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Abstract

Following the break down of the Bretton Woods agreement in the early 1970s, the trade effect of exchange rate variability (ERV) has been an issue in international economics. However, neither the purely theoretical nor the empirical literature provides uniform evidence on the trade effect of ERV. This paper applies meta-regression analysis (MRA) to the empirical literature. The results reveal that, though modestly, the estimated effect sizes may suffer from publication bias. Although the results show the existence of an overall authentic trade effect of ERV beyond publication bias, its size is very small and does not yield overwhelming evidence even on the sign of the effect. Most strikingly, the empirical effect is estimated with pronounced heterogeneity. Investigation of this heterogeneity reveals that the results are significantly influenced both by authors' modelling strategies and by the contexts of their investigations. MRA evidence on the pronounced heterogeneity of the empirical findings may be instructive for policy: first, by establishing that average trade effects are not sufficiently robust to generalize across countries; and second, by suggesting the importance of hedging opportunities – hence of financial development – for trade promotion. In general, our most important advice for policy makers is that economic research does not reveal a single representative effect size.

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Introduction

Since the breakdown of the Bretton Woods agreement, the rates at which currencies are traded have been subject to the forces of supply and demand. Following this event, the trade effect of floating exchange rate regime has become a debatable topic in the economics literature. Even though policy discussions seem to believe that pegging the exchange rate promotes international trade, the academics literature, both theoretical and empirical, fail to provide a one - sided conclusion on this notion (Stokman, 1995; Broll and Eckwert, 1999; Pugh, et al., 1999; Mckenzie, 1999; Pugh and Tyrrall, 2002; Tenreyro, 2006; Baum and Caglayan, 2010).

Exchange rate instability[1] results in increased uncertainty to traders, which in turn affects the flow of international trade. The early post- Bretton Woods literature was inclined to support that this effect on trade flow is adverse. Ethier (1973) and Clark (1973) showed that uncertainty about firms' trade revenue as a result of exchange rate instability reduces the volume of trade. They also noted that perfect forward markets would reduce this adverse effect on trade. Many others support this line of argument and concluded that exchange rate uncertainty adversely affects international trade flows (e.g. Baron, 1976; Demers, 1991; Hooper & Kohlhagen, 1978).

Other theoretical papers, however, showed that higher exchange rate volatility may have a positive effect on international trade flow. Franke (1991) showed that, under general conditions, a risk neutral exporting firm increases its trade with increased exchange rate instability. Sercu (1992) also showed that exchange rate instability increases the probability that prices received by the trader are higher than trade costs, and hence argued that instability increases the volume of trade. Many other studies also supported the view that the exchange rate instability-trade relationship may be positive (e.g. Broll & Eckwert, 1999; Kumar, 1992; Sercu & Vanhulle, 1992).

Still other theoretical studies concluded that uncertainty in the exchange rate movement has uncertain trade effects. De Grauwe (1988) showed that the instability-trade relationship depends on the degree of risk aversion of firms in the trading sector. He concluded that instability reduces the volume of export if the competitive producer is slightly risk averse while increasing export for an extremely risk averse producer. Using the asset-market approach Dellas and Zilberfarb (1993) provide additional evidence to the ambiguous trade effect of instability. Willet (1986) analysed the risk of instability in the exchange rate to specific industries and found that instability can have negative, positive or no effect on trade.

Given the importance of the topic, it was not long before the above theoretical studies were put into empirical test. A huge number of empirical studies analysed the instability-trade relationship

[1] Exchange rate "variability", "Instability", and "volatility" are alternatively used in this paper.

using different econometric models. While the empirical studies that investigated short-term trade effects of instability provide diversified evidence, the long-run studies, on balance, suggested adverse trade effects of instability (a conclusion suggested by two conventional narrative literature reviews published more or less simultaneously: McKenzie, 1999; and Pugh et al., 1999). In summary, neither the purely theoretical studies nor the empirical literature provide uniform evidence on the trade effects of exchange rate variability.

