A synthesis of the effects of exchange rate uncertainty on international trade via Meta-Regression analysis

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A Synthesis of the Effects of Exchange Rate Uncertainty on International Trade via Meta-Regression Analysis

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Abstract: The main focus of this paper is to survey the literature that investigates the effects of exchange rate uncertainty on international trade. Specifically, we carry out meta-regression analysis to 42 studies with 810 estimates. We show that the empirical studies on the focal link exhibit a substantial publication selection and a significant genuine exchange rate volatility effect on trade flows after correction of publication bias. Moreover, we find that most of the variables that may help explain the heterogeneity of results (such as the country sample, the choice of modeling strategies and potential political measures, etc) are significant. These results appear robust among the different methods used and the dummies for the type of research outlet and the publication year included in our estimates.

Keywords: Exchange rate uncertainty; trade; meta-regression analysis.

1. Introduction

The effect of exchange rate uncertainty on international trade has been and continues to be an extremely debated topic. Since the breakdown of the Bretton Woods system of fixed exchange rates, both real and nominal exchange rates have fluctuated substantially. This sizable volatility has often been viewed as detrimental, since a great uncertainty associated to exchange rate may threaten the international trade by increasing the riskiness of trading activity. The excessive ups and downs of exchange rate may inevitably create uncertainty in the development of macroeconomic policies, investment decisions and international trade flows. An increase in exchange rate instability leads to substitution and income consequences. On the one hand, the substitution outcome pushes traders to turn from foreign trade to internal trade. On the other hand, the income consequence may increase trading activities, since higher exchange rate risk gives greater opportunities to take profits and improve trade performance.

Since 1973, several countries have adopted the floating exchange rate system in order to enhance their exports competitiveness. This transition accompanied with a boom and bust in commodity prices have intensified the excessive volatile behavior of exchange rates which increase the uncertainty about international trade and threatens then the economic growth. This deeper increase in volatility may exacerbate a disconnection between exchange rate and its fundamentals, making very difficult to better cope with possible speculative attacks that heavily characterize international markets, especially in countries with inefficient financial system. The absence of hedging instruments due to their costs may yield to excessive ups and downs of exchange rate that may have harmful impacts on trade performance. The difficulty to tackle the causes of this volatility and to offset their main effects, the strong asymmetry of prices cycle and the high persistence of shocks have improved the plethora of studies analyzing the empirical connection between exchange rate uncertainty and international trade.

The literature on the focal issue is rather mixed and inconclusive. Various researches supported a negative and significant effect of exchange rate volatility on exports and linked it to the imperfect markets and the very cost hedging (Kumar and Dhawan (1991), Arize (1996, 1997), Arize et al. (2000), Véganzonès and Nabli (2002) and Clarck et al. (2004)). Others showed that higher exchange rate instability can give opportunities leading to an increase of trade flows, especially when exporters are sufficiently risk-averse (Hooper and Kohlhagen (1976), Bredin et al. (1998), Abott et al. (2001), Chang et al. (2002) and Olimoy and Nishanbay (2008)). A limited stream of literature provide evidence that exchange rate uncertainty may have no significant effect on foreign trade (such as Franke (1991), Aristotelous (2001), Achy and Sekkat (2001) and Bouoiyour and Selmi (2014 a)). From an empirical point of view, the literature since the 1984 has reinforced the evidence that there is an ambiguous linkage between exchange rate volatility and exports. The general presumption that international trade seems adversely influenced by the sizable exchange rate volatility depends substantially on the , the large number of countries in the data set that may lead to different effects depending on whether the country is advanced or developing, and to the fact that the estimation methods are quite different, etc (Coric and Pugh, 2010).

Given the diversity of findings on the linkage between exchange rate volatility and trade flows, we conduct meta-regression analysis (MRA). It is a quantitative literature review of the estimates observed from the existing empirical literature on the field. It aims at rigorously identifying the potential sources of heterogeneity in the previous regression analyses (i.e., the study-to-study variation) and examines the presence of publication selection bias (Stanley, 2005).

By applying this quantitative survey, we put in evidence that there is substantial publication selection bias towards a positive impact of exchange rate uncertainty on trade. We also show that the exchange rate volatility and its adverse impact on trade may be a result of the country sample, the modeling choices, the chosen exchange rate policy, the followed trade reforms, potential characteristics associated to the studied countries (the degree of oil dependency, the efficiency of financial system, the effectiveness of anti-cyclical price policy, if the country is price taker or price maker) and whether each study account for asymmetry and nonlinearity. These results seem robust among the different methods used and the dummies for the type of research outlet and the publication year included in the estimates.

To be effective in our investigation, the rest of the paper is organized as follows: Section 2 reviews the main empirical studies concerning the effects of exchange rate uncertainty on international trade. Section 3 presents accurately the construction methodology of our meta-data set and describes the meta-analysis estimation method employed. Section 4 presents the empirical results and discusses them. Section 5 summarizes our main findings and concludes the paper.

2. Review of the literature

Since the onset of generalized floating, international economists have long debated the likely impact that exchange rate uncertainty may have on international trade. While the empirical literature gives no thorough guidance on this relationship, the results have varied and remain ambiguous.

Although there are wide studies on how interacts exchange rate instability with trade (for instance, McKenzie and Brooks (1997), McKenzie (1998), Arize et al. (2000), Aristotelous (2001), Vergil (2001), Rey (2006), Egert and Zumaquero (2007), Bouoiyour and Selmi (2014 a), etc), the obtained evidence is up to now mixed. The different findings may be synthesized into three main evidences.

The first aspect represents the largest category, showing a negative effect of exchange rate volatility on international trade. Dell'Arricia (1991) and Kumar and Dhawan (1991) found that uncertainty about exchange rate lessens the volume of trade flows. They also noted that the "perfect forward markets" may mitigate the possible harmful effects of this great volatility on international trade. Pozo (1992) found that uncertainty with respect to exchange rate variations over long periods threatens the performance of total and sectoral exports. Accordingly, Lee (1999) and Lee and Saucier (2004) associated this negative connection to the imperfect markets and to the highly hedging costs. Obviously, exchange rate volatility can be hedged through effective financial instruments such as exchange rate derivatives. "These instruments can be considered as standard tools for hedging risks related to exchange rates or commodities prices" (Dohring, 2008). Important exchange rate volatility may be mitigated by a well developed financial system and then by hedging tools, since they allow firms to appropriately avoid negative shocks and the possible speculative attacks (Arize et al. (2000), Vergil (2001) and Sauer and Botara (2001)). Unfortunately, for developing economies with weaker financial system, there is a great difficulty to avoid the detrimental effects of sudden shocks and short-run disturbances (Frankel and Rose (2000), Véganzonès and Nabli (2002) and Kandilov (2005)). One of the main motivations behind the literature was the insight that in the absence of an efficient financial system and effective anti-cyclical price policy, trade would be threatened by the excessive exchange rate volatility (see for example, Cheong et al. (2002), Clarck et al. (2004), Sadikov et al. (2004) and Bouoiyour and Selmi (2014 b, c)).

