Agricultural Trade Bias in Exchange Rate Volatility Effect Estimation:
An Application of Meta-Regression Analysis

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Abstract:

Econometric estimates of the effect of exchange rate volatility on international trade are mixed and often wildly divergent, resulting in an ambiguous average effect. It is hypothesized that agricultural trade in particular is more sensitive to exchange rate volatility resulting in more consistent effect estimates. Meta-regression analysis is performed on a sample of 351 econometric exchange rate effect estimates, controlling for study specific characteristics including identification of agricultural sector studies. Results indicate that agricultural trade studies report more consistently significant and negative estimates than non-agriculture or aggregate trade studies, revealing a less ambiguous effect in this sector.

JEL: C83, F10, F31

Keywords: agricultural trade, exchange rate uncertainty, meta-regression analysis

The question of whether and how increased variability in the relative currency values of international trading nations influences the volume of trade between those nations lacks professional consensus within economic literature. Since the end of the Bretton Woods era of stabilized international exchange rate relations in the early 1970s, when many economically important nations began transitioning to free-floating exchange rates determined in the international currency exchange market, the effect of exchange rate volatility (ERV) on international trade flows has been a pressing economic concern.

Even today, as emerging economies consider more market oriented exchange rate regimes in response to political pressure, e.g. China, or after major recessions due to recent currency crises, e.g. Mexico in 1994, Asia in 1997, Russia in 1998, and Argentina in 1999, the effects of increased ERV on trade volumes remains immediately relevant. Yet, economic theory on ERV effects is conflicting and numerous econometric estimations produce contrasting results: many estimate a significant negative influence, others find no significant effect, while still others show a significant positive influence.

In this study, it is hypothesized that economic sectors respond differently to ERV and that agricultural trade in particular is much more sensitive to exchange rate volatility. Meta-regression analysis is applied to a cross-section of econometric studies conducted from 1980 to 2011 that estimate the marginal effect of ERV on international trade. Study-specific variables of primary interest include the effect of sectoral trade studies relative to aggregate trade studies and the effect of agricultural trade estimation over aggregate and other sector estimates.

The remainder of the article is organizes as follows: first, conflicting ideas behind the effect of ERV on trade is briefly introduced and conclusions of qualitative reviews of the literature are discussed; second, the concept of meta-regression analysis and its basic econometric model is introduced; third, the central results of previous applications of meta-regression analysis to the economic question are discussed; fourth, the data collection variable selection process is related; fifth, characteristics of the final data set are described; sixth, the utilized meta-regression model is specified; seventh, true effect and size effect estimation results are presented; and finally, concluding remarks are made on the implication of presented results.

Exchange Rate Volatility and the Volume of Trade

Several qualitative surveys of exchange rate volatility literature provide a summary of the two opposing theoretical views about the expected direction of influence ERV will have on international trade in general and collectively provide extensive reviews of available empirical literature attempting to econometrically estimate ERV effect on trade (Cote 1994; McKenzie 1999; Ozturk 2006; Bahmani-Oskooee and Hegerty 2007).

The first and most popular thought is that increases in variability of currency exchange rates between trading nations will lower trade volumes. This argument is based on the belief that volatility is associated with risk and uncertain foreign prices. Exporting firms plan production according to an expected selling price, valued in foreign currency. If the actual selling price is liable to fall below this expected price after production and before final sale, it is possible a firm could lose revenue by choosing to trade. To avoid this risky outcome, producers will prefer to direct sales toward domestic markets where prices are more certain, thus reducing the level of international trade.

The opposing view is that volatility will promote increased trade. Starting from the premise that there is an uncertain future foreign price due to high exchange rate volatility, this conflicting perspective considers the increased probability that the actual sale price will be above the initial price observed during production planning. A higher price with no change in production costs will bring higher profits to exporting firms. Since the value of the option to trade is higher, producers willingly increase volumes directed toward international market. Considering these contrary views, the actual choice to trade or not is believed to also be influenced by producers' level of risk aversion and available opportunities for hedging.

These reviews all agree that econometric analysis is necessary in order to test these alternate hypotheses but that the overall mixed results across individual ERV effect estimates makes the empirical results no less ambiguous and prevents consensus on the subject. All also find that while most studies tend to find a significant negative trade effect, many still find no significant effect, and several continue to find a significant positive effect.

Variation between study estimates is thought to be influenced by a combination of study characteristics that could be separated into data effects (sample period covered, countries involved, level of aggregation, industry sector, export/import or total trade, trade data frequency, and level of market in trade), specification effects (choice of volatility measurement, short or long-run volatility effects, use of nominal or real exchange rates, choice of model specification, use of error correction model), and publication effects (year of analysis).