The purpose of this paper is, therefore, to use meta-analysis to summarise and explain the heterogeneity of the results, and to estimate the trade effect of exchange rate variability more accurately. "Meta-analysis is a set of quantitative techniques for evaluating and combining empirical results from different studies" (Rose & Stanley, 2005, P. 350). Meta-analysis can improve the estimation of the parameter of interest by filtering out any publication bias, and by explaining heterogeneity in the results of previous studies through meta-regression analysis (Coric & Pugh, 2008; Rose & Stanley, 2005). In particular, this study conducts two meta-regression tests: funnel-asymmetry test (FAT) to detect publication selection and precision effect test (PET) to identify the existence of genuine effects beyond publication bias.

The rest of the paper is organized as follows. The following section explains how the data was collected. Section 3 explains the choice of the dependent variable (effect size) and the meta regression analysis (MRA) of the trade effects of exchange rate instability. Section 4 presents and interprets the econometric results, and the last section concludes.

2. Data

Meta-analysis is normally employed to a complete population of studies or to a random sample from the population of studies about a certain variable of interest (Doucouliagos & Laroche, 2009). We used extensive searches on Google Scholar and on databases such as EconLit and Web of Sciences to identify as far as possible a complete population of published econometric studies that investigate the trade effects of exchange rate instability. Keywords used in the search were "exchange rate instability", "exchange rate variability", "exchange rate volatility", "exchange rate uncertainty" and "trade effect". Additional studies cross-referenced in other studies were also manually identified. These searches resulted in 89 econometrics studies of the trade effect of exchange rate instability that have been published in refereed economics journals. The studies combined offer 1255 estimates of the variable of interest, which form the observations in the present MRA.

As is the norm in MRA, all non-econometrics studies were excluded (Doucouliagos & Laroche, 2009; Stanley, 2001, 2005). Only studies that have some measure of international trade as a dependent variable and that reported a statistic from which partial correlation coefficient could be calculated are included in the present meta-analysis. Even though our primary interest is the effect of exchange rate variability on trade, the studies in this MRA sample use different definitions of the variable of interest, units of measurement, and functional forms. Accordingly, following (Doucouliagos & Laroche, 2009; Doucouliagos & Stanley, 2009; Ludvigsen, 2008; Stanley, 2008) we used the partial correlation coefficient (henceforth PCC) between the dependent variable and the variable of interest as a standardized measure of the effect size. The PCC measures the degree of relationship between the dependent variable and the variable of interest, controlling for the effects of all other variables (Greene, 2008).

3. Meta- regression modelling

3.1. Meta-analysis of the effect size

For reasons explained later, the PCC divided by the inverse of the standard error of the PCC (1/*SEpcc*) makes the dependent variable for the present MRA. This variable is the t-statistics from each regression result and is termed as the exchange rate variability effect size (*ERVES*) throughout this paper. The null hypothesis that the mean value of *ERVES* for the whole sample is zero is rejected at any conventional statistical significance level (t = -9.8, p = 0.00). This result indicates that exchange rate variability has an adverse effect on international trade. However, the observed *ERVES* obtained from the sample ranges from -29.29 to 22.24, implying a considerable disparity around the mean. The null hypothesis that SD equals unity (H_0: SD = 1) against the alternative that SD exceeds 1 (H_1: SD > 1) tests if this variation around the mean is systematic. In our sample the null was rejected (χ^2 = 4292, p = 0.00), indicating a systematic variation around the mean. The following section applies MRA to conduct a further investigation of the reasons for such heterogeneity in the estimated effect size.

3.2. The moderator variables

To explain the heterogeneity of the results various variables - moderator variables - were selected and included in the MRA. These moderator variables reflect the main data and model specifications used for each regression result. The following table lists and defines the potential moderator variables identified for the purpose of this MRA.

Table 1. Moderator Variables to account for the variation among observed *ERVES*

Variable	***Brief definition***	***Mean(SD)***
ERVES	Exchange rate variability effect size, the dependent variable	-0.95 (3.43)
1/SEpcc	Inverse of the SD of PCC	22.85 (50.26)
BILATERAL	= 1, if bilateral exchange rate is used with effective exchange rate as a benchmark	0.63 (0.48)
SECTALT	=1, if sectoral trade flows is used with aggregate trade flows as a benchmark	0.23 (0.42)
IMPORT	=1, if effect is on import demand with export supply as a benchmark	0.13(0.33)
REALER	=1, if real exchange rate is used with nominal exchange rate as a benchmark	0.61 (0.49)
DAILYER	=1, if daily frequency of exchange rate variability (ERV) is used with	0.03 (0.16)

