Does Exchange Rate Volatility reduce misreporting of official trade statistics? The case of India-USA bilateral trade

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Abstract

In the context of bilateral trade, we study how exchange rate volatility affects the gap between reported import of partner country and reported export of home country. We construct a simple theoretical model using mean-variance analysis approach of modeling risk aversion, where an agent can invest either in the high risk export sector or in the completely risk free domestic sector. We observe that the extent of trade misreporting goes down as exchange rate volatility increases. Moreover, at lower levels of volatility, the drop in misreporting is quite significant, while at higher levels of exchange rate volatility, the effect peters out. We also establish this finding through a simulation based exercise for a varied range of parameters. In order to establish the viability of the theoretical findings we consider India-USA bilateral trade data from 1990-2018. We use a threshold VAR model, and observe that the effect of volatility on export-misreporting is negative and significant only in the low volatility regime, but is insignificant in the high volatility regime.

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1. INTRODUCTION

In this paper, we study how exchange rate volatility affects export misreporting in the context of bilateral trade. When a country enters into trade with a partner country, there is a possibility that the export reported by the country is not exactly equal to the import reported by its trading partner, even after factoring for transportation costs and insurance costs. It has been observed that the gap is often too high. Export misreporting or export misinvoicing is defined as the gap between reported import of the partner country and reported export of the home country. Here we study the relationship between exchange rate volatility and export misreporting both analytically as well as empirically. We construct a simple theoretical model with a representative agent. The agent can invest in a risk free domestic sector or the risky export sector. We find out the optimal amount of investment in the export sector and misreporting done by this individual using mean-variance analysis approach of modeling risk aversion. We observe that the extent of trade misreporting goes down as exchange rate volatility increases. Moreover, at lower levels of volatility, the drop in misreporting is quite significant, while at higher levels of exchange rate volatility, the effect peters out. We establish this finding through a simulation based exercise for a large range of parameters using specific functional forms. We also perform an empirical analysis in order to establish the viability of the theoretical findings. We consider India-USA bilateral trade data from 1990-2018. We use a threshold VAR model, and observe that the effect of volatility on export-misreporting is negative and significant only in the low volatility regime, but is insignificant in the high volatility regime.

Trade misinvoicing was first observed by Morgenstern (1963) while studying the accuracy of economic observations. He explained it in terms of inaccurate observation, deliberate falsehood and the fact that often a set of data was collected for one administrative purpose and was used for another. Trade data misreporting has been seen as an outcome of illegal trade and existence of an international currency black market. Naya and Morgan (1969) explained trade misreporting in South East Asian context as a result of illegal trade and undervaluation of export. Bhagwati (1974) was one of the first papers to show trade misinvoicing as a function of black market premium. Berger and Nitsch (2008) connected trade misreporting with corruption. Export misreporting has been traditionally related to trade policies such as export subsidies and even import tariffs. Fraudulent traders choose to underreport export to evade trade restrictions. They might even manipulate official trade documents. Marjit et al (2000) show that India's export misreporting decreased with devaluation between 1960 and 1990. Tax fraud and high BMP can lead to high export misinvoicing. Biswas and Marjit (2005) show the impact of BMP and tax policies on misinvoicing in the Indian context. McDonald (1985) showed that trade data discrepancies came from incentive to participate in smuggling. He constructed a measure of the incentive to smuggle using data for export taxation and the black-market exchange rate. Buehn and Eichler (2011) show that trade policies coupled with black market premium determine the extent of trade misinvoicing. They test their hypotheses using trade data from 86 countries between 1980 and 2005. However, as most countries move over to flexible exchange rate

regime, it is likely that black market and black market premium have both reduced to a great extent. Hidden capital movement is used to explain trade misreporting especially in the Chinese context. Kar and Freitas (2012) is an important report in this aspect. More recently, Biswas et al (2022) used FDI data of China to explain trade misinvoicing, along with hidden capital flows. Das and Biswas (2021) show that spot and forward exchange rate are important factors guiding misinvoicing. The difference between spot exchange rate and forward exchange rate occur when exchange rate is volatile. Hence we understand that the volatility of exchange rate plays a crucial role in misinvoicing.