Because of the expansive and expanding empirical literature available, the yet unresolved ambiguity of empirical results, and the many study-specific factors thought to contribute to variation in estimates, the economic problem of the unknown size and directional effect of exchange rate volatility on the volume of international trade lends itself to the use of Meta-Regression Analysis (MRA).

Meta-Regression Analysis as Literature Survey

MRA is a systematic method of objectively surveying extant primary empirical literature on a particular economic phenomenon by quantitatively estimating the biasing effect of study-specific characteristics on diverse reported estimates in a way that is replicable "in a manner not possible with traditional literature reviews" (Stanley and Jarrell 1989). The strength of MRA over other survey methods is in its ability to actually measure the influence of disparate specifications and approaches on a single variable of interest, thus continuing the statistical rigor applied to primary studies into the synthesis of those studies (Glass 1976). MRA has increased in popularity in applied economic research in recent years, thanks in part to supportive researchers promoting its benefits and demonstrating its usefulness in areas in which the empirical literature shows a lack of consensus among study estimates (Stanley 2001, 2005; Stanley, Doucouliagos and Jarrel 2008; Doucouliagos and Paldam 2008; Doucouliagos and Ulubasoglu 2008).

The basic econometric specification for MRA is similar to a primary study regression in that a single dependent variable is regressed on a vector of independent explanatory variables as well as a stochastic error term: $Y = \boldsymbol{X\beta} + \varepsilon$. The difference is that in the MRA specification the regressand, b_j, is the estimated coefficient of initial interest from the L individual study results and the regressors, Z_{jk}, are K separate moderator variables describing differences between the L studies such that:

$$\widehat{\beta_j} = \beta + \sum_{k=1}^{K} \alpha_k Z_{jk} + \mu_j \qquad (j = 1,2, \dots L)$$

The constant term, β, is the newly estimated true value of the coefficient of interest from primary studies, the meta-coefficient, α_k, measures the bias associated with the study-specific moderator variables, and e_j is the stochastic error term (Stanley and Jarrell 1989).

MRA of ERV

Rose and Stanley (2005) applied MRA to literature on the effect of a common currency union on international trade. A common currency union is a form of exchange rate regime policy quite opposite to a free-floating, differing currency regime. With a common currency, prices are known between trading partners and there is no variation in price between countries (due to differing currency values), an inverse outcome to the increased risk associated with ERV in a currency exchange market. Using 754 point estimates from 34 individual primary studies Rose and Stanley find a significant positive effect of currency unions on trade that overcomes any publication bias present. This implies a negative effect on trade is expected if currencies were not common between countries.

Coric and Pugh (2010) applied MRA directly to the ERV and trade literature[1]. Using 835 estimates from 58 studies, whose variable distribution of effect direction resembles that of the known literature surveys, and applying multiple significance tests to results Coric and Pugh suggest that the estimated average small negative trade effect across all studies "reflects a genuine negative relationship between exchange rate

[1] This analysis has recently been expanded in Haile and Pugh (2011).

variability and international trade rather than publication bias."

Two aspects of this study limit the usefulness of its results in resolving the ambiguous ERV effect question. First, the dependent variable is the "size effect" of primary study estimates as measured by the reported t-values. This regression is important in estimating what study variables contribute to the significance, thus accuracy, of individual estimates, but it lacks the "true value" effect found in the basic MRA model that leads to inference of directional influence of moderator variables on the primary study estimates. Second, no attention was paid to the influence of agriculture on the estimated coefficient. Literature suggests that agricultural trade studies tend to have a larger negative and significant response to ERV (McKenzie 1999; Cote 1994). It is hypothesized that accounting for the effect of agriculture in MRA and estimating the "true effect" specification with primary study estimate values as the dependent variable will tell a more accurate story of the effect ERV has on international trade volumes.

Data Collection and Variable Selection

Individual studies to be used in MRA were initially identified by investigating qualitative surveys' references[2]. Two of these surveys were identified through conversations with colleagues. Two more were located using internet searches. Literature archives contained in online databases such as OvidSP and EBSCOhost were searched for specific studies identified from reference lists as well for additional studies not included in the literature surveys. Google Scholar and AgEconSearch were used to collect papers, reports, and presentations not found in the above databases. Altogether 143 theoretical and empirical studies directly related to exchange rate volatility and international trade were identified.

[2] University Library services were employed exhaustively to access publically unavailable documents.

A cross-section of these studies was selected for investigation for relevant estimates and presence of moderator variable observations. The final sample set is a non-exhaustive collection of 41 studies containing 399 observation estimates representing mostly published articles from 1980 to 2011. A list of final studies and statistics on study estimates is included in Appendix A.