	quarterly frequency as a benchmark	
WEEKLYER	=1, if weekly frequency of ERV is used with quarterly frequency as a benchmark	0.05 (0.22)
MONTHER	=1, if monthly frequency of ERV is used with quarterly frequency as a benchmark	0.45 (0.50)
ANNUALER	=1, if annual frequency of ERV is used with quarterly frequency as a benchmark	0.10 (0.30)
MERV1	=1, if absolute values of ER percentage changes is the measure of ERV with SD of ER as a benchmark	0.06 (0.24)
MERV2	=1, if average absolute values of ER percentage changes is the measure of ERV with SD of ER as a benchmark	0.01 (0.09)
MERV3	=1, if absolute or squared differences between previous forward and current spot rates is the measure of ERV with SD of ER as a benchmark	0.02 (0.14)
MERV4	=1, if the moving SD of ER changes or percentage changes is the measure of ERV with SD of ER as a benchmark	0.25 (0.44)
MERV5	=1, if the SD of ERs from an ER trend equation is the measure of ERV with SD of ER as a benchmark	0.02 (0.16)
MERV6	=1, if the SD of ERs from a n-order autoregressive equation is the measure of ERV with SD of ER as a benchmark	0.03 (0.16)
MERV7	=1, if long-run uncertainty is the measure of ERV with SD of ER as a benchmark	0.02 (0.16)
MERV8	=1, if squared residual from an ARIMA model is the measure of ERV with SD of ER as a benchmark	0.01 (0.09)
MERV9	=1, if conditional variance calculated by an ARCH or GARCH model is the measure of ERV with SD of ER as a benchmark	0.33 (0.47)
MERV10	=1, if variance calculated by a linear moment model is the measure of ERV with SD of ER as a benchmark	0.01 (0.11)
MERV11	=1, if the variance of the ER around its trend prediction is the measure of ERV with SD of ER as a benchmark	0.01(0.12)
MERV12	=1, if unanticipated changes in ERs is the measure of ERV with SD of ER as a benchmark	0.01 (0.08)
MERV13	=1, if information contained in forward exchange rate concerning exchange rate expectations is the measure of ERV with SD of ER as a benchmark	0.01 (0.08)
THIRDCOUN	=1, if the model includes a third country effect	0.06 (0.23)
FIXPER	=1, if the study includes data from fixed exchange rate periods only with studies using both periods as a base	0.03 (0.17)
FLOPER	=1, if the study includes data from floating exchange rate periods only with studies using both periods as a base	0.76 (0.43)
LDC	=1, if the study used data from developing countries only with studies pooling both countries as a benchmark	0.17 (0.38)
DC	=1, if the study used data from developed countries only with studies pooling both countries as a benchmark	0.67 (0.47)
US	=1, if the study exclusively focuses on the US	0.25 (0.43)
GRAVITY	=1, if the studies applies gravity framework with studies applying conventional utility maximization models as the benchmark	0.10 (0.30)
LAGTEST	=1, if the studies applies lagged independent variables analysis with studies applying conventional utility maximization models as the	0.51 (0.50)

	benchmark	
ERRORCOR	=1, if the studies applies error correction model with studies applying conventional utility maximization models as the benchmark	0.09 (0.28)
LRCOIN	=1, if the studies applies co-integration analysis with studies applying conventional utility maximization models as the benchmark	0.07 (0.25)
CROSS	=1, if estimation is based on cross-sectional data with time series as a benchmark	0.07 (0.26)
POOLED	=1, if estimation is based on panel data with time series as a benchmark	0.18 (0.38)
SESONADJ	=1, if the study adjusts seasonality of the trade data	0.36 (0.48)
ROSE	=1, if the result is from regressions from Rose's study	0.03 (0.18)
DOCKSTR	=1, if the study controls for structural breaks	0.10 (0.29)
DF	The degree of freedom for each regression result	3033 (18195)
T	The mean year of the estimation period	83.37(8.23)

Note: All variables are included as independent variables in the general-to- specific multivariate modelling approach.