The second aspect relies limitedly on the positive linkage between exchange rate uncertainty and trade. Various studies supported the view that the exchange rate instability may increase trade flows, including McKenzie and

Brooks (1997) and Fountas and Aristotelous (2003). Abott et al. (2001) provide evidence that if exporters are sufficiently risk-averse, exchange rate uncertainty acts favorably with exporters' behaviors affecting positively trade. Consistently, Haile and Pugh (2011) showed that "under general conditions, a risk neutral exporting firm increases its trade with increased exchange rate instability". Moreover, Stockman (1995) argued that exchange rate uncertainty expands the probability that exports pricing costs exceeds the production prices, concluding thus that the instability of exchange rate may strength the performance of international trade.

The third aspect seems associated to a limited stream of literature, revealing that exchange rate uncertainty has no significant effect on international trade such as Franke (1991) and Achy ans Sekkat (2001) for agricultural sector. Some elements of explanations have been advanced to explain this result. Egert and Zumaquero (2007) and Bouoiyour and Selmi (2014 d) put in evidence that high degree of competitiveness in one sector makes it less vulnerable to exchange rate volatility. Specifically, the fact that each country is price maker (i.e. the country that plays an important role in setting its own prices in international markets) may allow each economy to maintain a quick recovery under crisis and to better cope with external shocks. The diversification may also reduce considerably the possible damageable effects of exchange rate uncertainty on exports (Clarck et al. 2004). Other element of explanation of the insignificant effect may be linked to the studied sector itself. For example, despite the boom-bust of primary commodity prices and the great volatile behavior of exchange rate, the exporters of agricultural products ("perishable" products) generally have a neutral attitude to the risk (Achy and Sekkat (2001) and Bouoiyour and Selmi (2014 b)). The insignificant connection between the two considered variables may be also a reflect of "the presence of sunk cost in exporting" (Franke, 1991), that is to say more important are the trade costs, the less sensitive will be exporters to exchange rate uncertainty.

Interestingly, the debate within the macroeconomic literature on the link between exchange rate uncertainty and trade covers a variety of countries and several econometric methods, which can reflect the difficulty to reach solid and unambiguous outcomes (Pugh et al. 2012). Moreover, when reviewing the existing literature, we clearly note a scarcity of studies that assess this "complex" relationship within nonlinear or asymmetrical fashions. For instance, Bouoiyour and Selmi (2014 a) examine empirically whether there is a nonlinear dynamic interaction between exchange rate volatility and exports for the case of Egypt. Their study relies on an optimal GARCH model chosen by information criteria among decomposed series on a scale-by-scale basis (i.e., wavelet decomposition). They show that the connection between exchange rate uncertainty and trade flows depends substantially on scale-by-scale variation (i.e., nonlinear relationship) and slightly on the leverage effect (i.e., asymmetrical relationship). They also argue that the correlation between the considered variables is stronger at low frequency than at high frequency. Other studies carry out asymmetrical GARCH models as measures of volatility (Lee and Saucier, 2005). Their results reveal that there is a significant leverage effect on the volatility process, and thus exports may respond positively to exchange rate depreciations and negatively to appreciations.

Intuitively, there are very few researches that account for possible excess of co-movements when assessing the effects of exchange rate uncertainty on exports. Bouoiyour and Selmi (2014 d), for example, applied a new approach based on a time varying dynamic coherence function, namely evolutionary co-spectral analysis in order to analyze the interdependence between exchange rate volatility and exports to GDP ratio in Russia. They find that cohesion between the two time series changes substantially over time. Moreover, they show that exports react weakly to changes in nominal exchange rate and heavily to those of differential price and. additionally, they provide evidence that the nominal exchange rate succeeds to smooth the real exchange rate in the short-run. This smoothing appears less obvious in the medium-run, whereas the effect of shocks becomes more persistent in the long-run. The great oil dependency and the ineffectiveness of anti-cyclical price policy have been offered as possible explanations for the sharply responses of trade flows to excessive ups and downs of exchange rate.

3. Meta-data set and methodology

Since the findings in several issues were inconclusive, meta-analysis is a helpful tool aimed at reconciling the inconsistencies (Stanley, 2005). Meta-analysis is a statistical technique for combining different results from independent researches. Its validity depends substantially on the quality of systematic review on which it is based. Our focus on this study is to conduct an effective meta-analysis aimed at completing coverage of all relevant and looking for the presence of heterogeneity in order to highlight appropriately the main factors behind the controversial linkage between exchange rate uncertainty and international trade. Specifically, we employ meta-regression analysis while trying to integrate several diverse results to see the excess study-to-study variation within previous empirical studies. The main role of meta-regression model is to accurately explain the conflicting findings largely obtained in the existing literature. Meta-regression analysis (MRA) also aims at investigating if there exists publication selection bias (Stanley, 2005).Publication bias may arise when editors or referees treat the significant findings that fully satisfy the theoretical expectations and reject the insignificant or the unexpected results (Stanley, 2008).

Throughout the rest of this research, we collect empirical works assessing the focal relationship. Accurately, the database for the analysis has been constructed based on several published empirical papers on the effects of exchange rate uncertainty on international trade. They have been collected by searching on the Econlit database as well as the Google Scholar search engine.

