MEASURING THE ECONOMIC IMPACTS OF EXCHANGE RATE UNCERTAINTY ON INTERNATIONAL TRADE

by

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A Thesis Submitted to the Faculty of the

DEPARTMENT OF AGRICULTURAL AND RESOURCE ECONOMICS

In Partial Fulfillment of the Requirements
For the Degree of

MASTER OF SCIENCE

In the Graduate College

THE UNIVERSITY OF ARIZONA

2004

STATEMENT BY AUTHOR

This Thesis has been submitted in partial fulfillment of requirements for an advanced degree at The University of Arizona.

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ACKNOWLEDGEMENTS

Firstly, I would like to thank my major advisor, Dr. Gary D. Thompson for his careful guidance, patience, encouragement, and understanding. I truly know that without him this thesis would not have been accomplished.

I would also like to express my gratitude to the members of my committee, Dr. Alan Ker, and Dr. Satheesh Aradhyula. Their advice and recommendations were so important to the improvement of this thesis.

My dear husband encouraged me throughout this thesis. And my dear parents gave me spiritual support from far away. Their sincere love accompanied me during the difficult time.

Finally, many thanks to staff and friends for being supportive. A special thanks to Nancy Smith and Nancy Bannister for their encouragement and help. Zhihua, my friend, provided cheerful help. I thank them all.

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ABSTRACT

The general purpose of this thesis is to explore the economic impact of the real exchange rate uncertainty on bilateral trade flows. To accomplish the objective, two types of exchange rate uncertainty measurements are examined, different ways of constructing uncertainty measurements are explored, and a gravity model is specified and estimated. A panel data set is used spanning 1980 through 1992 for 10 developed countries: Belgium, Canada, France, Germany, Italy, Japan, Netherlands, Switzerland, United Kingdom, and United States. Econometric results indicate that the real exchange rate uncertainty has had a significant negative effect on trade over this period.

1. INTRODUCTION

Since the 1980s the world economy has become increasingly integrated, and bilateral trade has attracted considerable interest. What does increased integration have on international trade? Analyses of forces underlying trade development using trade gravity models with various commonly used explanatory variables, augmented by the exchange rate uncertainty variable, suggest a plausible result for policymakers.

Using the arguments in the preceding paragraph as motivation, this thesis has three objectives: (1) to describe the importance and evolution of measurements of exchange rate; (2) to identify the proper model specification; and (3) to measure the economic impact of the exchange rate uncertainty on bilateral trade flows. To accomplish the objective, a gravity model describing bilateral trade flows is constructed and estimated. By understanding the impact of exchange rate uncertainty, decisionmakers can comprehend the relationship between exchange rate uncertainty and trade. Also better trade policy can be formulated so that consumers have access to cheaper imports and better quality products, and producers are subjected to stronger competition and forced to innovate.

Why does exchange rate play such an important role in international trade? What is the benefit of studying it? How many types of exchange rates exist? And how many types of exchange rate uncertainty measurements are there? What is the best way to model exchange rate uncertainty? All of these questions will be explored in this thesis.

Chapter 2 presents a literature review of two parts: first, a review of the gravity trade models; and, second, a review of the exchange rate and exchange rate uncertainty measurements. The first section emphasizes that the gravity model has been and still is the standard model in empirical studies of international trade to measure bilateral trade flows. The rest of this chapter deals with the exchange rate uncertainty. It introduces the concepts needed to understand what are exchange rates, and approaches to the exchange rates uncertainty. It also highlights the most common and important reasons to construct measurement of exchange rates uncertainty.

Chapter 3 presents the econometric specification and justification for the model. In the first stage, a general OLS regression frame is described. Then, attention turns to fixed and random-effects model specifications. The expected signs for the coefficient estimates are also discussed.

Chapter 4 provides the empirical results, including analysis and discussion. The first aspect describes the construction and performances of two types of the exchange rate uncertainty measurements. One is the standard deviation of the first differences in the logarithmic exchange rate; the other is proposed by Perée and Stainherr. Interesting results owing to the use of different frequency exchange rate series are then discussed. The second aspect presents different specifications of the gravity model and assesses the performance of alternative models.

Finally, Chapter 5 will present the conclusions and directions of further research. The empirical evidence reported in this thesis suggests that long-run real exchange rate adversely affects trade flows between the 10 industrial countries under review. The two uncertainty measures show slightly different effects on trade when different frequencies of exchange rate observations are used to calculate them. And results might suggest using higher frequency exchange rate data to calculate the standard deviation measure gives better estimates. For future study, researchers should be directed towards testing different functional form of the gravity model.

Additionally, a comparison between using nominal exchange rate and real exchange rate to construct uncertainty measures should be preformed to give decisionmakers a better idea of which type of exchange rate will play a more important role in revealing how exchange rate uncertainty affects trade.

2. LITERATURE REVIEW

2.1 Gravity Model

Modelling and predicting foreign trade flows has long been an important task to international economists. From an economic modeling perspective, there are several ways to tackle this problem. One of the most fruitful ways has been the use of gravity-type models. Starting in the 1960s, H.Carey first applied Newtonian physics to the study of human behavior, Tinbergen (1962) and Pöyhönen (1963) suggested using the Newtonian gravity concept to explain bilateral trade. In its basic form, the amount of trade between two countries is assumed to be increasing in their sizes, as measured by their national incomes, and decreasing in the cost of transport between them, as measured by the distance between their economic centers. This standard gravity model was later augmented with many other explanatory variables, such as population size, trade bloc and currency union membership dummies, and indicators for common cultural characteristics (De Grauwe and Skudelny, 2000; Glick and Rose, 2001). In this thesis the real exchange rate has been taken into account. In this manner, one objective is to estimate the effects of exchange rate uncertainty on trade.

The gravity model has been used widely as a baseline model for estimating the impact of a variety of policy issues, including regional trading groups, currency unions, political blocs, patent rights, and various trade distortions. Typically, these events and policies are modeled as deviations from the volume of trade predicted by the baseline gravity model, and, in the case of regional integration, are captured by dummy variables. The recent popularity of the gravity model is highlighted by Eichengreen and Irwin (1998,p.33) who call the it the "workhorse of empirical studies of (regional integration) to the virtual exclusion of other approaches." This is despite the fact that, as Deardorff (1984) points out, most early papers were *ad hoc* rather than being based on theoretical foundations. Exceptions to this include Anderson (1979), Bergstrand (1985, 1989), Helpman (1987), Hummels and Levinsohn (1995), Deardorff (1998), and Feenstra, Markusen, and Rose (2001), whose models are consistent with the gravity model. See also Evenett and Keller (2002) who, along with Deardorff (1998), evaluate the usefulness of gravity models in testing alternative theoretical models of trade. The recent flurry of theoretical work has led Frankel (1998, p.2) to say that the gravity equation has "gone from an embarrassment of poverty of theoretical foundations to an embarrassment of riches." Altogether the main reason for the popularity of the gravity model is its success in its empirical power which is simply based on goodness of fit.

2.2 Exchange Rate Uncertainty Measurement

2.2.1 Definition, Types of Exchange Rates

The foreign exchange rate is the rate at which one currency may be converted into another; it is also called the rate of exchange or exchange rate or currency exchange rate. Exchange rates represent the linkage between one country and its partners in the global economy. They affect the relative price of goods being traded (exports and imports), the valuation of assets, and the yield on those assets. In the period of fixed or constant exchange rates these prices, values, and yields were predictable over time. However, since 1973 we have been living in a world of flexible rates where foreign exchange markets determine these rates based on interest rate differentials, differing rates of inflation, and speculation about future events. Exchange rates can be expressed as the foreign price of a domestic currency (i.e., the

Euro price of a U.S. dollar) or its reciprocal. In this thesis, the exchange rates are collected in the form of foreign currency per U.S. dollar.

The above rates represent nominal exchange rates in that they are the actual posted trading rates on foreign exchange markets. These particular rates can be used to find the domestic price of foreign goods. For example, suppose that we are interested in the price of a portable CD player manufactured in Japan, P_{Japan} =¥8060, if the exchange rate is: ¥124 = $1, then the domestic (U.S.) price of this same good is: $P_{U.S.}$ = $65 (8060/124). As exchange rates fluctuate, the domestic prices of foreign goods will often be affected. The weaker yen (it now takes more yen to buy a U.S. dollar) or stronger dollar (a dollar now buys more yen), has led to a reduction in the price of Japanese exports and U.S. imports. We would expect that this change will lead to an increase in the flow of goods from Japan to the U.S. However, trade flows are likely affected not by nominal exchange rates, but instead, by real exchange rates.

The information between nominal exchange rates and foreign/domestic prices of a common good can be expressed as a single value—the real exchange rate, ER_{real}, which can be calculated as : $ER_{real} = ER_{nominal}(CPI_{domestic} / CPI_{foreign})$. In constructing the real exchange rate this way we can think about how differences in rates of inflation among nations either affect this real rate and thus trade flows or perhaps lead to changes in nominal exchange rates.

2.2.2 What Is Measurement of Exchange Rates Uncertainty?

2.2.2.1 Definition and Different Types

When one attempts to measure the effects of exchange rate variability on trade, the first question to answer is "What is the best proxy for the uncertainty and adjustment costs that traders face as a result of exchange rate movements?" There is probably no unique answer to this question, as different types of uncertainty will be important for different kinds of enterprises or for the economy as a whole. There are issues concerning the measurement of the exchange rate itself: whether it should be bilateral or effective, real or nominal, and the appropriate way of measuring risk: a short-run versus long-run horizon, ex ante versus ex post, sustained deviations from trend versus period-to-period movements.