Following suggestions from qualitative reviews and the previous MRA of ERV, the moderator variables of interest include those listed above as various data effects, specification effects, and publication-effects. Actual variables chosen and summary statistics are provided in table 1 and additional, clarifying descriptions are provided in Appendix B. It is expected that the binary independent variable for agriculture will be negative and significant in explaining the estimated ERV true effects, and positive and significant in explaining the calculated size, or significance, effect. This would reveal that agricultural trade volumes respond negatively to increased ERV, possibly being overlooked in estimates of aggregate trade volumes, and that agricultural trade estimates are consistently closer to a true trade response effect. Other regressors are included as control variables and carry no expectations.

Data Description and Publication Bias Test

Of the 399 recorded observations, 48 were dropped because they were extreme outliers. Table 1 provides the statistical means of the remaining observations. It is seen that around 79% estimate the effect of ERV on exports, 45% focus on bilateral trade effects, about half are based on the volatility of the real exchange rate, yearly trade observation studies make up 45%, agricultural trade estimates account for 40%, and developed countries are represented in 78% of estimates. The most frequent method used to measure exchange rate volatility is VM3 (see Appendix B), time-series data is used far more than panel or cross-section, log-log specification and error correction models are used in over 40% of estimates, and 75% of estimates were from the period after 1973 only. Publication time is categorized to explain possible trends in estimation techniques over time due to popularity or improved specification.

The estimated effect size of the ERV on trade, $\hat{\beta}$, is widely dispersed with equally weighted sample mean of 8.56, ranging from -617 to 836.2. Figure 1 includes funnel graphs for the un-standardized effect size and standard error. After removing extreme outliers (left panel), the funnel graph (right panel) is symmetric with respect to zero which implies the absence of publication bias and supports existence of an unbiased discrepancy of estimates. It is also interesting to note that of the unpublished studies identified from early time periods, most were found to be published at a later date thus few unpublished results are included (15 estimates) and all in the most recent period. This is further indirect evidence that little publication bias exists.

Meta-Regression Model Specification

Due to observed heterogeneity of ERV effect observations, the equally weighted sample will lead to inefficient estimates and the standard deviation of the effect size should be taken into account. There are two common methods of combining study estimates: fixed- or random-effects size estimators. The fixed effect method assumes a constant effect size across studies and assigns each estimate a weight of the inversed variance. The random effect method assumes the sample is randomly selected from a larger population with effect sizes randomly distributed about the population mean. The weights in this case are the inverse of the sum of the between- and within-study variances (Abreu, De Groot and Florax 2005).

The pooled random-effect estimates are 0.71 and the fixed-effect estimates are smaller than 0.001. Both estimates are significantly different from zero with a p-value <0.001. The assumptions of the fixed effect size estimation are unrealistic due to the observed heterogeneity among the studies, thus the random-effect size estimate is more appropriate. To further test which estimates are more appropriate, the Q test is utilized:

$$Q = \sum_{j=1}^{L} w_j b_j^2 - \frac{(\sum_{j=1}^{L} w_j b_j)^2}{\sum_{j=1}^{L} w_j} \sim \chi_{L-1}^2$$

Where L is number of study results and w_j is the inversed estimated variance. The null hypothesis assumes the effect size is same for all studies (Cochran 1954). The Q statistic on both pooled sample and restricted sample are highly significantly different from zero at the p-value <0.001, which further state that the random effect-size estimates are more appropriate for this research.

There are several methods to control for the heterogeneity in MRA studies. One is to use Huber-White standard errors to control for heteroskedasticity and autocorrelation (Wooldrige 2002). However, Huber-White robust standard errors are estimated in the meta-regression process rather than using the variance recovered from the original studies. Thus, this method does not fully use the available information from the original studies. Borenstein, Hedges, and Rothstein (2007), propose using the multivariate version of the fixed- and random-effect size model:

$$Y = \widehat{\beta_i} X + \varepsilon_i, \varepsilon_i \sim N(0, \sigma^2)$$

$$\widehat{\beta_J} = \alpha_0 + Z_j'\alpha_j + \mu_j, \mu_j \sim N(0, \tau^2)$$

Where α_0 is the common factor and Z_j' includes a set of variables which describe the difference among the studies. The within-study variance, σ_2, is usually obtained from the original studies. In this model form, the true effect size is allowed to vary across studies and the difference is explained by a vector of explanatory variables. The remaining difference is assumed to be normally distributed with mean zero and variance τ^2. If τ^2=0, it is a fixed effects model, otherwise a random effects model. With a non-zero between-study variance (τ^2), the weights to control for heterogeneity become

$$\widehat{w_J} = \frac{1}{\widehat{\sigma_J^2} + \hat{\tau}^2}.$$

We use the method of moments estimator to estimate τ^2 (Thompson and Sharp 1999). Table 2 and Table 3 present the results based on the random effects model. Table 2 presents MRA estimation results with effect size, $\hat{\beta}$, as the dependent variable and Table 3 presents MRA estimation results with the absolute value of effect size, $|\hat{\beta}|$, as the dependent variable.

