymmetry are established in at least half of Iranian exporting industries, that is the exporters of these goods behave differently when volatility in the value of ringgit declines rather than when volatility increases.

Long-run effects of China economic activities have a positive significant coefficient in 5 industries coded 28, 33, 57, 59, and 67. This means that China's growing economy will help these 5 Iranian industries export rather than to China. The real bilateral exchange rate has a negative significant coefficient in 5 industries coded 33, 57, 59, 65, and 76.

As can be seen, in all the industries (expect 03), the calculated F-statistic is significant, and in all models, the calculated ECMt-1 statistic is significant. Finally, in all models, coefficient estimates are stable, indicated by CUSUM test.

Now, we should turn to the estimates of the nonlinear import demand model in the Equation 10. Again, due to the volume of the results, they are reported in Tables 7–10. While Tables 7 and 8 report short-run coefficient estimates attached to ΔPOS and ΔNEG variables, respectively, Table 9 provides the long-run coefficient estimates, and Table 10 illustrates the diagnostics associated with all estimates.

Table7: Short-Run Coefficient Estimates of ΔPOS Variable in Nonlinear ARDL Import Model (10)

Industry	Δpos_t	Δpos_{t-1}	Δpos_{t-2}	Δpos_{t-3}	Δpos_{t-4}	Δpos_{t-5}	Δpos_{t-6}	Δpos_{t-7}	Δpos_{t-8}
07	0.008	0.061	-0.152	0.117	0.761*	-0.718*			
27	0.495*	-0.761*	0.290*						
33	0.068								
51	0.007*								
53	-0.018	0.031	-0.015	-0.041	0.184*	-0.123*			
54	-0.004	-0.103	0.093	-0.219*	0.414*	-0.293*	0.107	-0.116	0.097*
58	0.066*	-0.102*	0.085*	-0.072	0.109*	-0.072*			
66	0.121*	-0.139*	0.106	-0.153*	0.332*	-0.294*	0.055	-0.012	0.039
71	0.023	-0.055	0.096	-0.009	0.304*	-0.377*	0.123		
72	-0.051	0.083	-0.047	-0.004	0.109*	-0.081*			
77	0.039	-0.100	0.103	-0.114	0.303*	-0.335*	0.117		
78	0.150*	-0.231*	0.118*						

Source: Research Findings.

* indicate significance at 5% levels, respectively

Table 8: Short-Run Coefficient Estimates of ΔNEG Variable in Nonlinear ARDL Import Model

Industry	ΔNEG_t	ΔNEG_{t-1}	ΔNEG_{t-2}	ΔNEG_{t-3}	ΔNEG_{t-4}	ΔNEG_{t-5}	ΔNEG_{t-6}	ΔNEG_{t-7}	ΔNEG_{t-8}
07	0.037								
27	0.007								
33	-0.694*	0.721*							
51	-0.022*	0.024*							
53	-0.006	0.013	-0.002	0.026	-0.030	0.014	0.036	0.0003	0.034*
54	0.054*	0.068	-0.068	0.119*	-0.156	0.113*	-0.050		
58	0.028	-0.025	-0.016	0.051	-0.088*	0.063*			
66	-0.069*	0.051	-0.053	0.117*	-0.148*	0.110*			
71	-0.017	0.061	-0.035	0.065	-0.072				
72	-0.040	0.030							
77	0.016	0.009	-0.049	0.104	-0.156*	0.080*			
78	0.011								

Source: Research Findings.

* indicate significance at 5% levels, respectively

Comparing the estimates in Table 7 to those in Table 8, we first gather all selected industries, in which either ΔPOS or ΔNEG carry at least one significant lag coefficient, implying that the exchange rate volatility has short-run effects on Iranian imports from the China.

In order to determine that in how many of the industries, the short-run effects last into the long-run, we concern the long-run coefficient estimates of Table 9. From Table 9, we see that in 4 industries the POS variable carries a significant coefficient. As the exchange rate fluctuates, the risk of investment in these industries raises. Therefore, the production industry is reduced, and importers of these industries increase their import.