In particular, we perform a meta-regression analysis using data from 42 works and 810 estimates. As is the norm in meta-analysis, we excluded the non-empirical researches on this issue such as Stanley (2001) and Doucouliagos and Laroche (2009). Table 1 worthy reports the empirical researches employed in our MRA and all descriptive statistics of the estimated coefficient associated to the impact of exchange rate volatility on trade flows. This table clearly depicts that there is great variation in findings within the considered studies. As it well shown from table, the empirical studies have different mean values of the exchange rate uncertainty coefficients as well as a different number of coefficients. So, we define a meta-regression model. In this context, we examine particular independent meta-variables (Table 2) in order to distinguish between numerous criteria that appear important. More precisely, various moderator variables were rigorously chosen and included in the MRA to effectively explain the diverse findings in the literature on the studied field. We integrate variables expected to have a systematic influence on the effect of exchange rate uncertainty on foreign trade. The moderator variables are binary or dummy variables. These selected variables are grouped into contextual features of the model. For instance, whether the dependent variable measures trade flows between developed or between developing economies, between economies with well developed financial system or inefficient financial development, between price makers or price takers, between oil dependent economies; whether exports are defined at total, sectoral or bilateral level, without neglecting the "pulling" effects that may play modeling choices (i.e., "naïve models" [standard deviation, moving average deviation, absolute average deviation, etc] or "sophisticated techniques" [asymmetrical GARCH models, nonlinear GARCH extensions, time-varying GARCH technique, component GARCH with threshold orders, etc] to measure volatility). Together, the chosen moderator variables allow us to properly and appropriately evaluate the impact on estimated effect size of different types of data and distinct and well-parsimonious econometric techniques, while accounting for additional characteristics. We use also the earliest and the latest year of the sample in the considered empirical studies (i.e., a dummy variable presenting the publication year for each research) to see whether the sample period deeply and significantly affect the estimated exchange rate uncertainty coefficient mainly due to structural change. We also include dummy variable to analyze if the fact that each study has been published as working paper or in academic journal may have a great influence on the variation of the reported findings.

Meta-regression analysis enables to synthesize distinct findings in a common framework (Harmon et al. 2003). To combine the different results, we start by the following model.

$$\beta_i = \beta_0 + \alpha_k Z_{ik} + \beta_1 se_i + u_i ; i = (1,...,41) \quad (1)$$

where i indexes the regressions in the MRA database; β_i is the reported estimate of exchange rate uncertainty coefficient of the i^{th} study, β_0 is the true value of the volatility of exchange rate coefficient, Z_{ik} are the moderator variables that influence the magnitude of the published results and explain variation in coefficients β_i (i.e., Equation (1) is a multivariate regression model that includes different meta-independent variables), α_k are the meta-regression coefficients which reflect the effect of specific study characteristics, se_i is the standard error of the coefficient of the i^{th} study and u_i is the meta-regression disturbance term.

In the presence of publication selection, authors of studies with smaller sample sizes tend to select large and significant effects to mitigate the less accurate estimates. Thus, the statistical significance of β_1 can be an indicator for publication selection bias (Stanley (2005) and Haile and Pugh (2011)). Besides, MRA evaluates to what extent the statistical heterogeneity between the empirical outcomes obtained can be related to several characteristics across multiple researches. Obviously, it seems very difficult to fully explain the heterogeneity in the observed results, hence there will be “residual heterogeneity” (Benos and Zoutou, 2014). Generally speaking, the empirical works use different sample sizes and apply different econometric methodologies, implying that u_i in the equation (1), is likely to be heteroscedastic. Given this, the estimation of equation (1) may not be proper and effective. Because the variances are well known, the weighted least squares (WLS) may be more parsimonious and more appropriate to estimate the between-study variance. The WLS specification is obtained by dividing equation (1) by the se_{i}.

$$t_i = \beta_1 + \gamma_i K_i + \beta_0 (1/se_i) + \sum_{i=1}^{k} \alpha_k (1/se_i) Z_{ik} + \upsilon_i \qquad (2)$$

where t_i is the t-statistic which corresponds to the estimate β_i. Because publication selection remains deeply complex phenomenon, we have tried here to replace the coefficient β_1 in the equation(1) by $\beta_1 + \gamma_i K_i$, where K_i are supplementary factors heavily correlated with the publication process as political-economic variables (Doucouliagos and Stanley, 2009), β_0 corresponds to the true value of the exchange rate uncertainty coefficient, α_k are the meta-regression coefficients reflecting the impacts of specific characteristics associated to the considered studies, Z_{ik}, as mentioned above, are the meta-independent variables that may explain intensely the variation in coefficients β_i, υ_i is the weighted error term (u_i/se_i) where se_i is the standard error of the coefficient of the i^{th} study. Equation (2) is a multivariate regression model with different inversed moderator variables. This specification may be valuable and useful for testing the existence of publication selection bias on the one hand, and genuine exchange rate volatility's impacts on trade flows corrected for publication selection on the other hand. We can employ, for instance, the Funnel Assymetry Test (FAT) to properly test for the occurrence of publication bias (Benos and Zotou, 2011).

It is important to mention that several methods have been applied for the estimation of the between-study variance in MRA. The benchmark method for this purpose is the restricted maximum likelihood technique (REML). It was developed to effectively overcome the biased estimates possibly produced by ordinary maximum likelihood (ML) estimation, i.e., ML method does not consider the degrees of freedom used generally in estimating the effect size. Given the ML limits, both the REML and the Empirical Bayes method (EB) can avoid the biased estimates of the between-study variance (Thompson and Sharp, 1999). Although the MM estimator is a non-iterative technique as ML method, MM is much more favorable especially in checking robustness[1]. It seems more parsimonious than restricted likelihood method (Benos and Zotou, 2014). Ultimately, because the majority of works in our sample report more than one regression, it is likely that exchange rate uncertainty coefficients are sharply correlated across studies. This may highlight the usefulness of OLS with heteroskedasticity cluster-robust standard errors, since it is able to determine the error term correlation within each study (Coric and Pugh (2010) and Haile and Pugh (2011)). This method is widely carried out as a benchmark, because despite it ineffectiveness compared to the above mentioned methods, but may yield to meaningful results. It is also largely applied in the existing meta-regression studies such as Doucouliagos and Stanley (2009) and Effendic et al. (2011).

4. Meta-regression results

4.1. Publication selection bias

Publication selection bias has been one of the most important concerns among meta-analysts, as the majority of academic journals are more likely to publish researches that report significant and expected outcomes. The publication bias occurs when the considered meta-data have similar results, or when researchers have an incentive to conform. For example, when each study

[1] REML and EB estimators use the MM estimator as starting value.

suggests a positive or ambiguous relationship between two variables and the majority of works on the same field show a negative and significant link, the study is unlikely to be accepted by editors/referees for publication (Bom and Ligthart (2008) and Pugh et al. (2012)). As a result, researchers may not submit unconventional or weakly findings and the empirical literature on the concerned issue may be affected by publication bias (Bouoiyour et al. 2014). In light of these, we attempt in the following to test if there is publication bias in the existing literature on the relationship between exchange rate volatility and international trade.