Results Discussion

After the above weighted estimation procedure, Table 2 estimation coefficients can be interpreted directly as the estimated marginal effect size of one unit changes from the mean value of the dependent variable. The mean value constant term in MRA is said to be the 'true' value of the primary study estimates yet we cautiously interpret coefficients as unit-less measures, focusing on statistical significance, direction of effect, and relative size of effect. Thus the constant term for regression (1) in Table 2 is thought of as a statistically significant confirmation that exchange rate volatility has an actual lowering effect on trade volumes overall. But, the presence of extreme outliers and a large number of very significant moderator variables in regression (1) signal the strong presence of publication bias so this estimate is not trusted.

Instead, the without outliers regression (2) is preferred. Statistical significance is selective and meaningful. The constant term is negative but not significant. This reflects the expectations of previous qualitative reviews that the overall average effect may be negative but highly conditional on data and specification variables. Those variables most influential are whether or not the study was of bilateral trade volumes and if it involved agricultural sector trade. Bilateral studies will significantly increase the ERV effect estimates, while agricultural studies will significantly decrease the ERV effect estimates. Other significant variables include long-run effect over short run effect studies and world trade between developed and developing countries over trade between only developed countries. Insignificant variables can be interpreted has having no noticeable effect on differences in study estimates.

After the above weighted estimation procedure, Table 3 regressions become identical in practice to size effect meta-regressions using absolute t-values as the dependent variable. Moderator variables can be interpreted as having either a positive or negative effect on the significance, thus the accuracy, of the primary study estimates. Looking at regression (2) in Table 3, the constant term is insignificant–meaning the average ERV effect is insignificant, but variables that significantly increase the accuracy of study estimates include bilateral trade, use of real over nominal exchange rate measures, studies on agriculture, and long-run effect estimates.

With tests of significance in Table 3 and true effect influencing estimates in Table 2, it is possible to discover the influence of agricultural trade on the estimated effect exchange rate volatility has on international trade. Just from regression (2) in both Tables it can be said that studies estimating the ERV effect on agricultural trade report significantly accurate, negative results. Sector trade studies may produce more statistically significant estimates than aggregate studies, but they have no effect on the total study mean value. These results infer that agricultural trade is more responsive to changes in ERV than other sectors and aggregated trade, and that agricultural trade is consistently negatively influenced by increased ERV.

Regression (4) and regression (6) in both Table 2 and Table 3 separate studies into agriculture only or non-agriculture only–this includes other sector studies and aggregated studies–to estimate the true value of the ERV effect on agriculture. The true effect (Table 2) constant for regression (4) is significant and relatively large and negative, yet the constant for regression (6) is insignificant and positive. Considering how the total study regression (2) is the combination of studies in (4) and (6), the difference in regression constants show that the large negative ERV effect on agricultural trade is cancelled out in the total study sample. The coefficient on agriculture in regression (2) reveals this effect.

Concluding Remarks

This study applied meta-regression analysis (MRA) to a sample of empirical economic literature estimating the effect of exchange rate volatility (ERV) on international trade flows. A variable identifying agricultural studies was included to see what biasing effect agricultural ERV effect estimates have on the average effect over all studies. It is found that, while the total average ERV effect is negative and insignificant—a conclusion harmonious with qualitative reviews—estimates for agricultural trade were significantly more accurate and more negative than the average.

These results show that agricultural trade is likely to see a significant reduction in volume if exchange rates between trading nations becomes more variable. The ambiguous results across all studies hides this fact such that the inconclusive total trade effect estimates should not negate the real and negative effect increased ERV will have on the agricultural sector specifically. Countries with heavy reliance on agricultural trade (imports or exports) should be aware of this effect when weighing the potential gains and losses resulting from increased exchange rate volatility between trading partners.