As for the long-run effects of Iranian income and the real exchange rate itself, results are similar to those of the linear model in Table 2. Industrial production index, as a measure of Iranian income, carries a significant coefficient in 7 industries. Furthermore, in all cases, the estimate is positive. In other words, as the Iranian economy grows, these industries import more. Finally, the real bilateral exchange rate does not have a significant coefficient in any of the imported industries in the long-run.

Table 9: Long-Run Coefficient Estimates of Nonlinear ARDL Import Model

Industry	c	LNIPTIR	LNREX	LNV-POS	LNV-NEG
07-Coffee, tea, cocoa, spices, and manufactures thereof	-173.041*	5.473*	-0.861	0.416*	0.198
27-Crude fertilizers and crude minerals n.e.s.	-36.493	1.589	-0.694	0.319	0.093
33-Petroleum, petroleum products and related materials	-34.668	1.830	-1.802	0.393	0.156
51-Organic chemicals	-168.421*	5.310*	-0.270	0.147*	0.033
53-Dyeing, tanning and colouring materials	-212.995	6.482	0.108	0.338	0.334
54-Medicinal and pharmaceutical products	-276.205*	9.272*	-4.195	-0.521	-0.578
58-Plastics in non-primary forms	-604.635	17.838	-1.070	0.758	0.798
66-Non-metallic mineral manufactures n.e.s.	-212.121*	6.421*	0.063	0.328*	0.049
71-Power generating machinery and equipment	-101.114	3.445	-0.332	0.159	0.009
72-Machinery specialized for particular industries	-109.799*	3.629*	-0.119	0.074	-0.089
77-Electrical machinery, apparatus and appliances, n.e.s.	-220.556*	6.801*	-0.272	0.286	0.093
78-Road vehicles (including air-cushion vehicles	-252.203*	7.513*	0.479	0.330*	0.088

Source: Research Findings.
* indicate significance at 5% levels, respectively

Table 10 provides the diagnostics associated with all estimates. Results of this Wald test, reported in Table 11, supports impact asymmetry in 5 industries coded 53, 54, 66, 72, and 78. Once again, for the above long-run estimates to be valid, we must establish cointegration among the variables in the nonlinear import model. In all models our calculated ECMt-1 statistic is significant. Finally, results of the stability tests show that the coefficient estimates are stable in most instances.

Table 10: Diagnostics Associated with the Estimates of Nonlinear Import Models in Table 9

Industry	F	ECM(-1)	WALD	CUSUM
07-Coffee, tea, cocoa, spices, and manufactures thereof	3.158*	-0.188*	1.559	S
27-Crude fertilizers and crude minerals n.e.s.	1.692	-0.075*	2.323	S
33-Petroleum, petroleum products and related materials	2.337	-0.174*	1.407	S
51-Organic chemicals	4.004*	-0.050*	2.318	S
53-Dyeing, tanning and coloring materials	3.500*	-0.044*	3.257*	S

Industry	F	ECM(-1)	WALD	CUSUM
54-Medicinal and pharmaceutical products	6.896*	-0.049*	3.616*	S
58-Plastics in non-primary forms	2.270	-0.017*	2.511	S
66-Non-metallic mineral manufactures n.e.s.	3.436*	-0.168*	6.858*	S
71-Power generating machinery and equipment	1.288	-0.057*	0.990	S
72-Machinery specialized for particular industries	3.535*	-0.112*	3.446*	S
77-Electrical machinery, apparatus and appliances, n.e.s.	1.322	-0.053*	1.390	S
78-Road vehicles (including air-cushion vehicles	3.386*	-0.124*	5.645*	S

Source: Research Findings.
* indicate significance at 5% levels, respectively

In sum, Comparison of short-run and long-run effects of symmetric and asymmetric export demand and import demand are provided in Tables 11 and 12.