2.2.2.2 Reasons to Create the Uncertainty Measurements

There has been a considerable increase in the variation of bilateral exchange rates since the floating of exchange rates were initiated in the spring of 1973. For example, the dollar-mark rate has fluctuated by as much as 40 percent within periods of several months or less. Such fluctuations raise important questions about how much the risks associated with international transactions have increased and what impact the increase in risk has had on those transactions. There has been a controversy among economists to understand whether the break-down of the fixed exchange rate system has had a negative effect on international trade. The most common assertion has been that the risk associated with this exchange rate volatility has reduced the level of exports (Hooper and Kohlhagen). This is countered by the argument that use of forward markets could ameliorate risk in the short to medium run.

Many empirical studies have attempted to shed light on this issue, but the econometric evidence is ambiguous. For example, in early research, Cushman (1988) found a negative effect of flexible exchange rates on U.S. trade flows to other countries, while Klein (1990) found a positive effect. Both of these studies focused only on U.S. aggregate trade. Other notable studies include Thursby and Thursby (1987), Perée and Steinherr (1989), Frankel and Wei (1993), among others, all of which focus on world trade and find a negative impact of exchange rate volatility on trade. De Grauwe (1988) argues that real exchange rate misalignments will generate a net increase in protectionist pressures and therefore negatively affect trade. The idea is that producers in the countries whose currencies become overvalued and see their profits squeezed will organize themselves to pass protectionist legislation and that this legislation will tend to stay in place when the currency later drops and even becomes undervalued.

Until recently, there have been several empirical studies on this issue, based on the gravity model of trade, and also making use of panel data. For example, Rose uses bilateral trade for a panel of 186 countries, over the period 1970-90, finding a small, but statistically significant, negative effect of exchange rate volatility on trade.

Several empirical studies of international trade have measured the determinants and effects of bilateral trade patterns through gravity models for over thirty years (Bergstrand 1985; Deardorff 1998; Eichengreen and Irwin 1998; Sanso, Cuairan, and Sanz 1993).

There has been considerable theoretical work in the general area of the effects of uncertainty. For example, see Clark (1973), Ethier (1973), Heckerman (1973), and Baron (1976) for theoretical analyses of the effect of uncertainty on international transactions. And Leland (1972), Sandmo (1971) and Holthausen (1976) for more general analyses of the effect of uncertainty on the theory of the firm. There has also been some empirical analysis. Clark and Haulk (1972) investigated the effects of exchange rate fluctuations on the volume of Canadian trade during the 1950's Canadian dollar float (finding no significant impact).

Also another important issue in studying the effects of exchange rate uncertainty on trade is to distinguish between short- and medium/long-term changes in exchange rates. A common argument against using short-run variability is that exchange rate risk can be readily and cheaply hedged with appropriate short-term risk management instruments. Since short-run variability are more relevant for trading firms undertaking individual transactions in which purchase and selling price are known in advance. And it is well known that large corporations have adopted various strategies to cope with exchange rate volatility risk. On the other hand, hedging exchange rate uncertainty over a long horizon is much more difficult and costly. Because forward contracts are typically offered for relatively short horizons, and exchange needs can not be known with precision. In 1988, De Grauwe argued that trade is more likely to be affected by long-run variability in exchange rates rather than by the short-run variability. More recently, Obstfeld makes a similar observation that long-run exchange rate uncertainty is more likely to be a problem. However, attention has been on short-run exchange rate volatility according to recent literature on exchange rate variability. The effect of medium- to long-run exchange rate variability has been ignored whilst this is arguably more likely to have a more significant impact on trade.

As noted in previous sections, there is a widespread view that an increase in volatility will reduce the level of trade, even though there are mixed empirical results that are sensitive to the choices of sample period, model specification, proxies for exchange rate uncertainty, and countries considered. Some of recent studies that found negative effect of exchange rate uncertainty are listed in Table 2.1.

Table 2.1 Some of Recent Studies Finding Negative Effects of Exchange Rate Uncertainty on Aggregate Trade

Study	Data	Uncertainty Measure	Specification and Estimation Method	Main Results
Cushman (1983)	quarterly 1965-77 6 industrial countries	standard deviations of quarterly real exchange rate over a year	a model of market equilibrium that includes both import demand and export supply	6 out of 14 cases show negative effects on trade
Kenen and Rodrik (1986)	quarterly 1975I-1984III, except exchange rate is monthly; 11 industrial countries	3 measures of short-run real effective exchange rate uncertainty, in standard deviation form	estimate for global trade flows, OLS, with lag variables	negative effects for U.S. Canada, France, Germany, Netherlands, Sweden, and U.K., 7 countries' imports
Thursby and Thursby (1987)	annual 1974-82, except exchange rate is monthly 17 countries	variance of the spot (both real and nominal) exchange rate around its predicted trend	gravity model that allowing for the Linder hypothesis	significant negative effects for 10 countries.
Bélanger et al. (1988)	quarterly 1967-87 Canada-U.S.	squared of forecaset error defined as 90-day forward spread	U.S. export volumes to Canada: 5 sectors IVE, GIVE	significant and negative in two sectors
De Grauwe and Verfaille (1988)	annual 1979-85 bilateral trade among 15 industrial countries	variance of annual changes of real exchange rate	cross-section	negative effects on trade
Koray and Lastrapes (1989)	monthly 1961-71 1975-85 U.S. Bilateral trade	12-month moving standard deviation of growth rate of real exchange rate	U.S.bilateral import from 6 countries VAR	weak negative relationship
Perée and Steinherr (1989)	annual 1960-85 U.S., Janpan, U.K., W.G., Belgium	2 emasures of long-run uncertainty	aggregated export volume and bilateral exports to U.S. OLS	insignificant for U.S. aggregate equation, often significant negative in other equations
Bini-Smaghi (1991)	quarterly 1976-84 W.G., France, Italy intra-EMS trade	standard deviation of weekly rates of exchange of intra-EMS effective exchange rate within a quarter	prices and volums of exports of manufactured goods to EMS countries OLS	significant and negative effects in export volumes for all 3 countries

Table 2.1 Some of Recent Studies Finding Negative Effects of Exchange Rate Uncertainty on Aggregate Trade (continued)

Study	Data	Uncertainty Measure	Specification and Estimation Method	Main Results
Feenstra and Kendall (1991)	quarterly 1975-88 U.S.bilateral imports	GARCH model	import prices IVE, 3SLS	significant negative for U.K. and W.G., insignificant for Japan
Savvides (1992)	annual 1973-86 62 countries	standard deviation of change in exchange rate	cross-section	only unanticipated real exchange rate variability showssignificant negative effect
Frankel and Wei (1993)	annual 1980, 1985, 1990 63 countries	standard deviation of first difference of log of nominal (and real) exchange rate	cross-section OLS and IV	small effect, negative in 1980, positive in 1990
Rose (2000)	annual, 1970-90, 186 countries	standard deviation of the 1st-difference of the monthly natural log of the bilateral nominal exchange rate in 5 years preceding current period	gravity model, panel data estimation	negative effects on international trade
Cho, Sheldon, and McCorriston (2002)	annual 1974-95 10 industrial countries	standard deviation measure, and Perée and Steinherr measure 1 that using previous experience	panel data, fixed effects model	significant negative effects on agricultral trade, less significant negative effects on other sectors.

This thesis studies the effect of medium- to long-run exchange rate uncertainty on bilateral trade using a sample of bilateral trade flows across ten developed countries between 1980 and 1992. Two types of measures of uncertainty are used, one is the standard deviation of the first differences in the logarithm of real exchange rate. The other is proposed by Perée and Steinherr, whose central idea is that agents' uncertainty is based on previous experience where they remember the highs and lows of the previous period, adjusted for the experience of the last year relative to some idea of the "equilibrium" exchange rate.

2.3 Location of This Thesis in Literature

While short-run volatility may be hedged successfully, long-run exchange rate uncertainty is more likely to be a problem. However, attention has been on short-run exchange rate volatility even though medium- to long-run exchange rate variability is more likely to have a more significant impact on trade. This thesis emphasizes the effect of medium- to long-run exchange rate uncertainty on trade. In examining the exchange rate uncertainty, different frequency data series are used to analyze whether more frequently measured movements in real exchange rates have discernible effects in empirical models. Also, a gravity model is applied which allows for cross-country determinants of trade including income, distance, common border, common language and exchange rate uncertainty. In addition, with panel data a fixed effects model (FEM) and random effects model (REM) are applied to captures those time-invariant country and time-specific effects that can not be done with a simple ordinary least square (OLS) regression. Therefore, better explain the relationship between trade and explanatory variables.

3. THE GRAVITY MODEL

3.1 Initial Gravity Model Using OLS Regression

The foregoing literature review shows gravity models explaining bilateral trade patterns have become increasingly popular in recent years. Their application has been encouraged by a theoretical literature that has developed the micro-foundations for the gravity model. The gravity model has performed well explaining trade flows between countries, although the model does not distinguish whether trade is inter- or intra-industry. Consistent with the underlying micro-foundations, countries' gross domestic products provide a positive stimulant to trade, as do the countries' population. The standard gravity model also includes other variables that may affect the volume of trade between two countries including the existence of a common language, and a common border. Exchange rate variability can also influence the level of trade between two countries. The anticipated sign is negative, indicating that higher levels of uncertainty decrease trade.