This analysis is presently under revision to expand the selected sample to the full population of econometric estimates and test alternative estimation procedures. With the revision by Haile and Pugh (2011) of the previous MRA of ERV by Coric and Pugh (2010), any emphasis on data expansion will be less than the primary emphasis on identifying sector specific bias. Yet, comparing the total available ERV studies so far identified to that included in the above studies, it is clear that numerous agricultural estimates have been unnecessarily omitted. It is hypothesized that analyzing an exhaustive collection of estimates, including studies of all sectors of international trade, will impact the "true effect size" estimate significantly. Independent MRA on the agricultural sector as well as other sectors when possible will follow immediately.

Finally, it is important to remember that meta-regression analysis is susceptible to the same potential estimation problems as primary regression analysis. Issues like sample selection bias, omitted variable bias, variable measurement errors, collinearity of independent variables, model misspecification, and violation of homoskedasticity assumptions can cause inconsistency, bias, and inefficiency in meta-coefficient estimates. Attempts were made to mitigate these problems and additional post-estimation could be made to test for the presence of these problems, so opportunities for improvement exist. All these things considered, this analysis contributes significantly to economic literature of the effect of exchange rate volatility on international trade by identifying the presence of a clear negative bias among agricultural trade studies in the midst of otherwise ambiguous results.

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Table 1. Summary Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
β	351	8.56	94.16	-617	836.2
|β|	351	22.69	91.78	0	836.2
t ratio	350	5.08	80.34	-113.8	1,386.4
|t ratio|	350	8.83	80.01	0.01	1,386.4
S.E.	351	15.81	59.02	0.001	480.2
Total Trade	351	0.07	0.26	0	1
Import	351	0.14	0.34	0	1
Export	351	0.79	0.40	0	1
Bilateral	351	0.45	0.50	0	1
Real Exchange Rate	351	0.51	0.50	0	1
Monthly	351	0.20	0.40	0	1
Quarterly	351	0.31	0.46	0	1
Yearly	351	0.45	0.50	0	1
Agriculture	351	0.40	0.49	0	1
Aggregate	351	0.52	0.50	0	1
Sector	351	0.37	0.48	0	1
Short Run	351	0.31	0.46	0	1
Long Run	351	0.27	0.44	0	1
Developed Country	351	0.78	0.41	0	1
Developing Country	351	0.03	0.17	0	1
World	351	0.19	0.39	0	1
VM1	351	0.06	0.23	0	1
VM2	351	0.04	0.20	0	1
VM3	351	0.42	0.49	0	1
VM4	351	0.16	0.36	0	1
VM5	351	0.16	0.37	0	1
VM6	351	0.16	0.37	0	1
Time Series	351	0.69	0.46	0	1
Cross Section	351	0.16	0.36	0	1
Panel	351	0.16	0.36	0	1
Linear Model	351	0.13	0.34	0	1
Log-Log Model	351	0.49	0.50	0	1
Gravity Model	351	0.12	0.33	0	1
Dynamic Model	351	0.04	0.19	0	1
Error Correction	351	0.43	0.50	0	1
Others	351	0.21	0.41	0	1
Before 1973	351	0.01	0.08	0	1
After 1973	351	0.75	0.43	0	1
All Time	351	0.24	0.43	0	1
Published Before 1988	351	0.18	0.39	0	1
Published Between 1988 and 1996	351	0.31	0.46	0	1
Published Between 1996 and 2001	351	0.23	0.42	0	1
Published After 2001	351	0.28	0.45	0	1

