Exchange rate uncertainty and US bilateral fresh fruit and fresh vegetable trade: an application of the gravity model*

I. Sheldon[a,*], S. Khadka Mishra[a], D. Pick[b] and S. Thompson[a]

[a] *Department of Agricultural, Environmental and Development Economics, The Ohio State University, Columbus, OH 43210, USA*
[b] *Economic Research Service, United States Department of Agriculture, Washington DC, USA*

[*] Corresponding author. E-mail: sheldon.1@osu.edu

Running title: Exchange rate uncertainty and fresh fruit and fresh vegetable trade

In order to analyse the effect of exchange rate uncertainty, we apply an empirical gravity equation to two sets of US bilateral trade data: fresh fruit over the period 1976-99 for a panel of 26 countries; and fresh vegetables over the period 1976-2006 for a panel of 9 countries. Based on panel estimation methods, and using both a moving standard deviation measure and the Perée and Steinherr (1989) measure of exchange rate uncertainty, the results show that US bilateral fresh fruit trade has been negatively affected by exchange rate uncertainty. We also find some evidence that the exchange rate between the US dollar and the currencies of Latin American trading partners accounts for most of the negative impact of exchange rate uncertainty on bilateral trade flows in fresh fruit. In contrast, when using panel estimation methods and both measures of exchange rate uncertainty, we find no statistically significant evidence for any negative effect of exchange rate uncertainty on US bilateral fresh vegetable trade. However, we do find a statistically significant negative effect for exchange rate uncertainty when we estimate a US export gravity equation for fresh vegetables using the same panel of countries.

* Views expressed in this paper are those of the authors and not those of either the Economic Research Service or the United States Department of Agriculture. Funding for this research was provided through Cooperative Agreements No. 43-3AEK-3-80068 and No. 58-3000-7-0127.

I. Introduction

There has been controversy among economists on whether exchange rate volatility since the breakdown of the fixed exchange rate system has had a negative effect on trade. The most common assertion has been that risk associated with such exchange rate volatility has reduced the level of exports (Hooper and Kohlhagen, 1978). This is countered by the argument that use of forward markets could ameliorate risk in the short- to medium-run. Several empirical studies have investigated this issue, based on the gravity model of trade, and making use of panel data. For example, Rose (2000) 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. De Grauwe and Skudelny (2000) found a statistically significant negative impact of exchange rate volatility on trade in the European Union (EU), as did Dell'Arricia (2000). Other studies focusing on exchange rate issues in the context of gravity models with panel data include Rose and Wincoop (2001), Glick and Rose (2001), and Baldwin, Skudelny and Taglioni (2005), all of which look at currency unions and trade.

Despite this renewed interest, these studies typically use very aggregate data, ignoring the impact of exchange rates across sectors. As Maskus (1986) has noted, the impact of exchange rate volatility may vary across sectors because different sectors have different degrees of openness to international trade, and/or because different sectors make different use of long-term contracts. Cho *et al*. (2002) applied a gravity model to a panel consisting of bilateral trade flows for ten developed countries between 1974 and 1995, where the aggregate trade data were separated into trade in agricultural products, machinery, chemicals, and other manufacturing. They found that agricultural trade has been more adversely affected by medium- to long-run exchange rate uncertainty compared to trade in other sectors. In a recent article, Kandilov (2008) was able to replicate the earlier results of Cho *et al*., but in expanding the panel to include developing countries, he found the effect of exchange rate uncertainty on agricultural exports to be greater for developing than developed countries. While the Cho *et al*. and Kandilov studies represent a useful step towards applying gravity-type models to more disaggregated panel data, including the agricultural sector, it still ignores the impact of exchange rates on specific products and commodities.

There has been a certain amount of other research on the impact of exchange rate variability on agricultural trade.[1] Reflecting the earlier research in the general literature, empirical research relating to short-run exchange rate volatility and agricultural trade flows has given ambiguous conclusions. For example, Pick (1990) found that exchange rate risk had no effect on US trade flows to other developed countries, though it did have a negative effect on US exports to developing countries. In contrast, Klein (1990) found that short-run real exchange rate volatility negatively affected US agricultural exports compared to other sectors. Maskus also found that the sector most affected by short-run volatility was agriculture, his empirical model focusing on US bilateral trade flows. Anderson and Garcia (1989) found significant negative effects of exchange rate volatility on US exports of soybeans to three developed countries, while Langley *et al*. (2000) found that exchange rate volatility had a positive impact on Thailand's exports of poultry, but not on aggregate agricultural exports. Closer to the focus of the current paper, Pick and Vollrath (1994) found some evidence for real exchange rate misalignment having a negative

[1] Earlier work on agricultural trade and exchange rates, focused on the impact of, changes in the level of the real exchange rate, and agricultural exports. Examples include Batten and Belongia (1986), and Bessler and Babula (1987). This research has been summarised and reviewed in Kristinek and Anderson (2002).

effect on exports of specific agricultural commodities for a sample of developing countries. While more recently, Karemera *et al*. (2011) report mixed results for the impact of exchange rate volatility and exchange rate uncertainty on trade flows among OECD countries for various vegetables.