Following recent articles in the literature, the initial gravity model is specified as

$$\begin{aligned} \ln TRADE_{ij,t} &= \beta_0 + \beta_1 \ln(Y_{it} Y_{jt}) + \beta_2 \ln(Pop_{it} Pop_{jt}) + \beta_3 \ln Dis_{ij} \\ &+ \beta_4 Lang_{ij} + \beta_5 Border_{ij} + \beta_6 UM_{ij,t} + \varepsilon_{ij,t} \end{aligned} \tag{3.1}$$

where $TRADE_{ij,t}$ is gross bilateral trade in time t (imports plus exports in thousand dollars) between countries i and j, with imports by i from j proxied by exports from j to i, $Y_{it}Y_{jt}$ is the product of countries i and j's GDP (in billion dollars) in period t, $Pop_{it}Pop_{jt}$ is the product of population between country i and j in period t, $UM_{ij,t}$ is a measure of exchange rate uncertainty, Dis_{ij} is a measure of distance between i and j, and $Lang_{ij}$ is a dummy variable which is 1 if countries share a common language and is zero otherwise.

$Border_{ij}$ is a dummy variable which equals 1 if countries share a common border and is zero otherwise.

Estimating this preliminary model (3.1) with ordinary least square regression and using different uncertainty measures, we can get some idea of how different constructions of uncertainty measures will affect international trade flows. Some interesting patterns will be found. The same model can then be estimated as a fixed and random effect model for consistent and more efficient estimation.

3.2 Fixed Effects Model versus Random Effects Model

Until the early 1990s, most studies in the vast empirical literature on gravity models have employed a cross-sectional data. And the perceived empirical success of the gravity model has come without a great deal of analysis regarding its econometric properties. The empirical power has usually been advanced simply on the basis of goodness of fit; i.e. a relatively high R^2. Recently though, several papers have argued that standard cross-sectional methods yield biased results because they do not control for heterogeneous trading relationship. Consequently, a panel framework using data over time for the same cross-sectional units has been used for several reasons. For one, panel data allow analysis of the dynamic relationships, which cannot be adjusted with a single cross section. Panel data also allow researchers flexibility in modeling differences in behavior across countries, also referred to as the time invariant country-specific effects[1], thereby obtaining consistent estimators in the presence of omitted variables (Egger, 2000). The studies by Mátyás (1997), Rose (2000), Cheng and Wall (2002) employ panel data for their estimation.

With panel estimation, the question arises whether a random-effects model or a

[1] This study actually estimated the country-pair specific effects, for simplicity, the country-pair specific effects are just stated as country-specific effects.

fixed-effects model should be employed? The effects of the unobserved variables (also referred to as unobserved components, latent variables, and unobserved heterogeneity) can be investigated first. Fixed effects are due to omitted variables that are specific to cross-sectional units (exporting and importing countries' individual effects) or to time periods (Hsiao, 1986). Some of the main forces behind the fixed export effects should be tariff policy measures as well as environmental policies potentially affecting trade. The first type of forces can be thought of as tariff or non-tariff barriers (tariffs, taxes, duties, bureaucratic legal requirements, etc.) either on the exporting or importing countries. The second type of forces can include size of country (proxied by GDP and population), geographical and historical determinants. As most of these effects are not random but deterministically associated with certain historical, political, geographical and other facts, a fixed effects model could be the right choice from this intuitive point of view.

The data used here have ten countries from 1980 to 1992 resulting in a panel of 45 country pairs over 13 years. The form of the cross section and time series gravity model used to describe the international trade flows is given as:

$$\ln TRADE_{ij,t} = \beta_1 \ln(Y_{it}Y_{jt}) + \beta_2 \ln(Pop_{it}Pop_{jt}) + \beta_3 \ln UM_{ij,t} + \varepsilon_{ij,t} \tag{3.2}$$

Variables for distance, common language, and common border are excluded since the fixed effects model cannot estimate the effect of any time-invariant variables. These time-invariant variables are wiped out during the least squares dummy variable estimation; alternatively they are spanned by the individual dummies. And because we want to compare the results across fixed effects model and random effects model, the time invariant variables are also excluded from the random effects model. Since our interests focus on the effect of exchange rate uncertainty, it is convenient not to worry about modeling time invariant factors here. The intercept is also omitted, since individual dummies will capture that effect.

The error components $\varepsilon_{ij,t}$, can take different structures, and the performance of any estimation procedure for the model regression parameters depends on the statistical characteristics of the error components in the model. The specification of error components can depend solely on the cross section to which the observation belongs, such a model is referred to as a model with one-way effects. A specification that depends on both the cross section and time series to which the observation belongs is called a two-way effects model. The specification for the one-way model is $\varepsilon_{ij,t} = \omega_{ij} + e_{ij,t}$; and the specification for the two-way model is $\varepsilon_{ij,t} = \omega_{ij} + \theta_t + e_{ij,t}$. The term ω_{ij} is intended to capture the heterogeneity across individual country pairs (country *i* and country *j*) and the term θ_t represents the heterogeneity over time. Furthermore, ω_{ij} and θ_t can either be random or nonrandom. Whether ω_{ij} and θ_t are properly viewed as random variables or parameters to be estimated is what distinguishes random effects model from fixed effects model.

In the traditional approach to panel data models, errors represent random effects and are treated as random variables. Whereas with fixed effects, errors are treated as parameters to be estimated for each cross section unit of country pair ij and each time period t. T. Mundlak (1978) made a persuasive argument that the key issue involving $\varepsilon_{ij,t}$ is whether or not it is uncorrelated with the observed explanatory variables. $e_{ij,t}$ is the classical error term with zero mean and a homoscedastic covariance matrix.

The nature of the error structures leads to different estimation procedures depending on the specification. If the effects are fixed, the models are essentially regression models with dummy variables corresponding to the specific effects, and ordinary least squares (OLS) estimation is best linear unbiased. The other alternative is to assume that the effects are random. In the one-way case, $E(\omega_{ij}) = 0$, $E(\omega_{ij}^2) = \sigma_\omega^2$, for i, j=1, 2, ···, 10, $i \neq j$; and $E(\omega_{ij}\omega_{ik}) = 0$ for i, j, k = 1, 2, ···, 10, $i \neq j$, $j \neq k$; and ω_{ij} is uncorrelated with $e_{ij,t}$ for all ij and t. In the two-way case, in addition to all of the preceding, $E(\theta_t) = 0$, $E(\theta_t^2) = \sigma_\vartheta^2$ and $E(\theta_t\theta_s) = 0$ for $t \neq s$, and the θ_t is uncorrelated with the ω_{ij} and $e_{ij,t}$ for all ij and t. Thus, the model is a variance components model, with the variance components σ_ω^2 and σ_ϑ^2, as well as σ_e^2, to be estimated. For random effects models, the estimation method is a feasible generalized least squares (FGLS) procedure that involves estimating the variance components in the first stage and using the estimated variance covariance matrix thus obtained to apply generalized least squares (GLS) in the second stage. For this study, the models will be estimated using one way and two way for both fixed and random effects methods. F and Hausman's tests are used to evaluate the appropriateness of the model specifications.

3.3 Expected Signs of Coefficients

Gross domestic product (GDP) usually measures the economic sizes of the exporting and importing countries in terms of available goods. One would expect a country with higher real GDP tends to trade more. The population helps to define production capability of the exporting countries, and the potential overseas markets. A positive sign is expected. The distance variable in the first model (3.1) is a proxy for transportation costs; distance also indicates the time elapsed during shipment, which may impede trade. Therefore, a negative sign is anticipated. For common language in the first model, one would expect two countries in which the same language is spoken will trade more than those not sharing a common language. Part of the reason is probably the shared history that caused the two countries to share a language. Also, in the first model, border effects are expected to be positive since sharing a common border seems to stimulate bilateral trade flows. Finally, exchange rate uncertainty is expected to have a negative influence on trade flows in both models (3.1) and (3.2), indicating that higher levels of uncertainty decrease trade.

3.4 Sample Data

In this section, a brief description of the data is presented. A more detailed description of the data sources is provided in Appendix A. The sample period covers 13 years from 1980 to 1992 while exchange rates span the period from 1970 to 1992. The countries included are 10 developed countries: Belgium (with Belgium and Luxembourg treated as a single country), Canada, France, Germany, Italy, Japan, Netherlands, Switzerland, the United Kingdom, and the United States. Figure1 reports the total bilateral trade flows of the 10 sample countries, taken together these countries accounted around 46% of total world exports in 1985. The total trade flow decreased before 1983,

Figure1: Total Trade Flows of 10 Countries
(1980=100 U.S.Dollars)

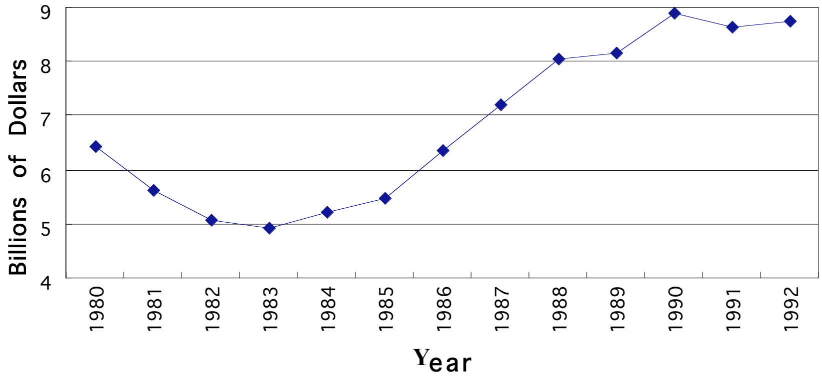


Figure 2: Total GDP of 10 Countries
(1980=100 U.S.Dollars)