However, we have not come across any paper that models volatility and misinvoicing explicitly. Therefore, in this paper, we try to understand the effect of volatility on misreporting. The rest of the paper is arranged as follows: in section 2 we describe the analytical model, followed by an example using simulated data. In this section we also try to examine the welfare implication of such an action. Section 3 shows the empirical findings. Section 4 concludes the paper.

2. THE MODEL

We begin with a representative individual with one unit of wealth. There are two activities the individual can participate in. She can invest λ units in export activities and $(1-\lambda)$ in other domestic activities. Export sector is denoted by X and domestic sector is denoted by Y. X can be seen as a Hicksian composite good, where if the prices of the goods increase in the same proportion, that group of good behaves like one commodity. While the X sector is affected by the exchange rate, the Y sector is insulated from any fluctuations in the exchange rate given a level of investment. Since the X sector is affected by the volatility of the exchange rate, the individual might choose to invest in the relatively safe sector Y in case of high volatility. Additionally, the individual might choose to underreport (or in some cases, overreport) the amount of actual volume export. This is known as export misinvoicing. Individual pays tax on the reported amount. The actual amount of export is denoted by X, while $\tilde{X}$ denotes the reported amount. Typically, it has been observed that for India USA bilateral trade, $X - \tilde{X} > 0$. In other words, most developing countries would tend to underreport their exports, as the monitoring is lax and there are ways to bypass the laws. The cost of transporting the reported amount is increasing and convex. We denote this cost as $c(.)$; $c' > 0, c'' > 0$. However, the cost of transporting the unreported amount is different from transporting the reported amount. For example, the unreported amount can be transported in a shipping container, which is supposed to take the reported amount but has some empty space. The trader might have to bribe the customs officers, and make arrangements with the shipping agency.[1] This cost is also increasing and convex. One can look at this cost as the cost of evading the law. There is a punishment cost imposed on the misreported amount. If an individual is caught misreporting export, she has to pay a penalty,

[1] For details one can refer to the field survey findings listed in EXIM Bank Report, Marjit S.(forthcoming)

which depends on the volume of misinvoicing. This cost, too, is increasing and convex. In other words, it does not matter if there is overrepporting or underreporting, the cost will depend on the magnitude of the misinvoicing. We can merge these two costs together and since sum of two convex functions is a convex function, we can denote the sum by $z(.)$; $z' > 0, z" > 0$. The revenue from exports is $X(\lambda)$, the net revenue from the domestic sector is $Y(1-\lambda)$. We can assume the Y sector to be perfectly competitive, and hence the individual is a price taker in the domestic market. The international price is fixed at $p^* = 1$, the exchange rate is denoted by denoted by e. The individual is a price taker in the international market. The exchange rate is a random variable with mean $\bar{e}$ and variance v. The objective function of the individual can thus be written as

$$\pi = X(\lambda)e + Y(1-\lambda) - t\tilde{X}e - c(\tilde{X})e - z(X-\tilde{X})e \quad \textbf{1}$$

Let us define $\pi_x = X(\lambda) - t\tilde{X} - c(\tilde{X}) - z(X-\tilde{X})$ as the net earnings from the export sector. The individual can choose how much λ to invest in X and can choose how much to report to the authority. We apply mean-variance analysis, where we use the mean of exchange rate as the weight to the returns and variance of the exchange rate as the weight to the risk. The modified objective function will, therefore, be

$$\Omega = \alpha\big(X(\lambda)\bar{e} + Y(1-\lambda) - t\tilde{X}\bar{e} - c(\tilde{X})\bar{e} - z(X-\tilde{X})\bar{e}\big) - \beta v\left(X(\lambda) - t\tilde{X} - c(\tilde{X}) - z(X-\tilde{X})\right)^2 \quad \textbf{2}$$

The parameters $\alpha, \beta > 0$.