Funnel plot is usually used to detect bias selection, since it is the simplest method (Jarell and Stanley (1990) and Doucouliagos (2005)). It worthy depicts the estimates of exchange rate uncertainty coefficients on the X-axis (horizontal) and the inverse of their standard errors on the Y-axis (vertical). In the absence of publication bias, the considered works will be distributed randomly and symmetrically about the combined effect size. By contrast, in the presence of bias, we would show a higher concentration of studies on one side of the mean than on the other. Figure 1 clearly shows that the plots seem more overweighted on the right side, implying the presence of publication bias towards positive values of the impact of exchange rate uncertainty on trade flows. This visual examination remains a "subjective test" for analyzing the publication selection (Benos and Zotou, 2014). This test is useful, but not the sole evidence of publication bias and authentic effects. There are effective "objective statistical tools" that may allow us to test more appropriately if publication bias occurs. Specifically, we carry out the funnel asymmetry test (FAT) and the precision-effect test (PET). This test assumes that α_k and γ_i in Equation (2) are zero. In other words, there is no heterogeneity effect. To do so, we estimate the following equation:

$$t_i = \beta_1 + \beta_0 (1/se_i) + \xi_i \qquad (3)$$

where t_i refers to the t-value of the estimated coefficient on the exchange rate volatility measure from the i^{th} regression results, β_0 and β_1 are coefficients to be estimated (these two coefficients together properly and accurately provide the basis for the FAT–PET testing procedure for the presence of publication bias and the genuine empirical effect (see for example, Doucouliagos and Stanley, 2008)), and ξ_i is the weighted error term. Equation (3) is a bivariate regression model with the inverse of se_i as the independent variable.

Normally, if there is no publication bias, the intercept term should not be significant (i.e., we accept H_0: β_1=0). In contrast, a non-zero intercept term implies an upward or downward publication selection bias on the estimated effects reported in the literature on the focal issue. For our case of study, the FAT test reveals that there exists a publication bias (Table 3), since the constant term is statistically significant for all considered estimators. Moreover, we can mention that there is an upward publication bias, since β_1 seems positive and precisely superior to 1 and inferior to 2 (Doucouliagos and Stanley, 2012). This model is also able to capture appropriately whether there is a genuine effect beyond the publication selection. The coefficient β_0 can be considered as a proper estimate of the effect corrected for publication selection. From Table 3, MM technique's outcomes reveal that there is no evidence of a genuine exchange rate uncertainty effect on international trade. However, the findings obtained through the rest of methods (i.e., cluster data analysis, REML and EB) suggest a positive genuine exchange rate volatility effect on exports. This effect appears small in all cases.

4.2. Effects on exchange rate uncertainty coefficients

Our meta-regression analysis (multivariate MRA) starts by incorporating potential moderator variables accurately listed in Table 2 (Equation (1)) and by dividing then the equation (1) by the standard error (i.e., all meta-independent variables are weighted by the inverse of se_i in the focal model). The intercept term appears statistically positive and significant. This suggests the presence of an upward publication bias among the empirical results reported in Table 4. Since se_i is sharply interacted with the moderator variables in the multivariate model, the combination of all these explanatory variables may allow us to appropriately see whether there is an "authentic empirical effect" (Haile and Pugh (2011) and Doucouliagos and Stanley (2012)). The F-test suggests that the meta-independent variables are jointly statistically significant (p=0.0863, Table 4), indicating therefore the existence of a genuine empirical exchange rate uncertainty effect on international trade beyond publication bias.

The following discussion and interpretation of our main findings draws on Table 4 (MRA considering working papers and publications in academic journals) and Table5 (MRA with dummies for publication in academic journal and the publication year).

Among three moderator variables or categories (total exports (TEXP), sectoral exports (SEXP) and bilateral exports (BEXP)) used as trade flows proxies, two have consistent and statistically significant coefficient estimates. Total exports (TEXP) display statistically negative estimated coefficients, implying that works focusing on investigating the interaction dynamic between TEXP and exchange rate volatility are more likely to discover a negative relationship. The SEXP is more likely to highlight an ambiguous effect, while BEXP displays a no significant coefficients.

Although the meta-independent variables for researches examining the link between exchange rate variability and trade across developing countries (DC), economies that adopt anti-cyclical price policy (ACP), countries with inefficient financial system (IFS) and price takers (PT) is in the majority of cases statistically significant and negative, the sign of coefficient estimate among these countries deeply indicates the utmost importance of forward markets in mitigating the excessive exchange rate volatility. Non-existent forward markets coupled with imperfect capital mobility, ineffectiveness of financial sector and inefficiency of fiscal policy in these economies may lessen the possibility of hedging ((Gervais et al. (2004) and Haile and Pugh (2011)). In sum, these results clearly indicate that the economic structure and the characteristics of the studied countries may explain the debate controversy, without neglecting the role that may play monetary policy in each economy than other for absorbing external shocks and avoiding the possible speculative attacks (Bahmani-Oskooee and Payesteh, 1993).

The empirical studies that analyze the focal relationship in real terms are more likely to report a negative connection between exchange rate volatility and exports, but this result seems not solid among the different econometric methods including Cluster data analysis, REML, MM and EB (Tables 4 and 5). The chosen exchange rate policy can be advanced here as element of explanation. Accurately, for floating exchange rate regime (FER), the nominal exchange rate may be the main determinant driver of real effective exchange rate variation. However, for pegged exchange rate regime (PER) where the nominal exchange rate moves into a target, the inclusion of the differential price volatility seems quite legitimate (Egert and Zumaquero, 2007). The significant coefficients associated to FER and PER, among majority of cases, reinforce this evidence. In addition, trade reforms may also play important role in explaining the effect of exchange rate uncertainty on international trade. Specifically, global trade agreement displays a negative effect, while regional trade agreement (RTA) reports a positive impact of exchange rate variability on exports.

Furthermore, it seems important to mention that considering high frequency exchange rate variability (HF) has led to an ambiguous relationship between the variables of interest, while low frequency variation seems sharply associated to a negative impact of exchange rate volatility on trade flows. This outcome may be mainly due to the fact that year-to-year variability (LF) is less subject to hedging than month-to-month or quarter-to-quarter variation (HF). This also corroborates the view that forward markets are essential in lessening the volatile behavior of real exchange rate. Moreover, the unclear link between HF and trade flows may be attributed to the stronger correlation between real exchange rate and international commodity prices, themselves highly influenced by speculation, cyclicality and seasonality (Bouoiyour and Selmi, 2014 a, b).