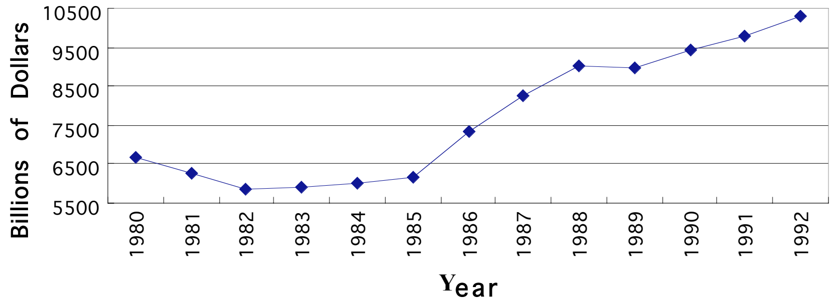
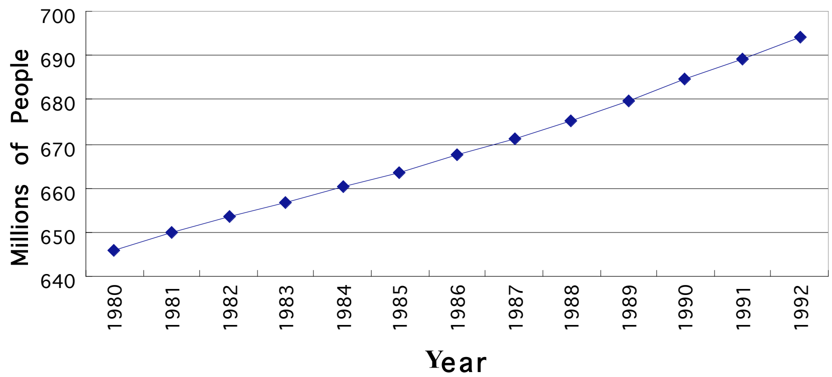
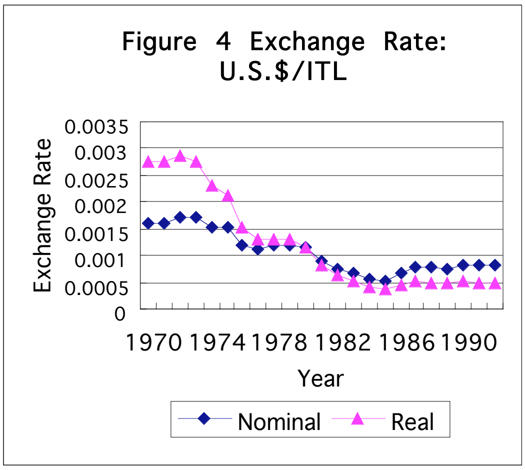
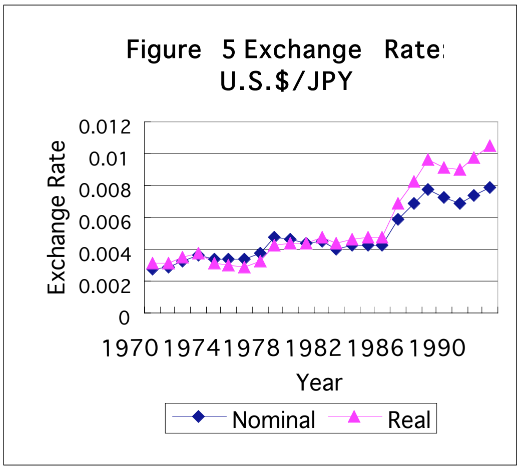


Figure 3: Total Population of 10 Countries







and kept increasing since 1983 to 1992, while the total gross domestic product of those 10 countries followed the same pattern (Figure2). Total population grew monotonically during that period (Figure 3).

Figure 4 and 5 individually show the changes of real and nominal exchange rates for the U.S.$/ITL, and U.S.$/JPY before and after the Bretton Woods system collapse. The exchange rate volatility increased dramatically since 1973 for both cases, while the exchange rate volatility show different patterns for the two currencies. Except for Italy, all other sample countries' exchange rates (represented as U.S. dollar versus foreign currency like U.S.$/JPY here) have experienced increases. Italy's exception might due to some exchange rate management policies associated with membership of the European monetary system for Italy during 1980s.

Table 3.1 Average Annual Growth Rates of Population for Sample Countries 1980-1992

Growth Rates	BEL[2]	CAN	CHE	FRA	GBR	GER	ITA	JPN	NLD	USA
1980-85	0.06	1.10	0.47	0.52	0.13	-0.09	0.08	0.67	0.53	0.97
1986-92	0.27	1.35	0.73	0.48	0.33	0.53	0.07	0.42	0.67	0.98

Table3.2 Population for Sample Countries at Mid-point 1986 (thousands of people)

Country	BEL	CAN	CHE	FRA	GBR	GER	ITA	JPN	NLD	USA
Population	9859	26100.6	7573	56935.2	56852	77690	56596.2	121490	14567	240682

Table 3.3 Average Annual Growth Rates of Real GDP for Sample Countries 1980-1992 (1980=100)

Growth Rates	BEL	CAN	CHE	FRA	GBR	GER	ITA	JPN	NLD	USA
1980-85	-13.13	-1.49	-6.04	-12.97	-9.40	-8.32	-14.78	2.32	-9.20	3.03
1986-92	13.46	3.09	11.73	11.60	7.35	11.82	9.77	14.83	13.16	2.05

Table3.4 Real GDP of Sample Countries at Mid-point 1986 (in billion U.S.$,1980=100)

Country	BEL	CAN	CHE	FRA	GBR	GER	ITA	JPN	NLD	USA
Real GDP	81.0	247.6	111.2	456.8	382.3	740.1	62.8	1754.9	151.5	3355.3

Table 3.5 Average Annual Growth Rates of Bilateral Trade for Sample Countries 1980-1992

Growth Rates	1980-1985		1986-1992	
	North America	Europe	North America	Europe
North American[3]	2.46		2.37	
Europe	-2.99	-6.84	4.37	9.71
Japan	7.06	-0.59	4.38	15.33

[2] International Organization for Standardization (ISO) three-letter code for countries: BEL (Belgium), CAN (Canada), CHE (Switzerland), FRA (France), GBR (Great Britain), GER (Germany), ITA (Italy), JPN (Japan), NLD (Netherlands), USA (United Sates).

[3] For North America and Europe, intra-regional trade is displayed.

To have a better idea of the different characteristics of the selected 10 industrial countries, average annual growth rate of their population and trade volumes are displayed in tables 3.1 – 3.5. Trade values are compared based on different regions, such as North America (United States and Canada), Europe, and Asia (Japan). Generally, most of the sample countries have a greater increase in their population and real gross domestic products during the period of 1986-92. And trade flows between different regions also show a big jump during the same period, except for the trade flows between: Japan and North America, Canada and United States. Those numbers also show that in 1986, the United States has the largest population, which is about 30 times larger than Switzerland who has the smallest population. Japan has the second largest population. Interestingly, in terms of real gross domestic products, still, the United States and Japan rank the first and second in 1986.

4. ESTIMATION, RESULTS, AND HYPOTHESIS TESTS

This chapter consists of three parts. Firstly, methods of constructing different exchange rate uncertainty measures are described. Then, the main results from preliminary OLS regression are presented to give some basic idea of the behavior of all the different uncertainty measurements. More detailed information is addressed in the Appendix B. Next, fixed effects verses random effects models are estimated, and Hausman's test and F-test are performed in order to find whether REM and FEM are appropriate estimation specifications. Finally, attention is focused on the effects of different uncertainty measurements on trade under the FEM specification.

4.1 Different Uncertainty Measurements and Results from Initial Gravity Model Using OLS Regression

The focus of this thesis is on the potential impact of exchange rate uncertainty on trade. As noted earlier, it has been suggested that medium- to long-run variability of exchange rates is likely to be more significant than short-run volatility. Therefore, when choosing the uncertainty measurements, attention has been paid to the number of years used to calculate the measurements. Trade and other variables' annual observations start from 1980; real exchange rate data series starts from 1973 since the 1980 observation for exchange rate uncertainty measure takes into account the previous 7 years' exchange rate fluctuation. The reason for choosing a 7-year period is that the flexible exchange rate in developed countries started in 1973; therefore, in order to calculate the uncertainty of the year 1980, the farthest year back is 1973[4].

As to the frequency at which the exchange rate is measured, three different types of exchange rate data series are collected: annual, quarterly and monthly. But no

[4] Kenen and Rodrik (1986) argued that tests of exchange rate uncertainty should be restricted to the flexible exchange rate era.

matter which frequency data series are used, the uncertainty measures for each year are calculated using exchange rate data for seven years preceding the year for which a measure is reported (described henceforth as the current year). The construction of variability measures using different frequency data series is inspired by the argument of Eisgruber and Schuman (1963) that more variability might be captured by using more disaggregated data. Therefore, the expectation is that the higher the frequency of explanatory variables, the more variation in the dependent variable will be captured by those explanatory variables. But as is obvious, some explanatory variables, such as GDP and population, do not vary much within a month or a quarter. In contrast, the exchange rate fluctuates significantly even within a single day. Given the goal of this thesis is to investigate the impact of exchange rate on trade, the exchange rate uncertainty are calculated from monthly, quarterly and annual exchange rate observations.