Table 2. Random Effect Size Regression on $\hat{\beta}$

VARIABLES	(1) Total With Outliers	(2) Total	(3) Agriculture With Outliers	(4) Agriculture	(5) Non-Agriculture With Outliers	(6) Non-Agriculture
Constant	-1.054***	-0.196	-11.92***	-11.90***	0.529	0.529
	(0.171)	(1.424)	(1.349)	(1.349)	(0.399)	(0.399)
Research Focus						
Bilateral	0.527***	1.238***	10,049***	4.762***	0.661**	0.662**
	(0.0378)	(0.398)	(92.52)	(0.900)	(0.283)	(0.283)
Import	-0.049***	-0.477	-0.862*	-0.862*	-0.234**	-0.234**
	(0.0138)	(0.362)	(0.488)	(0.488)	(0.0981)	(0.0981)
Total	-0.257***	-0.0531	-0.566***	-0.566***	-0.250	-0.250
	(0.0234)	(0.386)	(0.0955)	(0.0955)	(0.299)	(0.299)
Real Exchange Rate	0.454***	0.193	-3.844***	-3.826***	-0.0131	-0.0182
	(0.0386)	(0.366)	(0.898)	(0.898)	(0.587)	(0.587)
Monthly	0.259***	-0.128	-2.083**	-2.062**	-0.147	-0.147
	(0.0978)	(0.610)	(0.987)	(0.987)	(0.298)	(0.298)
Yearly	0.391***	0.242	-1.361	-1.339	-0.0154	-0.00843
	(0.0976)	(0.502)	(0.992)	(0.992)	(0.903)	(0.903)
Aggregation						
Agriculture	-0.0126	-1.268***				
	(0.0151)	(0.364)				
Sector	-1.102***	0.420	-1.167***	-1.167***	0.451	0.450
	(0.0448)	(0.371)	(0.0490)	(0.0490)	(0.361)	(0.361)
Long Run	0.130***	0.722**	-0.125***	-0.125***	0.115	0.115
	(0.000120)	(0.358)	(0.0432)	(0.0432)	(0.102)	(0.102)
Volatility Measure						
VM2	0.312**	-0.760			-1.386***	-1.386***
	(0.153)	(0.977)			(0.345)	(0.345)
VM3	-0.103*	-0.946	-4.36e-06	2.44e-08	-1.794***	-1.794***
	(0.0610)	(0.630)	(2.68e-06)	(6.04e-07)	(0.320)	(0.320)
VM4	-0.103*	-1.390	0	4.39e-06***	-1.750	-1.758
	(0.0610)	(0.866)	(0)	(1.69e-06)	(1.187)	(1.187)
VM5	0.0584	-1.378*	-8.137***	-8.096***	-1.720***	-1.720***
	(0.0618)	(0.831)	(1.883)	(1.883)	(0.285)	(0.285)
VM6	-0.103*	-1.301*	-4.38e-06		-1.797***	-1.798***
	(0.0610)	(0.739)	(2.68e-06)		(0.334)	(0.334)
Data Type						
Cross Section	1.283***	2.252**				
	(0.0648)	(0.888)				
Panel	0.360***	0.539	-20.01***	-19.94***		
	(0.0403)	(0.882)	(3.600)	(3.599)		
Research Region						
Developing	-0.0138	0.154	0.0914	0.0914	-0.0533	-0.0532
	(0.0368)	(0.465)	(0.0588)	(0.0588)	(0.156)	(0.156)
World	-0.189***	-0.837**	-0.340***	-0.340***	-0.168	-0.168
	(0.0346)	(0.327)	(0.0819)	(0.0819)	(0.152)	(0.152)
Model Specification						
Log-Log	0.384***	-0.367	16.43***	16.38***	2.158*	2.165*
	(0.126)	(0.680)	(2.749)	(2.749)	(1.157)	(1.158)
Gravity	-0.905***	-1.807	14.65***	14.60***	3.469	3.500
	(0.140)	(1.121)	(2.748)	(2.748)	(3.936)	(3.937)
Dynamic	-0.369***	-0.452				

VARIABLES	(1) Total With Outliers	(2) Total	(3) Agriculture With Outliers	(4) Agriculture	(5) Non-Agriculture With Outliers	(6) Non-Agriculture
	(0.133)	(0.866)				
Others	0.508***	-0.508	1.097	1.101		
	(0.137)	(0.786)	(0.713)	(0.713)		
Correct	0.186***	-0.0339	-4.822***	-4.803***	0.472	0.485
	(0.0495)	(0.508)	(0.894)	(0.894)	(1.387)	(1.387)
Research Time Range						
Before 1973	-0.723***	0.268			-2.031*	-2.039*
	(0.0845)	(1.023)			(1.176)	(1.176)
After 1973	-0.901***	-0.440	-10,031***	12.87***	-0.922	-0.929
	(0.0174)	(0.384)	(92.58)	(1.866)	(1.002)	(1.002)
Publication Time						
Published Between 1988 and 1996	1.047*** (0.0648)	0.693 (0.921)			-0.339 (1.037)	-0.346 (1.037)
Published Between 1996 and 2001	1.010*** (0.0732)	1.707* (0.990)	10,044*** (92.53)		-0.478 (1.074)	-0.486 (1.074)
Published After 2001	1.325***	1.373	5.164***	5.145***	-1.757	-1.784
	(0.109)	(0.952)	(0.894)	(0.894)	(3.340)	(3.340)
τ^2	3.0e-09	1.012	3.2e-12	3.6e-13	0.0406	0.0406
Observations	399	351	167	144	236	227

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 3. Random Effect Size Regression on $|\hat{\beta}|$