The choice of modeling strategies, especially the volatility' proxies, may also heavily explain the heterogeneity in results of the existing empirical literature. In Table 4, the coefficients measuring the effect of "sophisticated models" (SM) are statistically negative. In contrary, studies determining the volatility of exchange rate within "naïve models" (NM) are more likely to find adverse effect on trade. This finding is well expected. While a variety of exchange rate uncertainty measures has been used in the empirical literature, there is still no consensus on which measure is the most appropriate to identify a solid relationship between exchange rate volatility and international trade. The standard deviation and the moving average deviation previously largely applied in several studies (Chowdhury (1993) and Dell'Ariccia (1999)) may ignore the information on stochastic processes through which exchange rates are generated. Indeed, the use of several GARCH extensions (linear vs. nonlinear, symmetrical vs. asymmetrical, with power effect, with level shift, etc) may exert a potential impact on exchange rate volatility's effects (i.e., lead to multiple effects). GARCH models may be more effective and most convenient because financial markets data often exhibit volatility clustering, where time series show periods of high and low volatility than periods of constant volatility (Bouoiyour and Selmi, 2014 c). The fact that the majority of researches have excluded models that account for asymmetry and nonlinearity may be also considered as main contributors of the conflicting outcomes previously obtained. Consistently, our results clearly reveal that nonlinearity (NL) and asymmetry (AS) are likely to prompt an adverse impact of exchange rate volatility on international trade.

Almost similar results are obtained from the meta-analysis regression of the whole sample with dummies for publication in academic journal as well as the publication year (i.e., the earliest and the latest year of the sample period plays any role in explaining the adverse effect of exchange rate uncertainty on trade flows widely observed in the existing literature). The estimates reported in Table 5 suggest that the impact of exchange rate volatility on trade is likely to be adverse, when measured in real rather than nominal terms, when naïve models are used as volatility' measurements than "sophisticated" models, when high-frequency variations rather than low-frequency variations are considered and when developing rather than developed economies are investigated. We also worthy note that the conflicting relationship between the focal time series may be conditioning upon additional potential moderator variables such as oil dependency (OD), the degree of financial development (i.e., well developed or inefficient financial system), the adopted exchange rate regime and the followed trade measures, etc.

In a nutshell, the above outcomes reinforce, to some extent, the conclusions of Coric and Pugh (2010) and Haile and Pugh (2011) that the effect of exchange rate uncertainty on international trade varies substantially depending to country samples (developing or developed countries), the wide range of volatility measurements, the trade' categories (total, sectoral or bilateral exports) and whether the exchange rate is measured in nominal or in real terms. The present research contributes to the above MRA studies by adding other relevant moderator variables that allow us to find new paths. We provide insightful evidence that differences across studies can be also attributed to the chosen exchange rate policy, the trade reforms and additional characteristics associated to the studied countries. The latter include oil dependency, the degree of efficiency of financial system, if the studied economy adopts anti-cyclical price policy or countercyclical policy, if countries are price takers or price makers and whether each study considers asymmetry and nonlinearity when assessing this "complex" linkage.

5. Conclusion

The debate relative to the effects of exchange rate uncertainty on international trade is not recent. In this paper, we have worthy seen that a large body of literature has focused on the linkage between the volatile behavior of exchange rate and trade flows. Empirical findings on this relationship appear ambiguous and inconclusive, highlighting the complexity of this topic. In light of these, we make an attempt to survey the literature on the impact of exchange rate uncertainty on exports while trying to effectively explain the wide variation in reported estimates (i.e., the heterogeneity in the obtained results). For this purpose, we carry out meta-regression analysis to 42 studies with 810 estimates, correcting for publication bias. We assess the effect of several factors on the variation of exchange rate volatility coefficients.

Our meta-regression analysis shows interesting findings, which appear solid and robust among the majority of methods used and after including dummies for the type of research outlet where studies are published (i.e., working paper vs. academic journal) and the publication year (the earliest vs. the latest study). Our results clearly indicate that there is an upward publication selection bias in the existing literature and a statistically significant genuine exchange rate uncertainty effect on international trade after correction of publication bias. We also put in evidence that study-to-study variation can be attributed to the country sample, the modeling choices, the exchange rate policy (i.e., pegged or floating exchange regime) and the trade policy (i.e., some measures as global or regional trade agreement). Oil dependency, the efficiency of financial system and the adoption of anti-cyclical or countercyclical price policy, etc -excluded in the majority of studies on the issue- seem “substantial” factors, which should not be overlooked.

It is recommended to conduct the same analysis when more studies are available to confirm our results and to find better ways.

Table 1. Descriptive statistics

Studies	N° of coefficients	Mean	Median	Maximum	Minimum	Std. Dev.
Hooper and Kohlhagen (1978)	32	5.346250	0.360000	82.76000	-41.30000	31.99952
Franke (1991)	3	0.516500	0.516500	0.606000	0.427000	0.126572
Kumar and Dhawan(1991)	12	-0.022500	-0.027500	0.071000	-0.089000	0.062372
Pozo (1992)	2	-0.108050	-0.108050	-0.094800	-0.121300	0.018738
Chowdhury (1993)	6	-0.143200	-0.126600	-0.097500	-0.227400	0.051462
Stockman (1995)	6	1.901000	0.475500	6.981000	0.002000	2.763013
McKenzie and Brooks (1997)	8	608.2750	659.6500	836.2000	277.6000	243.3517
McKenzie (1998)	11	153.5583	133.4000	435.8000	29.32000	147.8287
Arize (1997)	13	-0.118000	-0.156000	0.089000	-0.273000	0.140862
Arize (1998)	9	-0.378333	-0.460500	0.183000	-0.869000	0.427761
Aize et al. (2000)	55	-0.212833	-0.242500	-0.063000	-0.373000	0.118016
Dell'Arricia (1999)	6	-0.129000	-0.099000	0.093000	-0.411000	0.253815
Bredin et al. (1998)	12	0.017600	-0.011000	0.273000	-0.153000	0.156057
Lee (1999)	3	-0.126000	-0.467000	0.621000	-0.532000	0.647737
Frankel and Rose (2000)	8	-0.145000	-0.098500	0.073000	-0.456000	0.223838
Abott et al. (2001)	2	0.020000	0.020000	0.100000	-0.060000	0.113137
Achy and Sekkat (2001)	6	-0.001400	-0.036000	0.121000	-0.042000	0.069522
Aristotelous (2001)	6	-0.153250	-0.196000	0.226000	-0.447000	0.298360
Doyle (2001)	6	-0.005333	-0.006500	0.089000	-0.092000	0.058168
Sauer and Botara (2001)	3	-0.001400	-0.036000	0.121000	-0.042000	0.069522
Vergil (2001)	4	-0.050000	-0.040000	0.010000	-0.130000	0.060553
Cheong et al. (2002)	4	0.003400	0.003100	0.004600	0.002800	0.000816
Véganzonès and Nabli (2002)	2	-0.185000	-0.185000	-0.100000	-0.270000	0.120208
Fountas and Aristotelous (2003)	3	-0.150667	-0.148000	-0.065000	-0.239000	0.087031
Yuan and Awokus	6	-0.068167	-0.020000	0.007000	-0.355000	0.141350