Before explaining the uncertainty measures, it is necessary to convert all bilateral exchange rates into a common benchmark. For this purpose, all bilateral exchange rates were first deflated by each country's deflator (CPI) so that all exchange rates are real. Real rates were then converted into the U.S. dollars as a common benchmark. Details are presented in Appendix A.2.

A variety of uncertainty measures has been used in the literature. Typically, the measures used have been some variant on the standard deviation of the exchange rate. For example, the standard deviation of the percentage change in exchange rates or the standard deviation of the first differences in the logarithmic exchange rate. Two measures will be used to study the effect of exchange rate uncertainty on trade: one is the method of standard deviation of the first differences in the logarithmic exchange rate and the other is the method proposed by Perée and Steinherr (1989), modified by Sheldon (2002). Detailed discussion about the two types of method follows.

4.1.1 Standard Deviation Measurement

An ex-post measure of uncertainty is derived using a moving standard deviation of the first differences of the natural logarithm of the bilateral real exchange rate in the 7 years preceding period t. Thus, for the 1980 Belgium-Canada measure, the standard deviation of the first difference of the log Belgium-Canada real exchange rate is estimated using annual, quarterly, and monthly data from 1973 to 1979.

$$U_{ij,t} \equiv S_{ij,t} = \sqrt{\frac{\sum_{l=1}^{7}(x_{ij,t-l} - \bar{x}_{ij,t})^2}{6}} \tag{4.1}$$

where $x_{ij,t} = \ln e_{ij,t} - \ln e_{ij,t-1}$, $\ln e_{ijt}$ is the log of the real exchange rate between countries i and j at time t, and $\bar{x}_{ij,t} = \sum_{l=1}^{7} x_{ji,t-l} / 7$ is the mean of $x_{ij,t}$ over the previous 7 years. The formula is similar for quarterly and monthly data.

For quarterly data:

$$U_{ij,t} \equiv S_{ij,t} = \sqrt{\frac{\sum_{l=1}^{28}(x_{ij,t-l} - \bar{x}_{ij,t})^2}{27}} \tag{4.2}$$

For monthly data:

$$U_{ij,t} \equiv S_{ij,t} = \sqrt{\frac{\sum_{l=1}^{84}(x_{ij,t-l} - \bar{x}_{ij,t})^2}{83}} \tag{4.3}$$

The only difference between above three formulas is the frequency of exchange rates used to calculate the uncertainty measurement. The first formula uses annual observations, the second formula uses quarterly exchange rates, and the last uses monthly observations. Each formula uses the previous 7 years' data to calculate current year's uncertainty measure. Therefore, the more frequent the observations used in calculating the uncertainty measure, the more variation can be captured. That is, the method using the monthly exchange rate will be able to capture the most variation.

Since exchange rate uncertainty is calculated using annual, quarterly and monthly data, while all other variables in the model are annual data, a single value of the uncertainty measures needs to be chosen from high frequency data series to represent each year. There are three groups of experiments done in order to check whether the results are sensitive to different values chosen to represent quarterly and monthly data. The three values generated were the last period (quarter or month), the mean, and the median of the higher frequency data series of each year.

The econometric results from preliminary OLS regression(shown in Appendix B.1, Table B.1 and B.2) indicate that the coefficient estimates for uncertainty measure all have anticipated negative signs, and the uncertainty measures calculated from higher frequency data explain more variation in the dependent variable. And among different values of the uncertainty measure picked, the last period, the mean, and the median, the mean values are slightly more significant than the other two. Interestingly, the parameter estimates for other explanatory variables in the model do not change much across the three uncertainty measures that are calculated from different frequency data series and no sign changes occur.

4.1.2 Perée and Steinherr Measurement

Instead of using the variance of exchange rates as a proxy for risk uncertainty, Perée and Steinherr proposed another measure. They argued that variances over past periods are of very limited relevance for appreciating uncertainty over periods of several years in the future. Therefore, their method's central feature is that agents' uncertainty is based on previous experience where they remember the highs and lows of the previous periods, adjusted for the experience of the last year relative to some idea of the "equilibrium" exchange rate. Specifically, they propose

$$V_{ij,t} = V_{ij,t}^{1} + V_{ij,t}^{2} = \frac{\max(X_{ij,t-10}^{t}) - \min(X_{ij,t-10}^{t})}{\min(X_{ij,t-10}^{t})} + \left[1 + \frac{\left|X_{ij,t} - X_{ij,t}^{p}\right|}{X_{ij,t}^{p}}\right]^{2} \qquad (4.4)$$

where $X_{ij,t}$ is the nominal exchange rate at time t, $\max(X_{ij,t-10}^{t})$ and $\min(X_{ij,t-10}^{t})$ refer to maximum and minimum values of the nominal exchange rate over 10 years up to time t, and $X_{ij,t}^{p}$ is the 'equilibrium' exchange rate. There is no obvious way to measure accurately the equilibrium exchange rate, $X_{ij,t}^{p}$, over the previous period. They prefer to use a sophisticated approach for the computations of the equilibrium exchange rate, derived from Williamson's study. $V_{ij,t}^{1}$ captures accumulated experience, and $V_{ij,t}^{2}$ adds more recent information to the historical component $V_{ij,t}^{1}$, as measured by deviations of the exchange rate $X_{ij,t}$ from the 'equilibrium' exchange rate $X_{ij,t}^{p}$.

Cuedae Cho, Ian M.Sheldon, and Steve McCorriston (2002) adopted Perée and Steinherr's method, but made some changes. Instead of using the nominal exchange rate, they used the real exchange rate. Also, they emphasized more the accumulated past experience and removed the square from the $V_{ij,t}^{2}$. As for the "equilibrium" exchange rate, they used the mean of the exchange rate over the previous 10 years as a proxy for $X_{ij,t}^{p}$.

In this thesis, the Perée and Steinherr measure is also modified following Cho, Sheldon and McCorriston. In this way, both the standard deviation measure and the Perée and Steinherr measure use real exchange rates, and attempt to use historical information to cast light on the unknown future. Therefore, comparison can be more properly made between the standard deviation measure and the Perée and Steinherr measure. The modified measure used in this thesis is

$$V_{ij,t} = V_{ij,t}^{1} + V_{ij,t}^{2} = \frac{\max(X_{ij,t-7}^{t}) - \min(X_{ij,t-7}^{t})}{\min(X_{ij,t-7}^{t})} + \left[1 + \frac{\left|X_{ij,t} - X_{ij,t}^{p}\right|}{X_{ij,t}^{p}}\right] \tag{4.5}$$

where $X_{ij,t}$ is the real exchange rate at time t, $\max(X_{ij,t-7}^{t})$ and $\min(X_{ij,t-7}^{t})$ refer to maximum and minimum values of the real exchange rate over 7 years up to time t, and $X_{ij,t}^{p}$ is the "equilibrium" exchange rate, proxied by mean of the real exchange rates over the previous 7 years.

As with the standard deviation measure, the Perée and Steinherr measure is recalculated for each year, each quarter, and each month of the data, following the same calculation comparison as was conducted with the standard deviation measure.

Preliminary OLS results (in Appendix B.2, Table B.3 and B.4) show some interesting patterns. The first thing to note is that the coefficient estimates for the uncertainty measures, V, have the expected negative signs, and are all statistically significant, but do not change much across three uncertainty variables calculated from different frequency exchange rate observations. Also, parameter estimates for other explanatory variables in the model do not change much across different measurements; no sign changes occur. However, the magnitude of the coefficient estimates for the Perée and Steinherr measure is dramatically smaller than those estimates for the uncertainty measure U.

4.1.3 Comparison of the Standard Deviation Measure and the Perée and Steinherr Measure

How can the different behaviors of the two uncertainty measures can be explained? The descriptive statistics for the two uncertainty measurements from the table

(4.1) might give some idea. The standard deviation of the U variables decreases when the frequencies of the exchange rate series increase. But for the V variables, the reverse is true. Secondly, the descriptive statistics show that within the same frequency group, whether the last period value, mean value, or the median is chosen has little effect on the value of the uncertainty measures.

Table 4.1: Summary Statistics for Different Uncertainty Measurement Variables (calculated using different frequency observations of real exchange rate) U-standard deviation measure; V- Perée and Steinherr measure

Uncertainty Measurement	Statistics	Annual	Quarterly				Monthly			
			Last Period	Mean	Median	Full	Last Period	Mean	Median	Full
U	N	585	585	585	585	2340	585	585	585	7020
	Mean	0.094	0.041	0.041	0.041	0.041	0.022	0.022	0.022	0.022
	Std Dev	0.049	0.016	0.016	0.016	0.016	0.008	0.008	0.008	0.008
	Min	0.007	0.007	0.007	0.007	0.006	0.003	0.004	0.004	0.003
	Max	0.209	0.067	0.067	0.067	0.068	0.035	0.035	0.034	0.035
V	N	585	585	585	585	2340	585	585	585	7020
	Mean	2.090	2.227	2.258	2.257	2.258	2.287	2.316	2.311	2.316
	Std Dev	0.822	0.919	0.931	0.932	0.936	0.961	0.961	0.961	0.967
	Min	1.039	1.046	1.052	1.050	1.046	1.052	1.054	1.054	1.048
	Max	6.544	7.435	7.203	7.256	7.435	7.740	7.411	7.372	7.948

Note: statistics for different U calculated using quarterly or monthly observations differ at the 5^{th} digit to the right of the decimal point. "Mean" indicates using mean value of the uncertainty measures within a year as the value for that year; while "Full" indicates keeping all uncertainty measure values calculated from quarterly or monthly exchange rate observations. Similar definitions for "Last period" and "Median".