The first order conditions of maximizing 2 w.r.t λ and $\tilde{X}$ are given by

$$\frac{\partial \Omega}{\partial \lambda} = \alpha[X'\bar{e} - Y' - z'X'\bar{e}] - 2\beta v\pi_x[X' - z'X'\bar{e}] = 0$$

$$\frac{\partial \Omega}{\partial \tilde{X}} = [\alpha\bar{e} - 2\beta v\pi_x][-t - c' + z'] = 0$$

From the first order conditions we get $t + c' = z'$ and $X'(\alpha\bar{e} - 2\beta v\pi_x)(1-z') = \alpha Y'$. For the second order conditions to satisfy, we need $z' < 1$, and $\alpha\bar{e} - 2\beta v\pi_x > 0$. We can easily check that $\frac{\partial^2\Omega}{\partial\lambda^2} < 0$, $\frac{\partial^2\Omega}{\partial\tilde{X}^2} < 0$, and $\left(\frac{\partial^2\Omega}{\partial\lambda^2}\right)\left(\frac{\partial^2\Omega}{\partial\tilde{X}^2}\right) - \left(\frac{\partial^2\Omega}{\partial\lambda\partial\tilde{X}}\right)^2 > 0$. Solving the two optimality conditions one can calculate $\lambda^*$and $\tilde{X}^*$, which are the individual's choice of λ and $\tilde{X}$. Now the question is how this decision get affects by the change in the volatility of exchange rate. We want to see the

change in equilibrium λ and $\tilde{X}$ as the v changes. In the following paragraph, we perform a comparative statics analysis on the equilibrium conditions.

By differentiating the first order conditions w.r.t. v, we will get two equations involving $\frac{\partial\lambda}{\partial v}$ and $\frac{\partial\tilde{X}}{\partial v}$. Solving them, we see that $\frac{\partial\tilde{X}}{\partial v} = \frac{z"X'}{c"+z"}\frac{\partial\lambda}{\partial v}$ and $\frac{\partial\lambda}{\partial v} < 0$. Therefore, $\frac{\partial\tilde{X}}{\partial v} < 0$. Moreover, one can see that $\frac{\partial(X-\tilde{X})}{\partial v} < 0$, too.

Proposition 2.1(i) Investment in export sector, and hence, the volume of export reduces as volatility in exchange rate increases.

(ii) Reported export reduces as volatility in exchange rate increases.

(iii) The gap between actual export and reported export decreases as volatility in exchange rate increases, i.e., misreporting of export goes down with increase in exchange rate volatility.

To understand it intuitively, suppose v falls leading to an increase in X. At unchanged $\tilde{X}$ this would mean that $X - \tilde{X}$, that is the extent of misreporting increases. This increases the marginal cost associated with misreporting. The cost is convex while the revenue is concave. The increase in cost will be more than that of the revenue. Hence, the reported amount will increase, too. However, that will increase the cost associated with exporting the reported amount. Therefore, $\tilde{X}$ will increase, but less than X. The extent of misreporting will increase although the volume of export in increasing, leading to loss in Government revenue. On the other hand, an increase in v will lead to a decrease in misreporting. A country can achieve improved governance, i.e., better trade statistics at the cost of reduced activities in the export sector.