VARIABLES	(1) Total With Outliers	(2) Total	(3) Agriculture With Outliers	(4) Agriculture	(5) Non-Agriculture With Outliers	(6) Non-Agriculture
Constant	-1.539***	2.491	11.14***	-12.06***	-2.302*	-2.229*
	(0.177)	(1.568)	(1.377)	(1.377)	(1.263)	(1.263)
Research Topic						
Bilateral	0.693***	1.503***	-10,051***	4.762***	1.243***	1.247***
	(0.0378)	(0.397)	(92.52)	(0.900)	(0.283)	(0.283)
Import	0.0127	0.674*	0.819*	-0.862*	-0.0387	-0.0389
	(0.0138)	(0.362)	(0.488)	(0.488)	(0.0983)	(0.0983)
Total	-0.445***	-0.779**	0.409***	-0.566***	-0.862***	-0.870***
	(0.0234)	(0.385)	(0.0955)	(0.0955)	(0.300)	(0.300)
Data Characteristics						
Real	-0.416***	1.335***	3.927***	-3.826***	6.112***	6.035***
	(0.0386)	(0.365)	(0.898)	(0.898)	(0.817)	(0.817)
Month	-1.241***	-0.439	2.085**	-2.062**	0.427	0.418
	(0.0978)	(0.610)	(0.987)	(0.987)	(0.306)	(0.306)
Year	-1.117***	-0.268	1.489	-1.339	-5.318***	-5.212***
	(0.0976)	(0.502)	(0.992)	(0.992)	(1.083)	(1.084)
Aggregation						
Agriculture	0.0606***	1.090***				
	(0.0151)	(0.364)				
Sector	0.141***	0.954**	1.180***	-1.167***	4.448***	4.386***
	(0.0448)	(0.371)	(0.0490)	(0.0490)	(1.108)	(1.108)
Long Run	0.130***	-0.836**	0.157***	-0.125***	0.0740	0.0730
	(0.000120)	(0.358)	(0.0432)	(0.0432)	(0.104)	(0.104)
Volatility Measure						
VM2	0.869***	-1.103			-2.147***	-2.149***
	(0.153)	(0.976)			(0.345)	(0.345)
VM3	1.049***	-1.378**	-4.39e-06*	2.44e-08	-1.842***	-1.849***
	(0.0610)	(0.630)	(2.66e-06)	(6.04e-07)	(0.320)	(0.320)
VM4	1.049***	-1.222	0	4.39e-06***	4.088***	3.962***
	(0.0610)	(0.865)	(0)	(1.69e-06)	(1.382)	(1.382)
VM5	1.294***	-0.644	8.337***	-8.096***	-1.344***	-1.347***
	(0.0618)	(0.830)	(1.883)	(1.883)	(0.285)	(0.285)
VM6	1.049***	-1.626**	-4.42e-06*		-1.803***	-1.812***
	(0.0610)	(0.738)	(2.66e-06)		(0.334)	(0.334)
Data Type						
Cross-Section	2.412***	-0.514				
	(0.0648)	(0.887)				
Panel	0.153***	-3.316***	19.65***	-19.94***		
	(0.0403)	(0.881)	(3.600)	(3.599)		
Research Region						
Developing	0.0337	-0.0217	-0.0931	0.0914	0.0835	0.0865
	(0.0368)	(0.464)	(0.0588)	(0.0588)	(0.158)	(0.158)
World	-0.0802**	0.125	0.311***	-0.340***	-0.175	-0.174
	(0.0346)	(0.326)	(0.0819)	(0.0819)	(0.152)	(0.152)
Model Specification						
Log-Log	0.282**	2.825***	-15.94***	16.38***	-1.261	-1.199
	(0.126)	(0.679)	(2.749)	(2.749)	(1.225)	(1.225)
Gravity	0.633***	5.194***	-14.15***	14.60***	-19.74***	-19.36***

VARIABLES	(1) Total With Outliers	(2) Total	(3) Agriculture With Outliers	(4) Agriculture	(5) Non-Agriculture With Outliers	(6) Non-Agriculture
	(0.140)	(1.119)	(2.748)	(2.748)	(4.057)	(4.057)
Dynamic	0.602***	-1.484*			1.896*	1.835
	(0.133)	(0.865)			(1.126)	(1.126)
Others	1.132***	1.056	-0.588	1.101		
	(0.137)	(0.785)	(0.713)	(0.713)		
Correct	-0.865***	-2.101***	4.748***	-4.803***	-11.57***	-11.38***
	(0.0495)	(0.507)	(0.894)	(0.894)	(1.778)	(1.779)
Time Range						
Before 1973	0.140*	-4.067***			3.150**	3.027**
	(0.0845)	(1.021)			(1.369)	(1.370)
After 1973	-0.986***	-1.681***	10,033***	12.87***	4.909***	4.794***
	(0.0174)	(0.383)	(92.58)	(1.866)	(1.215)	(1.215)
Publish Time						
Published Between 1988 and 1996	2.385***	0.394			6.009***	5.892***
	(0.0648)	(0.920)			(1.239)	(1.239)
Published Between 1996 and 2001	2.605***	0.0125	-10,046***		6.047***	5.925***
	(0.0732)	(0.989)	(92.53)		(1.250)	(1.250)
Published after 2001	2.229***	-1.067	-4.850***	5.145***	17.87***	17.51***
	(0.109)	(0.951)	(0.894)	(0.894)	(3.644)	(3.645)
τ^2	3.0e-09	1.008	3.2e-12	3.6e-13	0.0406	0.0406
Observations	399	351	167	144	236	227