However, the differences in the magnitudes of the estimated coefficients of U and V in the preliminary OLS results might be affected by the units of measure of the two types' uncertainty measures. In the preliminary OLS regression (model 3.1), estimates for uncertainty measures represent the following marginal effect:

$$\hat{\beta} = \frac{\partial \ln(Trade)}{\partial(UncertaintyMeasurement)} \qquad (4.6)$$

Different units of the uncertainty measurements will affect the value of $\hat{\beta}$, and make the comparison between the two different measurements spurious. In order to get rid of the effect of different units, model (3.1) is redefined as the equation (4.7), therefore, coefficient estimate $\hat{\tilde{\beta}}_6$ from model (4.7) will be the elasticity estimate for the exchange rate uncertainty measure.

$$\begin{aligned} \ln TRADE_{ij,t} &= \tilde{\beta}_0 + \tilde{\beta}_1 \ln(Y_{it}Y_{jt}) + \tilde{\beta}_2 \ln(Pop_{it}Pop_{jt}) + \tilde{\beta}_3 \ln Dis_{ij} \\ &+ \tilde{\beta}_4 Lang_{ij} + \tilde{\beta}_5 Border_{ij} + \tilde{\beta}_6 \ln UM_{ij,t} + \tilde{\varepsilon}_{ij,t} \end{aligned} \qquad (4.7)$$

$$\hat{\tilde{\beta}}_6 = \hat{E}^1 = \frac{\partial \ln(Trade)}{\partial \ln(UncertaintyMeasurement)} \qquad (4.8)$$

The corresponding elasticity estimates are reported in Table 4.2.

Table 4.2: Simple OLS Results for Two Types of Uncertainty Measurements (using different frequency exchange rate observations)

Variables	LnUyear	LnUquarter_mean	LnUmonth_mean	LnVyear	LnVquarter_mean	LnVmonth_mean
Elasticity	-0.108	-0.187	-0.191	-0.248	-0.245	-0.247
P-value	0.003	<.001	<.001	<.001	<.001	<.001

Results show that after removing the unit effect, the elasticity coefficient estimates of the two types measurements are very consistent with each other. Both have the negative signs and are very close in magnitude. Comparatively speaking, the V measures have slightly larger negative effects on trade. And for the standard deviation measure, the mean value calculated from monthly exchange rate observations performs best among the last period value and the median value. However, for the Perée Steinherr measure, elasticity estimates remain quite stable across three uncertainty variables calculated from different frequency exchange rate observations. These results indicate that although uncertainty can be captured in different ways, total trade is negatively affected by exchange rate uncertainty. Although the magnitude of the effects is very small, the effects are very statistically significant. For simplicity, the mean values of the uncertainty measures within a year are to be used to represent that year's uncertainty measure for further investigation of the fixed effects model versus random effects model.

4.2 Fixed Effects Model versus Random Effects Model Results

The data contains 10 countries, giving 45 possible trading pairs as cross sectional units; the data series cover a period of 13 years (1980-1992). This panel data set is balanced since it has the same numbers of time series observations across each cross section. That right-hand side of the model cannot include time-constant explanatory variables _ distance and dummies for common language or border must be a drawback in certain applications. But when interest focuses on time-varying explanatory variables, such as exchange rate uncertainty here, it is convenient not to have to worry about modeling time-constant factors that are not of direct interest. Generally, only when the time invariant variables are estimated, do researchers use the random effects models.

The one-way and two-way model for both fixed and random effects models were estimated, in order to choose the final specification. Two sets of hypothesis tests were performed. The effects of exchange rate uncertainty will be examined based on the preferred specification.

4.2.1 F-Test to Jointly Test the Country and Time Specific Effects

For a one-way FEM, a F-test is used to jointly test the significance of country specific effects, the null hypothesis is $H_0: \omega_{ij}=0\ \forall$ ij, where ω_{ij} is the country specific effects. The test statistic is

$$F = \frac{(RSS_R - RSS)/N}{RSS/(NT - N - K)} \qquad (4.9)$$

Under the null hypothesis, the above quantity has an F-distribution with degrees of freedom given by the deflators in the numerator and denominator, and where RSS_R and RSS are the residual sum of squares from the restricted and unrestricted models respectively. N (=45) is the number of cross section units, T (=13) is the number of time periods, and K is the number of explanatory variables.

For the two-way FEM F-test, a F-test is employed to jointly test the significance of country and time-specific effects. The null hypothesis $H_0: \omega_{ij}=\theta_t=0\ \forall$ ij and t, where θ_t is the time specific effects. The test statistic is

$$F = \frac{(RSS_R - RSS)/(N + T - 1)}{RSS/(NT - N - T - K + 1)} \qquad (4.10)$$

The large F-test statistic values shown in Table 4.3 significantly reject the null hypothesis in both one-way and two-way FEM. This strongly suggests the presence of individual specific effects and time effects in the data. Without taking into account those unobserved effects, estimation will suffer from omitted variable bias. Therefore, inference that drawn from biased estimate will be misleading and incorrect.

Table 4.3 F-test for Joint Fixed Effects

_	_	one-way		two-way	
		test stat	P-value	test stat	P-value
LnU	Annual	854.10	<.0001	525.00	<.0001
	Quarterly	932.10	<.0001	916.60	<.0001
	Monthly	933.47	<.0001	917.90	<.0001
LnV	Annual	1204.31	<.0001	1224.41	<.0001
	Quarterly	1164.39	<.0001	1176.94	<.0001
	Monthly	1152.57	<.0001	1164.23	<.0001
Numerator/Denominator Degree of Freedom		45 / 537		57 / 525	

4.2.2 Hausman's Test Comparing the Fixed Effects and Random Effects Estimators

The Hausman's specification test is the classical test of whether the fixed or random effects model should be used. This test is based on the idea that, under the null hypothesis H_0: $E(\varepsilon_{ij,t} / X) = 0$, which means there is no correlation between the unobserved country-specific random effects variables and the regressors. OLS estimates of the FEM and GLS estimates of the REM are consistent, but OLS is inefficient. However, if H_0 is not true, the REM remains consistent, while the REM is not. Hence, a test can be based on the result that if there is no statistically significant difference between the covariance matrices of the two models, then the correlations of the random effects with the regressors are statistically insignificant. The Hausman's test has k degrees of freedom (where k=number of explanatory variables). The test statistic is

$$m = (\hat{\beta}_{FE} - \hat{\beta}_{RE})'[Var(\hat{\beta}_{FE}) - Var(\hat{\beta}_{RE})]^{-1}(\hat{\beta}_{FE} - \hat{\beta}_{RE}) \qquad (4.11)$$

which is asymptotically distributed as χ_k^2 under H_0. Rejection of the null hypothesis might suggest that the fixed effects model is more appropriate. The test results are shown in Table 4.4.

Table 4.4 Hausman's Test for Random Effects

		one-way		two-way	
_	_	test stat	P-value	test stat	P-value
LnU	Annual	5.92	0.116	45.21	<.0001
	Quarterly	4.83	0.185	23.32	<.0001
	Monthly	2.09	0.554	17.79	<.0001
LnV	Annual	11.76	0.011	41.62	<.0001
	Quarterly	11.18	0.011	36.10	<.0001
	Monthly	11.17	0.008	35.25	<.0001
Chi-square Degrees of Freedom		3		3	

The outcomes from the Hausman's χ^2 test tend to favor the FEM which is as expected to be. The fixed effects model is an appropriate specification if we are focusing on a specific set of N country pairs while the random effects model is appropriate if we are drawing N individuals randomly from a large population. Surprisingly, the null cannot be rejected in the cases of one-way REM using the standard deviation uncertainty measure. However, from the parameter estimate point of view, the null indicates that the two estimation methods are both consistent (but the REM is more efficient). Therefore, the two estimations should yield coefficients that are "similar". The alternative hypothesis is that the fixed effects estimation is appropriate and the random effects estimation is not; if this is the case, then we would expect to see differences between the two sets of coefficients, which is so for the two-way REM (see Appendix B.3, Table B.5 and B.6). The Hausman test statistics are very big, and both significantly reject the null, and the coefficients from the two-way REM are quite different from those in the two-way FEM, the differences are big enough to be obvious. This fact clearly shows that two-way REM is not a proper estimation method here. This is because the random effects estimator is based on the assumption that the random effects are orthogonal to the regressors whereas the fixed effects estimator does not require that assumption. If the assumption is wrong, this will be reflected in a difference between the two sets of coefficients. The bigger the difference (the less similar are the two sets of coefficients) is, the bigger the Hausman statistic is. A large and significant Hausman statistic means a large and significant difference in the coefficients from the REM and FEM.