3.3. The meta- regression of publication bias and authentic empirical effect

3.3.1 MRA tests for publication bias and genuine effects

Following (Stanley, 2005, 2008; Sutton et al., 2000), modelling of publication selection involves a simple MRA that regresses a standardized effect size on its standard error.

$$PCC_i = \beta_0 + \beta_1 SEpcc_i + u_i \qquad (1)$$

where $i = 1,\ldots, n$ indexes the regressions in the MRA data base; u_i is the regression error term; and β_0 and β_1 are coefficients to be estimated.

With no publication bias, the estimated PCC will randomly vary around the 'true' effect β_0, which measures the average of the partial correlation coefficient. In this case the precision of the estimated effect, measured by the standard error of the PCC (*SEpcc*) does not affect the estimated effect size, in which case β_1 will not be significantly different from zero. In the case of large sample studies with high precision the standard error approaches zero as the number of observations in a study increases indefinitely. In the presence of publication selection, however, authors of studies with smaller sample sizes are on average inclined to choose large and significant effects to compensate for their less precise estimates. Hence, publication bias is proportional to the standard error (Stanley, 2005) and the test for the statistical significance of β_1 can be an indicator for selection bias.

An ordinary least squares (OLS) estimation of the model in Equation (1) may not be appropriate since the random estimation of the error term, u_i, is likely to be heteroscedastic[2]. Since the

[2] This is because different studies "…use different sample sizes and different econometric models and techniques" (Doucouliagos and Stanley, 2009, P. 410).

variances are known, the weighted least squares (WLS) transformation provides the efficient estimates. The WLS is obtained by dividing Equation (1) by the standard error of the PCC:

$$t_i = ERVES_i = \beta_0 \cdot {}^{1}\!\big/_{SEpcc_i} + \beta_1 + \varepsilon_i \qquad (2)$$

where t_i (henceforth *ERVES*) refers to the t-value of the estimated coefficient on the exchange rate variability measure from the i^{th} regression result[3], and ε_i (= $u_i/SEpcc_i$) is the standard error term. Equation (2) is a bivariate regression model with the inverse standard error of the PCC as the independent variable. The intercept and the slope coefficient are also reversed compared to Equation (1). Together, the intercept term and the slope coefficient provide the basis for FAT-PET testing procedure for both the presence of publication bias and genuine empirical effect in the research literature (Doucouliagos & Stanley, 2009; Ludvigsen, 2008; Stanley, 2005, 2008). Although by no means the only approach to meta-regression analysis, this "FAT-PET" approach is becoming more common in recently published studies. The t-statistic for the null hypothesis that $\beta_1 = 0$ is a test for publication bias and if it is statistically significant, the magnitude of β_1 (the intercept in Equation 2) measures the degree of the bias (Egger et. al, 1997; Stanley, 2008). A statistically significant intercept term indicates that the effect size is subject to publication bias. According to Stanley (2008), the estimate of β_0 in Equation (2) provides the underlying genuine empirical effect of the effect size in terms of the PCC. Since it tests the precision of the model corrected for publication bias, this test (H_0:$\beta_0 = 0$) is called PET (Stanley, 2005).

Besides the inverse standard error of the PCC, dummy variables concerning authors' context of investigation and empirical methods can be added to explain the variation in empirical effects discovered in the literature. This is because each moderator variable in Equation 2 is interacted with the measure of precision, the inverse of *SEpcc*; without this interaction, the moderator variable moderate the intercept term and thus capture influences on publication bias. Such moderator variables, interacted with the inverse standard error, can be included in Equation (2) above to yield a multivariate WLS- MRA model. Equation (2) would thus become:

$$ERVES_i = \beta_1 + \beta_0 \cdot {}^{1}\!\big/_{SEpcc_i} + \sum_{1}^{K} \alpha_k \cdot {}^{1}\!\big/_{SEpcc_i} \cdot Z_{ki} + \varepsilon_i \qquad (3)$$

where Z_{ki} are k moderator variables that reflect the main data and modelling characteristics of the i^{th} regression, α_k are coefficients to be estimated and that measure the effect of the corresponding moderator variable on the underlying effect of exchange rate variability on trade, and ε_i is the disturbance term.