2.1. AN EXAMPLE

Let us try to illustrate the above model by taking some specific functions. Consider $X = \bar{x}\lambda$ and $Y = \bar{y}(1-\lambda)$, where $\bar{x}, \bar{y} > 0$ and are fixed in the model. The cost of exporting the reported amount is given by $c\tilde{X}^2$, where c is the constant marginal cost. The cost function z is quadratic and is given by $z = \frac{\mu}{2}\left(X - \tilde{X}\right)^2$. The modified objective function will be given by

$$\Omega = \alpha\left(x\lambda\bar{e} + y(1-\lambda) - t\tilde{X}\bar{e} - \frac{c}{2}\tilde{X}^2\bar{e} - \frac{\mu}{2}\left(X-\tilde{X}\right)^2\bar{e}\right) - \beta v\left(x\lambda - t\tilde{X} - \frac{c}{2}\tilde{X}^2 - \frac{\mu}{2}\left(X-\tilde{X}\right)^2\right)^2$$

3

The first order conditions from maximizing 3 w.r.t. $\tilde{X}$ and $x\lambda$ are given by $t + (1+c)\tilde{X} = \bar{x}\lambda$ and $(\alpha\bar{e} - 2\beta v\pi_x)\bar{x}\left(1 - \mu\left(\bar{x}\lambda - \tilde{X}\right)\right) = \alpha\bar{y}$. Since we are interested in the effect of volatility on the equilibrium, we perform the comparative statics analysis. We get $\bar{x}\frac{\partial\lambda}{\partial v} < 0, \frac{\partial\tilde{X}}{\partial v} < 0$, and

$\frac{\partial(X-\tilde{X})}{\partial v} < 0$ as before. We use this result to run a simulation and check if the theoretical model holds for a wide range of the parameters. Let us denote $X - \tilde{X} = \bar{M}$. Let us further assume $\bar{x} = \bar{y} = 1$. Furthermore, let us take $\alpha = \beta = 1$. From the two first order conditions, $\bar{M} = \frac{\left(\bar{e}-1-\frac{t}{c}+\frac{t^2}{c}\right)}{2v\left(1+\frac{\mu}{c}\right)+\bar{e}\mu+\frac{2vt\mu}{c}-\frac{vt^2\mu}{c}}$, ignoring the higher order terms by using Taylor's series expansion around $\bar{M} = 0$. It is evident that $\frac{\partial\bar{M}}{\partial v} < 0$ and $\frac{\partial^2\bar{M}}{\partial v^2} > 0$.

We now want to see the effects of various parameters, such as tax rate, cost of exporting, punishment cost etc. on misinvoicing by using simulated data. We randomize the parameters $\bar{e}, v, t, c, \mu$. All the parameters are assumed to be independently distributed. $\bar{e}$ follows a uniform with range [1,5], v follows a normal distribution with mean 1 and variance 2. t, c, μ follow uniform distribution with ranges $[-0.5,0.5]$ (negative range signifies export subsidy), [1,2] and [0,1] respectively. Typically, the cost of exporting the reported amount must be greater than the cost of exporting the unreported amount (which includes physical as well as punishment cost, as mentioned earlier. Without the cost differential, the incentive to misreport drops. This is reflected in the ranges of c and μ respectively. We ensure that the first and the second order conditions are satisfied. Figure 2.1 shows the simulation result.