4.3 FEM Estimation Results

The foregoing hypothesis tests favor the FEM, so that uncertainty measure effects will be investigated using the FEM. As mentioned earlier, elasticities can remove the units of the measures, allowing comparison across different exchange rate uncertainty measures. Elasticities of uncertainty measures are calculated in two ways in order to check the robustness of the results. First way E^1 (shown in equation 4.8) gives a constant value across all observations, while the second way does not assume constant elasticities.

$$E_{ij,t} = \frac{\partial(LnTrade_{ij,t})}{\partial(UncertaintyMeasurement_{ij,t})} * (UncertaintyMeasurement_{ij,t}) \qquad (4.12)$$

$$E^2 = \frac{1}{NT}\sum_{ij,t} E_{ij,t} \qquad (4.13)$$

Elasticity E^1, E^2 for the standard deviation measure and Perée Steinherr measure (each calculated from different frequency data series), and their standard deviation are shown in Table 4.5 and 4.6 for FEM. The information contained in the two tables reveals several interesting tendencies.

First, when comparing the elasticities for the two different uncertainty measurements _ the standard deviation measure and the Perée and Steinherr measure _ generally the former has slightly larger magnitude than the latter one. Secondly, within the standard deviation uncertainty measurement, the magnitude of elasticity estimates always increase when the frequency of the exchange rate observations used to calculate that uncertainty measure increases, as well as the standard deviations of those estimates. It seems that the higher frequency of the explanatory variable, the more variation of the dependent variable can be explained. However, the Perée and Steinherr measure, which is based on historical experience rather than using variance of exchange rates, does not change much when the frequency of the exchange rate observations used for calculation increases. Thirdly, the two different ways used to calculate the elasticity result in quite different values for the standard deviation uncertainty measure, but not for the Perée and Steinherr measure. E^2 usually gives larger elasticity estimates, which again is possibly due to the its ability to capture more variation.

Finally, elasticities are quite different across specifications. The two-way FEM specification produces smaller estimates for uncertainty measures than does the one-way FEM. While elasticity estimates for other explanatory variables (GDP, population) are larger in magnitude under two-way FEM than those under one-way FEM.[5] This might suggest that without including the time-specific effects, the model would have exaggerated the negative effects of exchange rate uncertainty and under estimated effects of GDP and population.

[5] Estimates for other explanatory variables are reported in the Appendix B.3, table B.5 and B.6.

* Table 4.5 Elasticity E1			U			V		
			Annual	Quarterly	Monthly	Annual	Quarterly	Monthly
FEM	one-way	Estimator	-0.058	-0.127	-0.147	-0.089	-0.096	-0.096
		Std Err	0.015	0.020	0.023	0.019	0.018	0.018
	two-way	Estimator	-0.030	-0.041	-0.061	-0.034	-0.046	-0.048
		Std Err	0.014	0.025	0.028	0.020	0.020	0.020

** Table 4.6 Elasticity E2			U			V		
			Annual	Quarterly	Monthly	Annual	Quarterly	Monthly
FEM	one-way	Mean	-0.081	-0.217	-0.249	-0.083	-0.089	-0.089
		Std Err	0.042	0.084	0.093	0.032	0.047	0.060
	two-way	Mean	-0.060	-0.122	-0.160	-0.038	-0.048	-0.049
		Std Err	0.031	0.047	0.060	0.015	0.020	0.021

Note: Numbers in above tables represent uncertainty measures' elasticity estimates and standard errors. U refers to standard deviation measure; V refers to Perée Steinherr measure. Annual, Quarterly, and Monthly present the frequency of exchange rate observations used to calculate uncertainty measure.

* The parameter estimates in table 4.5 are from the model (3.2): $\ln TRADE_{ij,t} = \beta_1' \ln(Y_{it} Y_{jt}) + \beta_2' \ln(Pop_{it} Pop_{jt}) + \beta_3' \ln U_{ij,t} + \varepsilon_{ij,t}'$, as shown in equation 4.8, $\hat{\beta}_3'$ is the elasticity estimate for uncertainty measure.

** The numbers in table 4.6 are the mean and standard deviation of the elasticities from equation 4.12, model used is:

$\ln TRADE_{ij,t} = \beta_1' \ln(Y_{it} Y_{jt}) + \beta_2' \ln(Pop_{it} Pop_{jt}) + \beta_3' U_{ij,t} + \varepsilon_{ij,t}'$

4.4 Estimates Comparison with Other Empirical Studies

In order to find out whether the values of the coefficient estimates obtained in this thesis are in the reasonable range, a comparison of the uncertainty measure estimates is made between several studies reviewed in previous chapters and this thesis. The comparison is displayed in Table 4.7.

Results show that the estimates from this thesis are within the range of the estimates from other studies even though no two model specifications or uncertainty measure constructions identical across all of these studies. And the comparison indicates that the majority of these estimates are quite close to each other in magnitude despite of their differences in model specification and sample data. A disadvantage of this comparison is that only one study (Cushman 1983) besides this thesis gives elasticity estimates for uncertainty measures. To better show the comparison, estimates for uncertainty variable not for its elasticity are also calculated using the final version of two-way fixed effects model, and are presented in the last row of the table. Not surprisingly those estimates still fall within the range reported in the literature with values close to those in Kenen and Rodrik's study.

This comparison suggests that the current study produces a reasonable range of the estimates for the exchange rate uncertainty effects.

Table 4.7 Range of Uncertainty Variable Estimates

Study	case with min estimate		case with max estimate		Note
Cushman (1983)	-0.036 (NA)	U.S.export to Canada	-0.065 (NA)	Japan export to U.S.	elasticity estimates
Kenen and Rodrik (1986)	-3.650 (-1.58)	France imports	-14.900 (-4.38)	U.S. imports	variable estimates
Thursby and Thursby (1987)	-0.010 (-0.03)	export of Finland	-3.910 (-3.47)	export of Japan	variable estimates
Perée and Steinherr (1989)	-0.004 (-0.08)	export of U.K.	-0.897 (-3.54)	export of Belgium	variable estimates
Bini-Smaghi (1991)	-0.010 (-2.47)	export of France	-0.017 (-2.20)	export of Germany	variable estimates
Savvides (1992)	-0.2213 (4.65)	export of less developed countries	-0.2601 (1.98)	export of developed countries	variable estimates
Rose (2000)	-0.002 (0.045)	OLS with fixed effects	-0.044 (-0.98)	OLS	variable estimates
Cho, Sheldon, and McCorriston (2002)	-0.026 (-0.64)	total trade of chemical sector	-0.672 (-13.9)	total trade of agriculture	variable estimates
Current Study (2004)	-0.030 (-0.25)	Two-way FEM using annual exchange rate using U variable	-0.249 (-0.82)	One-way FEM using monthly exchange rate using U variable	elasticity estimates
	-0.020 (-2.27)	Two-way FEM using annual exchange rate using V variable	-11.539 (-8.15)	One-way FEM using monthly exchange rate using U variable	variable estimates

Note: All values in parentheses are t-values, U variable refers to the standard deviation measure, V variable refers to Perée and Steinherr measure using previous experience. NA means not available.

5. CONCLUSION

Through a cross-sectional and time-series data set involving trade flows between ten developed countries for the period 1980-1992, this thesis demonstrates that the exchange rate uncertainty has negatively affected bilateral trade flows between ten industrial countries.

International trade is so important and complex that numerous studies have sought to explain it. Methods to examine the trade have been in highly diverse ways. The gravity model has been and still is the standard model in empirical studies. In this thesis, a gravity model was applied to estimate long-run exchange rate uncertainty effect on trade flows.

In order to explore the effects of long-run exchange rate uncertainty on trade, different types of uncertainty measures were used, and different frequencies of exchange rate observations were used to calculate the uncertainty measurements.

In the model specification, an initial gravity model is estimated using ordinary least squares. Results gave us some idea of how different uncertainty measures have affected trade. First, the signs of the uncertainty variables are unanimously negative. The standard deviation measure U tends to have a larger negative effect on trade when higher frequency exchange rate series are used to calculate U, while the Perée Steinherr measure V shows stable effect on trade across different versions of V variables calculated from different frequency exchange rate observations. Comparatively speaking, elasticity estimates for U and V are very close in terms of magnitude with V being slightly larger.

In the second stage, both fixed effects and random effects gravity specifications were estimated. Tests indicate that the proper econometric specification of a gravity model would be one of fixed country and time effects. This was demonstrated by the Hausman's χ^2 test and F joint test of fixed effects as widely predetermined because of geographical or political contexts. Using one-way FEM model may misdirect policy by under estimating the effects of GDP and population by exaggerating the negative effects of exchange rate uncertainty.

Overall results show that long-run exchange rate uncertainty has consistent significant negative effect on trade across different uncertainty measurement methods, across measurements calculated from different frequency observations of exchange rates and across different model specifications; only the magnitude of the estimates varies slightly. Among these different measurements, the elasticity estimates for the standard deviation measure of uncertainty U are slightly larger than those for the Perée and Steinherr measure V. And among the same measurement method, the standard deviation measure U has larger elasticity estimate when using higher frequency exchange rate observations for calculation. This might suggest that variables with higher variations can explain the dependent variable better. Whereas the elasticity estimates for the Perée and Steinherr measure V, which is based on historical experience rather than using variance of exchange rates to measure uncertainty risk, does not change much when the frequency of the exchange rate observations used for calculation increases.

Therefore, given the significant negative effects of long-run exchange rate uncertainty on trade, and given the magnitude of those effects, policymakers might be able to decide on whether just providing important means of diluting risks associated with international transactions, or more seriously constituting an independent addition to risks. The interesting patterns shown from using different frequency exchange rate data series might suggest that for the uncertainty measure, that uses variance to approximate exchange rate uncertainty risk, using higher frequency exchange rate data observations to construct that uncertainty measure might give better estimates. While for other types of uncertainty measures, this might not be the case.