Table 11: Comparison of Short-Run and Long-Run Effects of Symmetric and Asymmetric Export Demands

Industry	Short run		Long run	
	symmetric	asymmetric	symmetric	asymmetric
03-Fish, crustaceans and molluscs, and preparations thereof	✓		✓	
26-Textile fibers (other than wool tops) n.e.s.		✓		✓
28-Metalliferous ores and metal scrap	✓		✓	
33-Petroleum, petroleum products and related materials	✓			✓
57-Plastics in primary forms		✓		✓
59-Chemical materials and products,n.e.s.		✓		✓
65-Textile yarn, fabrics, made-up aricles, n.e.s.	✓		✓	
67-Iron and steel		✓		✓
76-Telecommunications and sound recording n.e.s.	✓			

Source: Research Findings.

Table 12: Comparison of Short-Run and Long-Run Effects of Symmetric and Asymmetric Import Demands

Industry	Short run		Long run	
	symmetric	asymmetric	symmetric	asymmetric
07-Coffee, tea, cocoa, spices, and manufactures thereof	✓			✓
27-Crude fertilizers and crude minerals n.e.s.	✓		✓	

Industry	Short run		Long run	
	symmetric	asymmetric	symmetric	asymmetric
33-Petroleum, petroleum products and related materials	✓		✓	
51-Organic chemicals	✓			✓
53-Dyeing, tanning and coloring materials		✓	✓	
54-Medicinal and pharmaceutical products		✓	✓	
58-Plastics in non-primary forms	✓		✓	
66-Non-metallic mineral manufactures n.e.s.		✓		✓
71-Power generating machinery and equipment	✓		✓	
72-Machinery specialized for particular industries		✓	✓	
77-Electrical machinery, apparatus and appliances, n.e.s.	✓		✓	
78-Road vehicles (including air-cushion vehicles)		✓		✓

Source: Research Findings.

5. Conclusion

The shift from fixed to floating exchange rates in 1973 generated a debate among economists against and for such a move. One of the arguments against the floating exchange rates at that time is the impact of uncertainty or volatility of exchange rates on trade flows. Economists developed theories which suggested that exchange rate uncertainty could either hurt or boost trade among nations. Some traders reduce trade, so that they can avoid any loss due to exchange rate volatility. However, some may increase trade in order to maximize their current revenue, so that they have the potential to account any future loss. As time passes and more time series data become available for any country, researchers become more curious in discovering hidden effects either as a result of short data span or due to the aggregation. Indeed, today one can classify all studies related to an individual country into three categories. The first category uses trade flows between one country and the rest of the world. The second category relies upon bilateral trade data between two countries. Both categories are said to suffer from aggregation bias. In order to resolve the bias, the third group uses disaggregated trade data at commodity level between two countries. In this study, we question this assumption and argue that, indeed, there are reasons to believe that exchange rate volatility could have asymmetric effects on the trade flows. It has been shown that trade flows and traded goods' prices respond to the exchange rate fluctuations in an asymmetric manner. If so, the trade volume should respond to exchange rate volatility in an asymmetric manner, as well. In this paper, the symmetric and asymmetric effects of exchange rate volatility on Iran's export and import industries (for 9 industries export to China and 12 industries imported from China) were estimated for the period of 1992-2016. Assuming symmetric effects of the exchange rate volatility on trade flows amounts, standard linear model was used. However, in order to investigate asymmetric effects, we used nonlinear specifications of the same models. Results show that among the 21 industries, almost half of the imported and exporting industries have asymmetric effects of exchange rate volatility surveyed. Moreover, results of this study show that the asymmetric effects vary by industry. Small as well as large industries react to exchange rate volatility in an asymmetric manner. Our approach indeed identifies industries which benefit from increased and decreased volatility versus those which are hurt by increased and decreased volatility. The asymmetric effects seem to be industry specific and have implications for other industries in other countries. Additional studies in this regard are needed to achieve a thorough conclusion.

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