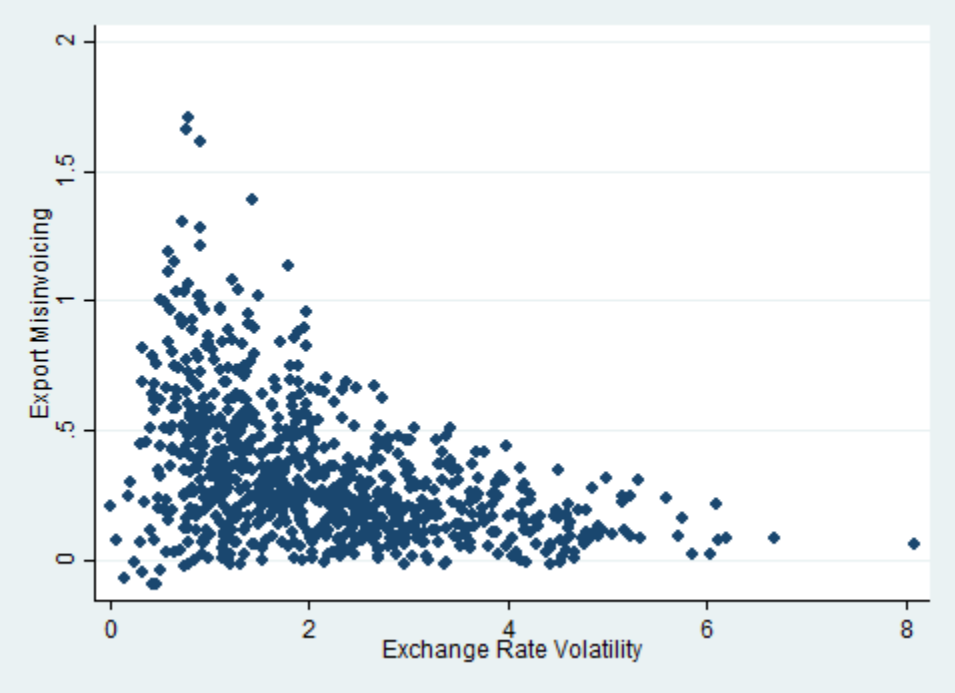

Figure 2.1

Proposition 2.2: Export misreporting is a decreasing and convex function of exchange rate volatility.

2.3 WELFARE IMPLICATIONS

With an increased volatility in exchange rate, the obvious effect will be on the export sector. There will be withdrawal of investment from that sector. There will be more investment in the domestic safe sector. On the other hand, volatility will make misreporting more costly, hence there will be more truthful revelation of exports, leading to more transparency in the government. It is essentially an indicator of good governance. In case if export sector has more employability, then government might choose to ignore transparency. Otherwise, in case government wants to promote good governance, it might choose to achieve a target level λ, thereby keeping a control on misreporting.

3. EMPIRICAL ANALYSIS

3.1 DATA

India's reported export to the USA between 1990 and 2018 has been increasing as measured by the dotted line in the first panel of Figure 3.1. USA's reported import from India between the same time is also increasing over time. However, we see a divergence between the two, as evident in the bottom panel of Figure 3.1.The gap between import reported by the USA and export reported by India is being referred to as export misinvoicing. To reduce the magnitude of fluctuation of the export misinvoicing, we are taking the log transformation of the data. Figure 3.2 shows the time series graph of Real Exchange Rate and its volatility.