(2003)						
Baum et al. (2004)	14	-0.140714	0.231000	6.264000	-6.104000	3.257404
Clarck et al. (2004)	36	-0.093800	-0.111000	0.091000	-0.224000	0.115329
Gervais et al. (2004)	5	-0.316000	-0.330000	0.610000	-0.940000	0.631015
Sadikov et al. (2004)	3	-0.579667	-0.519000	-0.484000	-0.736000	0.136515
Honroyiannis et al. (2005)	6	-0.039333	0.015500	0.149000	-0.316000	0.194519
Kandilov (2005)	228	-2.265000	-0.945000	-0.150000	-8.930000	3.347696
Lee and Saucier (2005)	8	-0.710667	-0.700500	0.611000	-1.817000	0.790533
Rey (2006)	24	-0.619167	-0.760000	0.506000	-1.405000	0.795990
Egert and Zumaquero (2007)	100	-0.105833	-0.079000	0.006000	-0.346000	0.124035
Olimov and Nishanbay (2008)	3	1.416667	1.180000	2.000000	1.070000	0.508167
Hosseini and Moghadsi (2010)	6	-0.013550	-0.011600	0.078000	-0.109000	0.078573
Chit and Judge (2011)	12	-2.080167	-0.687000	-0.302000	-5.256000	2.457727
Bouoiyour and Selmi (2014 a)	16	-0.021000	-0.076000	0.183000	-0.121000	0.123432
Bouoiyour and Selmi (2014 b)	98	-0.086333	-0.131500	0.201000	-0.281000	0.187422
Bouoiyour and Selmi (2014 c)	14	-0.049400	-0.054000	0.228000	-0.314000	0.192374
Bouoiyour and Selmi (2014d)	6	0.004250	0.002500	0.011000	0.001000	0.004573
Total	810	16.68535	-0.069000	836.2000	-41.30000	96.16141

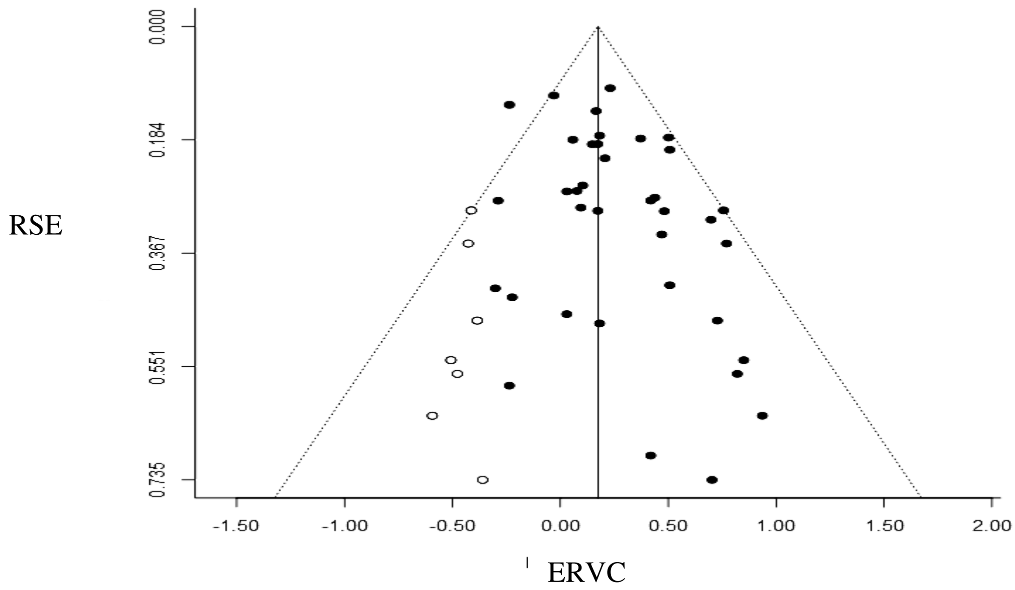
Table 2. K and Z variables for Meta-regression analysis

	Description of the variables
	Variables[a]
t-statistic	The t-statistic of the coefficient of interest of the study.
	K-variables[b]
Sample size (SZ)	The sample size used in this study.
	Z-variables[c]
Antse (1/se)	=1/the standard error of the coefficient of interest of the study
Total exports (TEXP)	=1, if the study considers total exports as dependent variable.
Sectoral exports (SEXP)	=1, if the study considers sectoral exports as dependent variable.
Bilateral exports (BEXP)	=1, if the study considers bilateral exports as dependent variable.
Low frequency (LF)	=1, if study considers low frequency exchange rate variability.
High frequency (HF)	=1, if study considers high frequency exchange rate variability.
Naïve models (NM)	=1, if the study uses "naïve models" as measure of volatility.
GARCH models (GM)	=1, if the study uses GARCH models as proxies of volatility.
Cross-sectional data (CROSS)	=1, if estimate relates to cross-sectional data.
Panel (PANEL)	=1, if the study employs panel data.
OLS method (OLS)	=1, if the study uses OLS method for the estimation of the link between exchange rate volatility and exports.
Developed countries (DC*)	=1, if the study focuses on the case of developed countries.
Developing countries (DC)	=1, if the study focuses on the case of developing countries.
Nominal terms (NT)	=1, if the relationship between exports and exchange rate volatility has been investigated in nominal terms.
Real terms (RT)	=1, if the relationship between exports and exchange rate volatility has been investigated in real terms.
Pegged exchange regime (PEXCH)	=1, if the study focuses on the countries that adopt pegged exchange regime.
Floating exchange regime (FEXCH)	=1, if the study focuses on the countries that adopt floating exchange regime.
Global trade agreement (GTA)	=1, if the countries under consideration have signed a global trade agreement.
Regional trade agreement (RTA)	=1, if the countries under consideration have signed a regional trade agreement.
Developed financial system (DFS)	=1, if the studied countries are characterized by developed financial system.
Inefficient financial system	=1, if the studied countries are characterized by inefficient financial

(IFS)	system.
Anti-cyclical policy (ACP)	=1, if the concerned countries adopt an anti-cyclical price policy.
Countercyclical policy (CCP)	=1, if the concerned countries adopt countercyclical price policy.
Price maker (PM)	=1, if the studied economies are price makers.
Price taker (PT)	=1, if the studied economies are price takers.
Oil dependency (OD)	=1, if the studied countries are highly dependent to oil sector.
Asymmetry (AS)	=1, if the study accounts for asymmetry.
Nonlinearity (NL)	=1, if the study accounts for nonlinearity.
Academic journal (AJ)	=1, if the study has been published by an academic journal.
Publication year (PUBY)	The year the study was published.