Finally, further research should be directed towards testing different functional form of gravity model for bilateral trade flows through Box-Cox transformation. Very possibly an optimal form rather than loglinearity could be found, and therefore, enhance the performance of the gravity model. Also, instead of just using real exchange rate to calculate uncertainty measurement, researchers should also look at nominal exchange rate. By comparing real versus nominal exchange rate model results might help policymakers to decide which will be a more appropriate indicator of uncertainty risk.

APPENDIX A DATA DESCRIPTION

A.1 Data Sources

A descriptive summary of the data series used in this thesis is represented in TableA.1. It includes the names of the series, the source, the period it covers, and the website address. Generally speaking, the data were taken from different statistical offices in the United States, and a international organization. The international source is the International Monetary Fund's International Financial Statistics (IFS), which has an electronic database on line. From the IFS: annual, quarterly, and monthly exchange rates[6]; annual, quarterly, and monthly individual country's consumer price index (refers to wage earners' families of husband and wife without children or with non-income earning children living in the household.); individual country's nominal gross domestic product, in billions domestic currency units (Italy's GDP is in trillions of Lires). Other variables are from academic or official website of United States: bilateral trade data was taken from the Center for International Data at UC Davis; population was taken from Penn World Table 6.1 (PWT6.1)[7]; distance, language and border data were collected from Andrew K.Rose's personal website.

[6] Market Rates are used for 8 countries whereas official exchange rates are used for Switzerland, principal exchange rates are used for Belgium. All exchange rate series used are period-average national currency units per U.S. dollar

[7] PWT6.1:Alan Heston, Robert Summers and Bettina Aten, Penn World Table Version 6.1, Center for International Comparisons at the University of Pennsylvania (CICUP), October 2002

Table A.1

Data Source				
Name of Series	**Units**	**Periodicity**	**Sample Period**	**Web Address**
Nominal Exchange Rate	national currency units per U.S.dollar	annual, quarterly, monthly	1973:1-1992:12	International Financial Statistics electronic database http://ifs.apdi.net/imf/logon.aspx ; except for Germany, collected from IFS paper issues
Consumer Price Index		annual, quarterly, monthly	1973:1-1992:12	International Financial Statistics electronic database http://ifs.apdi.net/imf/logon.aspx
Nominal Gross Domestic Product	in billions of domestic currency, except for Italy in trillions of Lires	annual	1980-1992	International Financial Statistics electronic database http://ifs.apdi.net/imf/logon.aspx
Total Exports from country A to country B	in thousands of U.S.dollar	annual	1980-1992	Center for International Data at UC Davis http://www.internationaldata.org/
Population	in thousands of people	annual	1980-1992	Penn World Table 6.1, http://pwt.econ.upenn.edu/php_site/pwt_index.php
Distance, Language, Border	distance in mile	annual	1980-1992	Andrew K.Rose's personal website http://faculty.haas.berkeley.edu/arose/

Table A.2

Foreign-Exchange Value of a U.S. Dollar (Jan 1980)

Country	Currency	Abbre.	Symbol	Rate
Belgium	Belgian Franc	BEF	NA	28.255
Canada	Canada Dollar	CAD	C$	1.158
France	French Franc	FRF	_	4.071
Germany	Deutsch Mark	DEM	NA	1.739
Italy	Italy Lira	ITL	_	807.750
Japan	Japan Yen	JPY	¥	238.800
Netherlands	Netherlands Guilders	NLG	*f*	1.921
Switzerland	Swiss Franc	CHF	Sw_	1.626
U.K.	Pound	GBP	£	0.580

A.2 Transformations to the Data

Raw data series were transformed. Firstly, the nominal value of exports from i to j in U.S. dollars was deflated by the exporting countries' consumer price index (1980=100). Second, nominal gross domestic product was converted into U.S. dollars by dividing nominal exchange rates and then deflated by individual country's consumer price index (1980=100) using the following formula:

$$Real\ GDP = \frac{NominalGDP}{ER * CPI} \qquad (A.1)$$

where ER is nominal exchange rate expressed as foreign currency per U.S. dollar, CPI is individual country's consumer price index.

Finally, the nominal exchange rate is converted to real exchange rate using the following formula:

$$Real\ ER = \frac{ER * CPI^{domestic}}{CPI^{foreign}} \qquad (A.2)$$

Where $CPI^{domestic}$ represents the domestic country's consumer price index, and $CPI^{foreign}$ represents the foreign country's consumer price index.

APPENDIX B ESTIMATION RESULTS

B.1 Standard Deviation Measurement _ OLS Estimation

Table B.1

Simple OLS Results from 3 Different Groups of Experiments

Experiment	Variable	Parameter Estimate	t value
Group1	Uyear	-0.535	-1.07
	Uquarter_last	-3.654 *	-2.40
	Umonth_last	-6.292 *	-2.01
Group2	Uquarter_mean	-4.017 *	-2.61
	Umonth_mean	-6.889 *	-2.20
Group3	Uquarter_median	-3.982 *	-2.60
	Umonth_median	-6.745 *	-2.17

Note: * significant at 1% level.
Group1 represents last-period value of each year. Group2 represents mean values of each year. Group3 represents medians of the series of each year.

In group1, the estimated coefficient for U calculated from monthly data is –6.292, and for that from quarterly data is –3.654, and for that from annual data is –0.535. It is apparent that the absolute value of uncertainty increases monotonically when data frequency increases. In terms of magnitude, the estimated coefficient from monthly data is about 10 times bigger than that derived from annual data. The t-statistic from the monthly data is –2.01 which is also larger in absolute value than –1.07 calculated from annual data. Therefore, the result shows that the uncertainty calculated from monthly data has the biggest negative impact on natural log of annual total trade.

In table B.2, more detailed results from experiment group 2 that used mean values are presented, since mean values are slightly more significant than the other two.

Table B.2

Detailed Results from Experiment Group2
Using Mean Value of Uncertainty Measure

Variables	Annual	Quarterly	Monthly
Intercept	2.937	2.886	2.931
LnGdp	0.456	0.452	0.454
LnPop	0.462	0.466	0.463
LnDis	-0.936	-0.919	-0.922
Lang	0.049	0.052	0.043
Border	0.019	0.029	0.037
Uyear	-0.535	-	-
Uquarter_mean	-	-4.017	-
Umonth_mean	-	-	-6.889
R-square	0.885	0.887	0.886

Note: annual, quarterly, monthly indicate the frequency of the exchange rate series used to calculate uncertainty measurement.

B.2 Perée and Steinherr Measure _ OLS Estimation

Table B.3

Simple OLS Results from 3 Different Groups of Experiments

Experiment	Variable	Parameter Estimate	t value
Group1	Vyear	-0.100 *	-4.22
	Vquarter_last	-0.089 *	-4.14
	Vmonth_last	-0.085 *	-4.13
Group2	Vquarter_mean	-0.088 *	-4.15
	Vmonth_mean	-0.085 *	-4.16
Group3	Vquarter_median	-0.088 *	-4.15
	Vmonth_median	-0.085 *	-4.16

Note: * significant at 1% level. Other definitions are same as those for table B.1

Table B.4

Detailed Results from Experiment Group2 Using Mean Value of Uncertainty Measure

Variables	Annual	Quarterly	Monthly
Intercept	2.742	2.705	2.700
LnGdp	0.422	0.422	0.422
LnPop	0.495	0.496	0.496
LnDis	-0.930	-0.928	-0.927
Lang	0.006	0.010	0.011
Border	0.074	0.071	0.070
Vyear	-0.100	-	-
Vquarter_mean	-	-0.088	-
Vmonth_mean	-	-	-0.085
R-square	0.889	0.889	0.889

Note: annual, quarterly, monthly indicate the frequency of the exchange rate series used to calculate uncertainty measurement

B.3 Estimation for Fixed-Effects Model and Random-Effects Model

Table B.5: Estimation Results from Using Standard Deviation Measure

Models	One-Way FEM	One-Way REM	Two-Way FEM	Two-Way REM
LnGdp	.495 * (.012)	.470 * (.01)	.548 * (.022)	.505 * (.019)
LnPop	-.135 (.132)	.235 * (.008)	-.925 * (.270)	.219 * (.012)
LnUmonth_mean	-.147 * (.023)	-.165 * (.023)	-.060 * (.028)	-.150 * (.022)
F-value Pr>F	933.47 [<.0001]	-	917.90 [<.0001]	-
Hauseman Test Pr>F	-	2.09 [.35]	-	17.79 [.001]
R-Square	0.999	0.946	0.999	0.930

Table B.6: Estimation Results from Using Perée and Steinherr Measure

Models	One-Way FEM	One-Way REM	Two-Way FEM	Two-Way REM
LnGdp	.509 * (.012)	.481 * (.01)	.560 * (.022)	.531 * (.019)
LnPop	-.217 (.134)	.262 * (.001)	-.999 * (.244)	.235 * (.013)
LnVmonth_mean	-.096 * (.018)	-.095 * (.019)	-.048 * (.020)	-.096 * (.018)
F-value Pr>F	1152.57 [<.0001]	-	1164.23 [<.0001]	-
Hauseman Test Pr>F	-	11.17 [.004]	-	35.25 [<.0001]
R-Square	0.999	0.938	0.999	0.914

Note:
* significant at 1% level.
All values in parentheses are standard error; all values in square bracket are p-values. Results are for mean value of uncertainty measure calculated from monthly observation.

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