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3 $${}^{1}\!\big/_{SEpcc_i} = \frac{1}{PCC_i / t_i} = \frac{t_i}{PCC_i} \Rightarrow t_i = \frac{PCC_i}{SEpcc_i}$$ (Ludvigsen, 2008, P.7)

4. FAT-PET meta-regression results

As it is the standard in any conventional econometric analysis, meta-regression model should be tested for statistical model (mis)specification. Compared to other economic models, however, MRA is more likely to pass specification tests and to satisfy classical regression assumptions (Stanley, 2001; Stanley and Jarrell, 1989). Since the effect size (the dependent variable) is obtained from heterogeneous studies with different methodologies and characteristics, it is likely that the model exhibits a heterosckedastic error term. Accordingly, we reported only WLS estimators. However, the WLS estimators of models (2) and (3) above might be inefficient since the estimates are not sampled independently (several studies reported multiple results). Thus the coefficients were also estimated with cluster-robust standard errors where each cluster identifies the estimates from the same study (Cipollina & Salvatici, 2010; Coric & Pugh, 2008). Econometric results from the bivariate MRA models (2) and (4) are summarized in Table 2 below.

Table 2. Bivariate MRA tests for genuine effect and publication bias, *Dep. variable: ERVES*

Moderator variable	***White's OLS SEs***	***Cluster-robust SEs***
Intercept	-0.53 (-5.52)	-0.53 (-1.51)
1/SEpcc	-0.02 (-5.52)	-0.02 (-1.71)
Logdf	-	-
R-Squared	0.07	0.07
F-test	F(1,1253 = 30.51 Prob > F = 0.000	F(1,88)= 2.93 Prob > F = 0.0907
Ramsey RESET test	F(3,1250) = 46.39 Prob > F = 0.000	F(3,1250) = 46.39 Prob > F = 0.000

Besides the precision-effect test, the results provide tests for publication selection. The alternative hypotheses for these test (H_1:$\beta_0 \neq 0$) cannot be rejected at conventional level of significance suggesting the presence publication bias in the empirical literature. The statistically significant slope coefficient ($p = 0.00$), however, suggests that there is a genuine negative trade effect beyond this publication bias.

However, the results from these bivariate regressions should not be trusted for they might suffer from omission of relevant variable bias. To this end, the Ramsey RESET test shows that the null of no omitted variable bias is rejected at conventional levels of significance ($p = 0.00$). Since the Ramsey RESET test is usually interpreted as test for functional form, the result shows a clear evidence of nonlinearity of the bivariate model. Strictly speaking, this invalidates statistical inference using the t-statistics and F-statistics tests (Wooldridge, 2008; Gujarati, 2004). The small R-squared value also indicates that the inverse standard error is not sufficient to explain the heterogeneity in the empirical literature. Accordingly, we use a multivariate MRA model in order to minimize the bias from omitted variables and to explain the wide variation in the effect size. This is done by including the meta-independent variables listed in Table 1 above. All these moderator variables are weighted by the inverse of *SEpcc* in the multivariate MRA model. These moderators are dummy variables which control the influence of key characteristics of the studies such as the use of different datasets and choice of modelling techniques. The resulting WLS-MRA model offers tests for both publication selection and the existence of authentic empirical trade effect of exchange rate variability in the literature. The authentic empirical effect, if any, is estimated after controlling for sources of heterogeneity in the literature and after publication bias is 'filtered out'.

The multivariate precision-effect MRA model reported in the table below explains about 39% of the variation in the reported exchange rate variability effects (Table 3). The included moderator variables are jointly statistically significant (p = 0.00). The RESET test suggests that correct functional form (and/or no omitted variable) is a reasonable assumption (p = 0.67).

Table 3. Funnel asymmetry and precision effect tests using the more up-to-date MRA model, Dep. Variable *ERVES**