Notes: [a] All variables are included in a general-to-specific modeling approach.
[b] K variables may affect the likelihood of being selected for publication.
[c] Z variables may affect the magnitude of the exchange rate volatility coefficient.

Figure 1. Funnel plot graph



Notes: The variables ERVC and RSE represent, respectively, the exchange rate volatility coefficient and the inverse of the standard error.

Table 3. Funnel Asymmetry and precision-effect tests (FAT-PET)

Variables	Cluster[a]	REML[b]	MM[c]	EB[d]
Antse=(1/se)	0.0179*	0.0176**	0.0362	0.0254***
	(1.6982)	(3.0126)	(1.6048)	(3.4951)
Intercept	1.3824***	1.3895***	1.3512***	1.4118***
	(4.7613)	(3.8640)	(4.2067)	(3.9254)
R-squared	0.1638	0.1495	0.1430	0.1846
Ramsey Reset test	F(3,612)=4.79			
	Prob>F=0.0932[e]			

Notes: **, *** denote statistical significance at 5% and 1% levels respectively; t-values are reported in parentheses (dependent variable: t-statistic); [a] Cluster data analysis presents the FAT results with cluster-robust standard errors; [b] REML presents the FAT-PET results with restricted maximum likelihood; [c] MM presents the FAT-PET results with the moment estimator; [d] EB presents the FAT-PET results with the empirical Bayes iterative procedure; [e] The Ramsey reset test rejects the null at all levels of statistical significance, indicating an incorrect specification of the model.

Table 4. Meta- regression analysis (considering working papers and publications in academic journals)

Moderator variables	Cluster[a]	REML[b]	MM[c]	EB[d]
ANTSE=1/se	1.5287**	1.1422*	0.5682	1.3679***
	(2.3456)	(1.6988)	(1.0234)	(4.1355)
Intercept	1.3467***	1.3652**	1.0159*	1.3584***
	(5.1289)	(2.8916)	(1.6954)	(3.6175)
SZ	-0.4513	-0.3256	0.6752	-0.2894
	(-0.8660)	(-1.1431)	(0.5419)	(-1.5137)
TEXP/se	-0.0147*	-0.0256***	-0.0102	-0.0311**
	(-1.8705)	(3.8714)	(-0.6853)	(-2.7819)
SEXP/se	-0.1136*	0.0997*	-0.1014*	-0.0986***
	(-1.9124)	(1.8562)	(-1.7325)	(-5.0127)
BEXP/se	0.0879	0.0345	0.0096	0.0671
	(1.1348)	(0.7651)	(1.1512)	(1.000)
NM/se	0.2715***	-0.1692**	0.2019*	-0.3147***
	(3.8641)	(-2.1174)	(1.6933)	(-4.1769)
SM/se	-0.0489***	-0.0512**	-0.0161	-0.0495***
	(-5.1167)	(-2.7650)	(-1.3259)	(-3.8924)
CROSS/se	-0.1230*	-0.1002**	-0.0876*	-0.1376***
	(-1.7804)	(-2.4357)	(-1.7924)	(-4.1098)
PANEL/se	0.0195	0.0086	-0.0213	0.0201*
	(0.8724)	(1.1453)	(-1.0007)	(1.7624)
OLS/se	0.0946***	-0.0675**	-0.0414	0.1013***
	(3.8772)	(-2.9211)	(-1.2539)	(5.6197)
DC*/se	-0.2369*	-0.1946**	-0.1856*	0.2380***
	(-1.8122)	(-2.3857)	(-1.7129)	(4.4569)
DC/se	-0.1055**	0.0768*	-0.0616	-0.0928**
	(-2.3493)	(1.8320)	(-1.0117)	(-2.8073)
NT/se	0.0026	0.0194	0.0102	0.0063
	(1.4807)	(1.1552)	(0.7869)	(1.0002)
RT/se	0.1725**	-0.1023***	-0.0952*	0.2011***
	(2.6149)	(-5.6718)	(-1.7487)	(4.3276)
LF/se	-0.1027*	-0.1000**	0.0675	-0.0876***
	(-1.6928)	(-2.4519)	(1.4113)	(-3.1542)
HF/se	0.0654***	-0.0542*	-0.0234	0.0708**
	(4.4963)	(-1.6988)	(-1.0000)	(2.6415)
PER/se	-0.1013*	0.1237*	0.1000*	-0.1613***
	(-1.9485)	(1.7814)	(1.7169)	(-3.9825)
FER/se	0.1604***	0.0950*	0.0868*	0.1920**
	(3.2875)	(1.7266)	(1.9153)	(2.4568)
GTA/se	-0.0241*	-0.0328**	-0.0094	-0.0303**

	(-1.7985)	(-2.1156)	(-0.2561)	(-2.6157)
RTA/se	0.1126*	0.1571*	0.0917*	0.1653***
	(1.8456)	(1.6904)	(1.8205)	(4.1172)
DFS/se	0.0991***	0.0762*	0.0512	0.0965***
	(5.3642)	(1.8053)	(0.4387)	(4.0177)
IFS/se	-0.2610***	-0.1987**	-0.1546***	-0.3107***
	(-4.1837)	(-2.6513)	(-3.3729)	(-5.1822)
ACP/se	0.0892**	-0.0256*	-0.3109	0.0875***
	(2.5111)	(-1.7344)	(-0.8525)	(3.9136)
CCP/se	-0.0957*	-0.1131***	-0.2371	-0.1084**
	(-1.8834)	(-3.6510)	(-1.1549)	(-2.5963)
PM/se	0.1447***	0.2356*	0.0966	0.1801***
	(2.6513)	(1.8742)	(0.8732)	(5.0423)
PT/se	-0.1123***	0.1004***	-0.0456	-0.1325**
	(-3.3954)	(3.5721)	(-0.4300)	(-2.7641)
OD/se	0.0365**	-0.0615*	-0.0234	0.0288***
	(2.1286)	(-1.6992)	(-1.1016)	(-4.3512)
AS/se	-0.1276*	-0.0976*	-0.0921*	-0.1159***
	(-1.8045)	(-1.8793)	(-1.7635)	(-3.6127)
NL/se	0.1413***	-0.1275**	-0.1068*	0.1391***
	(3.5621)	(-2.4038)	(-1.9172)	(5.0020)
R-squared	0.3826	0.4120	0.1085	0.4637
Ramsey Reset test	F(3,765)=1.09 Prob>F=0.0863[e]			

Notes: **, *** denote statistical significance at 5% and 1% levels respectively; t-values are reported in parentheses (dependent variable: t-statistic); [a] Cluster data analysis presents the MRA results with cluster-robust standard errors; [b] REML presents the MRA results with restricted maximum likelihood; [c] MM presents the MRA results with the moment estimator; [d] EB presents the MRA results with the empirical Bayes iterative procedure; [e] The Ramsey reset test rejects the null at all levels of statistical significance, indicating an incorrect specification of the model.