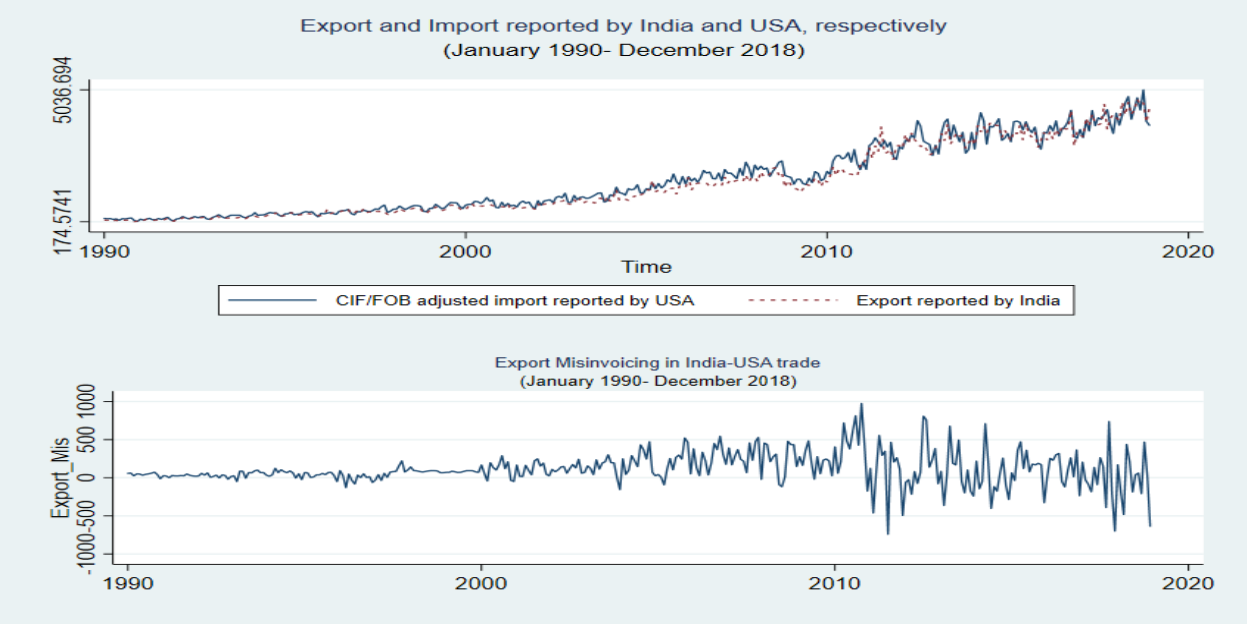

Figure 3.1

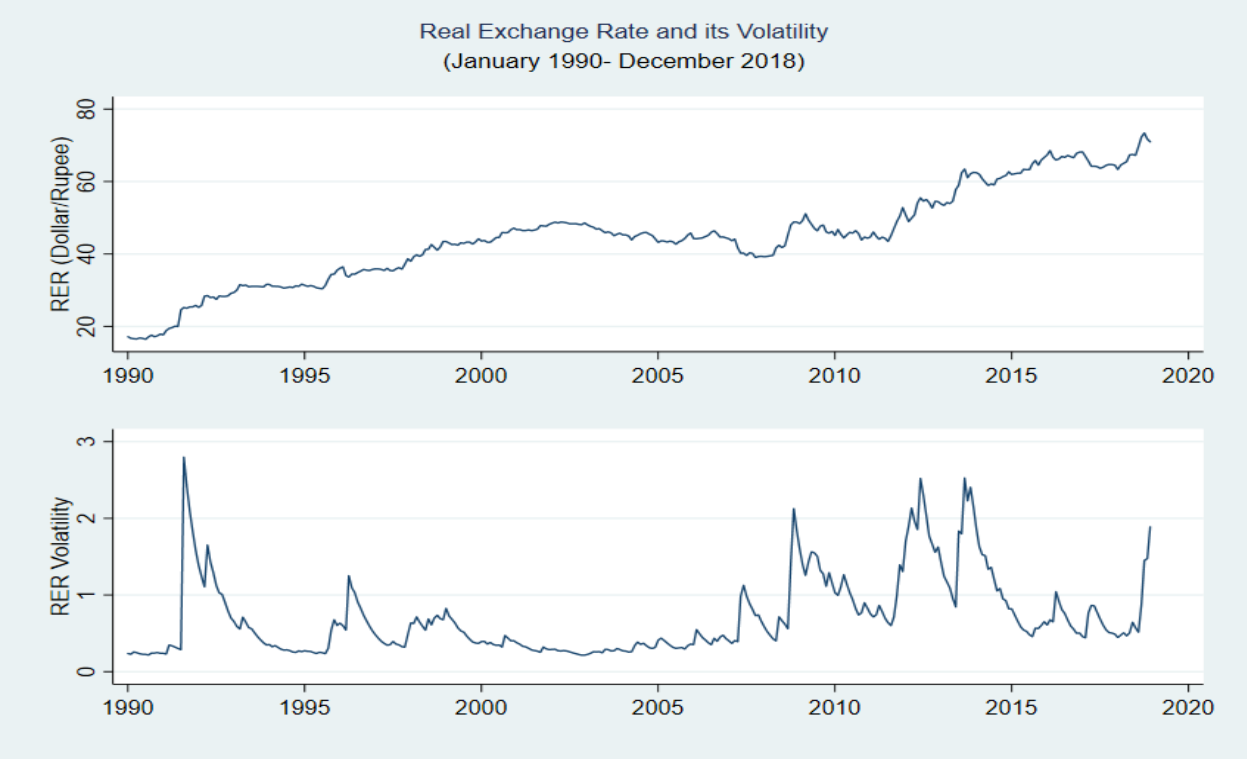

Figure 3.2

For the value of **Export misinvoicing** (Actual export-Reported export), we have used the logarithmic values of the absolute values of export misinvoicing labeled as **EXMIS**. We have obtained the data from monthly bilateral trade data from IMF's Direction of Trade Statistics (DOTS) website. The data on **Real exchange rate (RER)** was found to be non-stationary of degree 1. Hence we have taken its first difference to make it stationary, which is denoted as DRER. We have obtained this data from datafred. **Exchange rate volatility,** denoted by v, is estimated from the data on exchange rate by fitting a GARCH(1,1) Model of the exchange rate. The range of the data is from January 1990 to December 2018. We present the summary statistics of all the variables used in this study in table 3.1.

Table 3.1 Summary Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
RER	348	44.73	12.82	16.48	73.42
DRER	348	0.15	0.92	-2.46	4.58
v	348	0.71	0.51	0.22	2.80
EXMIS	348	115.97	214.60	-739.82	974.85

ADF and PP tests are carried out to find if all the variables in question are stationary. From the test results given in Table 3.1.1 we can conclude that EXMIS and v are stationary at 1% and 5% levels of significance, respectively. However, for RER null hypothesis of unit root cannot be rejected. Hence we take first difference of RER (i.e., DRER) to make it stationary.

Table 3.2 Results of unit root tests

Variables	ADF test	PP test
EXMIS	-7.36***	-16.09***
RER	-2.24	-2.00
DRER	-15.65***	-15.52***
v	-3.85**	-3.93**

Note: i) The optimal lag orders of the variables in ADF regressions are selected by the Schwarz Information Criterion.
ii) '***'& '**' denotes significance at 1% and 5% level, respectively.