Moderator variable	***OLS SEs***	***Cluster-robust Linear Regression***
Intercept	-0.84 (-4.09)	-0.84 (-2.92)
1/SEpcc	0.08 (3.18)	0.08 (2.55)
FIXPER	0. 02 (0.97)	0.02 (0.61)
LDC	-0.03 (-1.80)	-0.03 (-1.61)
US	0.06 (1.75)	0.06 (1.35)
IMPORT	0.07 (2.29)	0.07 (1.52)
DAILYER	-0.07 (-1.09)	-0.07 (-0.71)
WEEKLYER	-0.12 (-3.43)	-0.12 (-2.28)
ANNUALER	-0.13 (-4.81)	-0.13 (-4.22)
REALER	-0.06 (-3.92)	-0.06 (-3.16)
CROSS	-0.03 (-1.62)	-0.03 (-1.34)
GRAVITY	-0.09 (-3.71)	-0.09 (-2.99)
ERRORCOR	-0.13 (-4.11)	-0.13 (-3.24)
LRCOIN	-0.13 (-2.07)	-0.13 (-2.17)
SECATLT	-0.02 (-1.42)	-0.02 (-1.06)
THIRDCOUN	-0.08 (-4.06)	-0.08 (-3.37)
SESONADJ	-0.02 (-0.64)	-0.02 (-0.49)
DOCKSTR	-0.07 (-1.10)	-0.07 (-2.35)
MERV1	0.09 (3.39)	0.09 (2.52)
MERV2	-0.04 (-1.42)	-0.04 (-1.82)
MERV3	-0.15 (-8.64)	-0.15 (-8.96)
MERV4	0.01 (3.71)	0.01 (4.04)
MERV5	-0.03 (-0.99)	-0.03 (-0.59)
MERV6	-0.04 (-1.93)	-0.04 (-1.65)
MERV7	-0.15 (-7.34)	-0.15 (-9.14)
MERV8	0.24 (1.78)	0.24 (1.21)
MERV9	0.10 (5.95)	0.10 (4.84)
MERV13	-0.03 (-9.39)	-0.03 (-7.88)
ROSE	-0.04 (-9.10)	-0.04 (-17.64)
	Diagnostic tests	

N	1255
R-squared	0.39
F Test:	
H_0: independent variables are jointly equal 0	F (28, 1226) = 154 Prob > F = 0.000
Ramsey RESET Test: *H_0: No omitted variable bias*	F(3, 1223) = 0.52 Prob > F = 0.67

**The estimated model is given by* Equation *(3) above*

The results are based on WLS estimators, i.e., the explanatory variables are weighted by 1/SEpcc.

The funnel asymmetry test does not reject the presence of publication selection. The results reveal a negative statistically significant intercept term, suggesting a publication selection process in favour of adverse trade effect of exchange rate variability. This interpretation is consistent with the bivariate MRA model results (Table 2). The implication is that journal editors, referees, and authors are inclined to favour a statistically negative effect of exchange rate volatility on trade.

Since the inverse of *SEpcc* is interacted with the moderator variables in the multivariate model, it is the combination of all the explanatory variables and the respective reference categories that indicate the existence and capture the size of the 'authentic empirical effect' (Doucouliagos and Stanley, 2009). The F-test suggests that all the meta-independent variables are jointly statistically significant ($p = 0.00$), implying the existence of genuine empirical effect beyond publication bias. However, unlike in the bivariate model, the effect size in the multivariate model is not simply the coefficient estimate on the inverse of *SEpcc*. For instance, in Table 3 above while the estimated coefficient of 1/*SEpcc* is 0.08 (extended dataset), the coefficient for those regressions with long-run co-integration as independent variable is -0.13. Thus, holding all other factors constant, the genuine empirical trade effect of exchange rate variability is lower by 0.13 for studies that employ co-integration analysis than those which employ the conventional utility maximization model. Even though what truly matters is our finding about the existence of publication selection and genuine exchange rate volatility effect on international trade after controlling other factors, it is also crucial to identify the factors for the variation in the estimated empirical effect. The moderator variables explain causes and consequences of the variation in the empirical literature.

With studies of 'nominal' exchange rate variability as the reference category, those studies that use a real exchange rate series are more likely to report a negative relationship between exchange rate variability and trade. Since it is only over long periods that real variability diverges from its nominal value, the statistically significant negative coefficient for the *REALER* dummy corroborates the view that forward markets have a role in reducing the trade effects of exchange rate uncertainty. This interpretation is supported by the statistically significant negative coefficient on the dummy variable for studies of the trade effects of annual variability of the exchange rate (*ANNUALER*). Again, the explanation may be that, compared to higher frequency exchange rate variability, year-to-year variability is less subject to hedging (quarter-to-quarter variation is the benchmark). The dummy for studies focusing solely on trade among less developed countries (*LDC*) is statistically significant at the 10% level of significance. The consistently negative coefficient estimate for trade among these countries is further evidence that hints at the importance of forward markets in reducing exchange rate uncertainty. Less advanced or nonexistent forward markets together with imperfect capital mobility in LDCs decrease the possibility of hedging in these countries (Coric and Pugh, 2008, P. 10).