Table 5. Meta-regression analysis with dummies for publication in academic journal and the publication year

Moderator variables	Cluster[a]	REML[b]	MM[c]	EB[d]
ANTSE=1/se	1.2998***	0.8826**	0.8109**	1.5128***
	(4.1763)	(2.3956)	(2.7615)	(5.0679)
Intercept	1.0976***	1.1123***	1.1054*	1.2575***
	(3.4150)	(3.6738)	(1.7811)	(3.5016)
SZ	-1.0971	-0.7543	-0.7128	-0.5342
	(-1.000)	(-1.0148)	(-0.9512)	(-1.0510)
TEXP/se	-0.0147**	-0.0183**	-0.0234	-0.0311***
	(-2.2456)	(-2.5413)	(-1.1016)	(-4.3965)
SEXP/se	-0.1468*	-0.1025**	-0.1382	-0.1194**
	(-1.7069)	(-2.3419)	(-0.9754)	(-2.5423)
BEXP/se	-0.1086	0.2618	0.1934	0.0671*
	(-1.0974)	(0.8561)	(1.0000)	(1.6984)
NM/se	0.1987**	0.1100***	-0.5612	-0.2506***
	(2.7965)	(3.8225)	(-1.3317)	(-3.5924)
SM/se	-0.0262*	-0.0317***	0.0354	-0.0328***
	(-1.8743)	(-4.2560)	(1.3061)	(-3.6540)
CROSS/se	-0.1230*	-0.1067*	-0.0038	-0.1513**
	(-1.7804)	(-1.9108)	(-1.0126)	(-2.6801)
PANEL/se	0.0097**	0.0154	0.0602	0.0115**
	(2.3515)	(1.0082)	(-1.0000)	(2.8916)
OLS/se	0.1143***	0.0983*	-0.1000*	0.1312***
	(6.0271)	(1.9874)	(-1.7219)	(4.3685)
DC*/se	-0.1657*	-0.1608*	-0.1421	-0.3015**
	(-1.8122)	(-1.7517)	(-1.8306)	(-2.6111)
DC/se	-0.0761*	0.0549*	-0.0513	-0.0811***
	(-1.8512)	(1.7263)	(-1.0024)	(-3.2469)
NT/se	0.0456	0.0182	0.0329	0.1125
	(1.0000)	(1.0009)	(1.1243)	(0.7641)
RT/se	0.1608***	-0.1239**	-0.1378**	0.1594***
	(3.2414)	(-2.5406)	(-2.5109)	(5.3248)
LF/se	-0.0895***	-0.0667*	0.1216	-0.0785***
	(-4.1132)	(-1.8315)	(0.8539)	(-3.6421)
HF/se	-0.0257***	-0.0218**	0.0500	0.0192***
	(-3.6410)	(-2.4476)	(1.1763)	(4.1534)
PER/se	-0.1233**	-0.1195***	0.0681*	-0.1303***
	(-2.7156)	(-3.2064)	(1.7053)	(-4.1154)
FER/se	0.1102**	0.1058*	0.0923***	0.1064*
	(2.6513)	(1.8362)	(3.7415)	(1.8972)
GTA/se	-0.1149	-0.0688*	0.1135	-0.0976***

	(-1.0007)	(-1.7954)	(1.1000)	(-4.2815)
RTA/se	0.0876*** (3.5501)	0.0601** (2.4438)	0.0505 (0.3419)	0.0803** (2.6419)
DFS/se	0.1125* (1.9032)	0.0854* (1.7312)	0.0632 (1.2810)	0.0924*** (3.2608)
IFS/se	-0.1768* (-1.9431)	-0.1305** (-2.5907)	0.0881 (1.4715)	-0.1792** (-2.6311)
ACP/se	-0.1017*** (-4.8329)	-0.0845* (-1.8357)	-0.0661* (-1.7695)	0.1203* (1.8234)
CCP/se	-0.1765* (-1.9923)	-0.2519 (-1.1376)	-0.1083 (-0.1695)	-0.1825*** (-3.7349)
PM/se	0.1286* (1.8053)	0.0985** (2.3174)	0.0754 (1.0102)	0.0826*** (4.3895)
PT/se	-0.1567** (-2.8019)	0.1215* (1.8235)	0.0872 (0.9651)	-0.1581* (-1.9146)
OD/se	-0.0671*** (-4.5423)	-0.0423** (-2.3862)	-0.1269 (-1.0004)	0.0455** (2.7120)
AS/se	-0.1019*** (-3.6234)	-0.0786** (-2.2514)	0.1819 (1.0123)	-0.1157** (-2.6329)
NL/se	0.0761* (1.8235)	-0.0518*** (-4.2867)	0.0634** (-2.2059)	0.0810*** (3.6124)
AJ/se	-0.0234*** (-3.5672)	-0.0210* (-1.7958)	0.0069 (0.8711)	-0.0351*** (-4.7248)
PUBY/se	0.0307 (1.0000)	-0.0094 (-1.2916)	0.0606 (0.9710)	0.1569 (1.3472)
R-squared	0.4015	0.4198	0.1976	0.4537
Ramsey Reset test	F(3,765)=1.13 Prob>F=0.0904[e]			

Notes: **, *** denote statistical significance at 5% and 1% levels respectively; t-values are reported in parentheses (dependent variable: t-statistic); [a] Cluster data analysis presents the MRA results with cluster-robust standard errors; [b] REML presents the MRA results with restricted maximum likelihood; [c] MM presents the MRA results with the moment estimator; [d] EB presents the MRA results with the empirical Bayes iterative procedure; [e] The Ramsey reset test rejects the null at all levels of statistical significance, indicating an incorrect specification of the model.

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