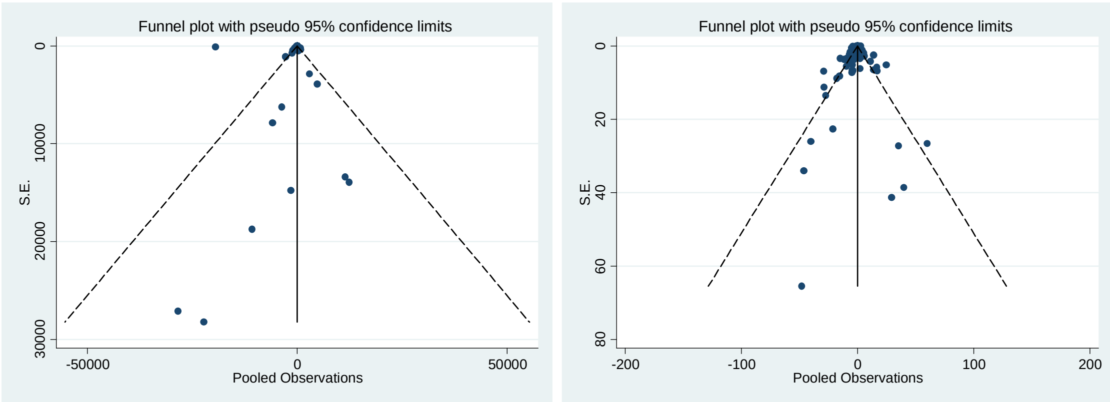
Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Appendix A.

Article	Count	Mean	Article	Count	Mean
Abrams (1980)	2	-0.07	Gagnon (1993)	20	0.09
Akhtar and Spence-Hilton (1984)	4	-0.09	Giorgioni and Thompson (2002)	3	-0.11
Almarwani et.al. (2007)	12	0.02	Grobar (1993)	16	-0.85
Anderson and Garcia (1989)	3	-38.25	Hassan (1998)	1	-0.50
Arize (1995)	1	-0.07	Holly (1995)	1	0.43
Arize (1996)	8	-0.19	Kargbo (2006)	9	2.71
Arize (1996b)	1	-1.82	May (2010)	24	-112,163
Arize (1997a)	7	-0.05	Kandilov (2008)	15	-2.39
Arize (1997b)	7	-0.05	Kenen and Rodrik(1986)	11	-3.72
Arize (1998a)	1	-0.05	Langley et.al (2000)	40	7.06
Awokuse and Yuan (2006)	6	-0.0005	Lee (1999)	3	-20.14
Bailey et.al(1986)	28	0.27	McKenzie (1998)	29	300.17
Belongia (1992)	24	1.19	Pick (1990)	20	-3.50
Bonroy et.al (2007)	10	-0.20	Qian and Varangis (1994)	22	-0.28
Cho and McCorriston (2002)	12	-0.20	Usman and Aavvides (1994)	32	-0.75
Chou (2000)	2	-0.02	Warner and Kreinin (1982)	19	0.90
Daly (1998)	14	0.89	Sun et.al (2002)	4	-0.28
Karemera et. al (2011)	16	0.84	Christopher et al.(2011)	4	-0.39
De Grauwe (1988)	2	0.05	Chen (2009)	3	21.59
Doyle (2001)	2	37.10	Bajpai and Mohanty (2009)	3	-9.86
Fountas and Aristotelous (2003)	4	2.36			

41 paper, 9.73 observations per paper

Figure 1. Funnel Plot, $\hat{\beta}$



Appendix B.

Measures of exchange rate volatility
VM1=1 if the volatility measured by standard deviation VM2=1 if the volatility measured by standard deviation of percent change VM3=1 if the volatility measured by standard deviation of moving average or autoregressive VM4=1 if the volatility measured by absolute value of exchange rate percentage changes VM5=1 if the volatility measured by ARCH, GARCH or ARIMMA model