3.2 METHODOGOLY

Threshold Vector Autoregressive (TVAR) Model

For our analysis we follow the approach used by Balke (2000) and Li and St-Amant (2008) for the estimation of a threshold vector autoregression (TVAR). The TVAR model has a number of interesting features that make it attractive for our purpose. First, it is a relatively simple way to capture possible nonlinearities such as asymmetric reactions to shocks or the existence of multiple equilibria. Secondly, the variable by which different regimes are defined can itself be an endogenous variable included in the VAR. In this study, we use exchange rate volatility, an endogenous variable, as the threshold variable.

The TVAR model can be defined as

$$Y_t = \begin{cases} C_1 + A_1^1 Y_{t-1} + A_2^1 Y_{t-2} + \cdots + A_p^1 Y_{t-p} + U_{1t} & if \quad v \leq \gamma \\ C_2 + A_1^2 Y_{t-1} + A_2^2 Y_{t-2} + \cdots + A_p^2 Y_{t-p} + U_{2t} & if \quad v > \gamma \end{cases}$$

4

where Y_t represents a $(n \times 1)$ vector of endogenous variable, C_j $(j = 1,2)$ represents $(n \times 1)$ vector of constant, A_i^j $(i = 1, \dots, p; j = 1,2)$ is the $(n \times n)$ parameter matrix, U_{jt} $(j = 1,2)$ is the $(n \times 1)$ vector of random disturbance term and γ is the threshold value.

The lag length of the endogenous variables, p, is determined by the usual information criteria (Schwarz SIC), which gives a larger penalty to the number of coefficients estimated in the model. If the threshold values γ were known, the conventional F-test for the null hypothesis $A_1^2 = A_2^2 = \cdots = A_p^2 = 0$ would give reliable results. However, in our case the threshold value is not known a priori, and the testing procedure involves non-standard inference, because γ is not identified under the null hypothesis of no threshold.