The coefficients measuring the effect of gravity (*GRAVITY*), error-correction (*ERRORCOR*) and co-integration (*LRCOINT*) modelling strategies are consistently negative and statistically significant. This implies that studies which apply these modelling strategies are more likely to find statistically significant negative effects of exchange rate variability on trade than the conventional utility maximization modelling approach. Thus, the choice of modelling strategies explains some of the heterogeneity in this empirical literature. However, there is no noticeable difference between studies that use sectoral trade flows and those that use aggregate trade flows. There is also little distinction to be made between the implications of the studies that use cross-section and time series data as compared to those using longitudinal datasets. Moreover, the statistically significant negative results for dummy variables used to model third-country effect (*THIRDCOUN*) and structural breaks (*DOCKSTR*) show that studies that model third-country effects and that control for shocks in time series data are more likely to find a negative and less likely to find a positive trade effect of exchange rate variability than those studies that do not control for these effects.

Finally, among the 13 moderator variables used to distinguish the measures to proxy exchange rate variability, six have consistent and statistically significant coefficient estimates at the 5% level. *MERV1*, *MERV4*, and *MERV9* display positive estimated coefficients indicating that studies using these definitions are more likely to discover a statistically positive relationship between exchange rate variability and trade. On the contrary, *MERV3*, *MERV7*, and *MERV13* have negative estimated coefficients indicating that studies employing these definitions are less likely to find a statistically positive relationship between trade and exchange rate variability.

5. Conclusions

There is an extensive dispute in the literature on whether exchange rate variability has an adverse effect on international trade, on the magnitude of the effect, whether the effect is contaminated with publication bias, and on the sources of the wide variation in the reported effects. This study applied MRA to the extant empirical literature on the trade effects of exchange rate variability. MRA makes use of conventional statistical methods and criteria to summarize and evaluate heterogeneous empirical literatures. A total of 89 econometric studies published since 1978 provide 1255 estimates of our effect size, which is the partial correlation coefficient of trade and exchange rate variability.

The results are summarized in Table 3. The intercept term is statistically significant and negative (t = -2.92, $p < 0.05$) which is strong statistical evidence of publication selection in favour of significantly negative trade effects of exchange rate variability. However, the magnitude of the publication bias is very small (less than unity as can be noted from Table 3). The small mean effect size (-0.95) and the empirical results of the MRA model do not – ceteris paribus – suggest a strong overall authentic empirical effect in either direction. The MRA provides a range of research characteristics which help to explain the heterogeneity in the reported estimates. Although there is still a large variation in the estimated effect size which is not explained by the meta-regression models, our results show the role played by authors' context of investigation and their choice of empirical strategies in explaining this variation. We found that authors' choice of modelling strategies significantly influence the effect of exchange rate variability on trade. In particular, studies that employ gravity, error-correction, and long-run co-integration modelling strategies are more likely to discover an adverse trade effect of exchange rate variability. The results also show that alternative measures to proxy exchange rate uncertainty do significantly affect the trade effect of exchange rate variability compared to the conventional measure. Moreover, our results also show that the possibility of hedging in the currency market may have a significant effect in lessening the adverse trade effect of exchange rate variability. The results suggest that studies investigating lower frequency measure of exchange rate uncertainty (*ANNUALER*), those investigating trade among LDCs (*LDC*), and those investigating real exchange rate variability (*REALER*) are more likely to discover adverse trade effects. The development of forward markets in developing countries might be one way of trade promotion in these countries. The results from the cluster-robust estimation methods are mainly robust with respect to those of the baseline OLS estimation.

In a nutshell, the empirical literature of the relationship between trade and exchange rate variability is characterised by considerable heterogeneity. Although close to half of the variation is explained by the meta-independent variables included in our model, excess variation still remains. This complements the finding of weak evidence for an overall authentic empirical effect. Thus, this study provides evidence for policy makers that "… the average trade effects *of exchange rate uncertainty* suggested by this literature are not sufficiently robust to generalise across countries (Coric and Pugh, 2008, P. 11; italics added). Further research is needed to identify the different channels through which exchange rate uncertainty affects international trade.

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