3.3 FINDINGS

We use the threshold VAR model where the exchange rate volatility v is considered to be the threshold variable. The threshold value of v is endogenously determined to be $\gamma = 0.655$. We consider $\gamma \geq 0.655$ as the high exchange rate volatility regime and $\gamma < 0.655$ as the low exchange rate volatility regime. We see that the effect of DRER with lag 2 on EXMIS is positive and significant in both the high volatile and the low volatile regimes. The effect of v on EXMIS is negative and significant in the low volatile regime but is insignificant in the high volatile regime. The result is in line with our theoretical model and the simulation that we have presented in the previous section. We can say that as volatility increases in the low volatile regime, export misinvoicing falls but at the high volatile regime the effect is not significant. If we are in a high volatile regime, the export sector will shrink due to uncertainty. If the actual level of export is low, volatility will not have much impact on export misinvoicing.

Table: 3.3 Estimation results from TVAR model

	Low volatile regime ($\gamma < 0.655$)				**High volatile regime** ($\gamma \geq 0.655$)		
	$EXMIS$	$DRER$	V		$EXMIS$	$DRER$	V
$CONSTANT$	1.16**	0.08	-0.08		0.82**	-0.00	-0.08
$EXMIS(-1)$	-0.17**	0.03	0.00		-0.19**	0.06	-0.01
$DRER(-1)$	-0.19	-0.22**	-0.10***		-0.02	-0.15*	-0.06***
$v(-1)$	-2.81	1.25	-0.50		-0.62	-0.21	-0.89***
$EXMIS(-2)$	-0.07	-0.06	0.00		-0.07	0.02	0.01
$DRER(-2)$	0.44**	0.08	-0.02		0.23**	0.13	-0.00
$v(-2)$	3.03	-0.81	-0.39		0.04	-0.07	0.00
$EXMIS(-3)$	-0.32**	-0.01	-0.00		-0.11	-0.05	-0.00
$DRER(-3)$	-0.24	-0.17	-0.02		-0.21	-0.04	-0.03*
$v(-3)$	3.88	-3.03	0.15		0.18	0.07	0.06
$EXMIS(-4)$	0.18**	0.03	-0.00		0.08	-0.01	-0.00
$DRER(-4)$	-0.43*	0.01	-0.02		0.11	0.22**	0.00
$v(-4)$	-4.54**	1.98	-0.05		0.28	0.10	-0.06

Note: '***', '**', '*' indicates significance at 1% , 5%, and 10% levels, respectively.

4. CONCLUSION

We see that there is an inverse relationship between exchange rate volatility and export misinvoicing. The relationship becomes insignificant at a higher level of volatility. It is understandable that at higher levels of volatility the investment in export sector will be less, misreporting also cannot be very significantly different from actual export. Hence a further increase in volatility will not affect the level of misreporting. We have observed that in most papers, including ours, the developed country (here USA) is assumed to be truthfully revealing while developing country (here India) is misreporting. The historical premise behind this assumption is that the developed countries are better in keeping records, have less corruption vis-à-vis developing country. However, following Marjit (forthcoming) we can use Freedom House Index ranking as weights and use them as an index of truthful revelation. We intend to extend our work in that direction, so that evidences from more countries can be accommodated in our analysis. A very interesting contribution of our analysis is perhaps in the welfare implication. We see that there is a trade-off between good governance and employability in the export sector. In presence of high exchange rate volatility, government can choose policies to maintain high level of investment in the export sector, which ensures high employability in the sector. However, it comes at the cost of sacrificing the integrity of official statistics. Such actions will increase misreporting, despite high level of volatility. On the other hand, if the government wants an improvement in official statistics when volatility is high, it might be achieved at the cost of the size of the export sector.

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