A key criticism of most of the current literature on exchange rate variability and agricultural trade is the focus on short-run exchange rate volatility. In studying the effects of exchange rate uncertainty on trade, it is important 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. Vianne and de Vries (1992), however, have shown that even with the possibility of hedging, exchange rate volatility will still affect trade because it gives rise to a risk premium in the forward exchange rate. Notwithstanding this, De Grauwe and de Bellefroid (1986), and De Grauwe (1988), argue that short-run variability is irrelevant to considering trade; rather it is long-run variability in exchange rates that is likely to affect trade. An additional feature of the floating rate system has been that real exchange rate movements have been characterised by 'long swings', and have deviated from what is thought to be their equilibrium levels for long periods of time. This is what De Grauwe and de Bellfroid refer to as 'sustained misalignment', where misalignment is defined as the persistent departure of nominal exchange rates from their long-run equilibrium level. Similarly, Perée and Steinherr (1989) suggest that while short-term exchange rate risk can be hedged in financial markets, uncertainty beyond a one-year time horizon cannot be hedged at low cost. Using a sample of industrial countries, they find that exchange rate uncertainty defined over the medium term adversely affects trade flows for all countries in their sample except for the US. Obstfeld (1995) makes a similar observation that while short-run volatility may be hedged successfully, long-term exchange rate uncertainty is more likely to be a problem.

What then is the broader concern with long-term exchange rate uncertainty? In the late- 1960s and early-1970s, the majority view among economists was that a market based floating exchange rate system was the proper way to avoid exchange rate misalignment, such as the chronic overvaluation of the US dollar in the 1960s, where a misalignment refers to the departure of nominal exchange rates from their long-run equilibrium level or market fundamentals such as relative prices and interest rate differentials between countries (Williamson, 1985). Considering the fact that under the fixed exchange rate system, the main source of misalignment was largely due to governments trying to maintain nominal exchange rates that were no longer justified by fundamentals, this view was quite reasonable.

However, in contrast to this view, the new international monetary system seems to have produced new problems. Casual empirical observation suggests that under the floating exchange rate system, movement of nominal exchange rates has not reflected the movement of economic fundamentals between countries, especially, in the short-run (Mark, 1995; Frankel, 1996). Deviation of nominal exchange rates from monetary fundamentals has been both substantial and persistent so that the misalignment problem seems not to be dramatically mitigated under the new system (Williamson, 1985; Dornbusch, 1987; Rogoff, 1996). As Williamson describes, demonstration that the floating system is viable has not been matched by a consensus that it is desirable. Reflecting these empirical observations, there have been several controversial proposals concerning international monetary reform, i.e., Williamson (1985), Dornbusch (1986), McKinnon (1988), and Mundell (1992). Therefore, while economists have different views concerning the source of unexpected exchange rate movements during the post-Bretton Woods era, the very existence of these differing views indicates how seriously the economics profession takes the problem of exchange rate misalignment.

The argument in favor of flexible exchange rates is that they take care of any balance of payments disequilibrium, freeing up countries to focus on domestic policy objectives (Perée and Steinherr, 1989). Consequently, shocks in the rest of the world should be taken care of through the exchange rate. This argument though relies on the assumption that purchasing power parity (PPP) is the long run equilibrium condition of the nominal exchange rates. PPP should hold because exchange rates equalize relative price levels in different countries. Allowing for factors such as transport costs, PPP in its relative form implies that a stable price differential should exist for the same good(s) selling in different countries, the implication being that real exchange rates between countries should be equal to a constant in the long run, and, consequently, there is no persistent misalignment of exchange rates from relative PPP, i.e., the real exchange rate should be mean-reverting (MacDonald, 1999).

There has actually been a long debate in the literature as to whether departures from PPP under flexible exchange rates are regular phenomena that are both persistent and of some magnitude. For example, empirical evidence published mostly in the 1980s could not reject the hypothesis of a random walk of real exchange rates under the flexible rate regime (Adler and Lehman, 1983; Meese and Rogoff, 1983). As a result, it led to the belief that PPP was of little use empirically, and real exchange rate movements were highly persistent (Dornbusch, 1987). More recent research has focused on the use of co-integration methods, with some studies finding no evidence of significant mean reversion of exchange rates toward PPP (Mark, 1990; Fisher and Park, 1991), while other studies find evidence rejecting the random walk hypothesis, reviving the notion that PPP is a long-run condition of nominal exchange rates (Lothian and Taylor, 1996; Flood and Taylor, 1996; Frankel and Rose, 1996; MacDonald, 1999). Nevertheless, even the latter studies show that the speed of convergence to PPP is very slow, the deviations appearing to dampen out at roughly 15% per year (Rogoff, 1996).

The key to this discussion is that if exchange rates closely follow PPP, then there should be no difference between the uncertainty associated with domestic economic activity and that of participating in export markets. However, with persistent exchange rate misalignment, foreign trade is then exposed to uncertainty that is additional to that created by movements in relative prices and aggregate demand (Perée and Steinherr, 1989). It is important, therefore, as global integration of markets increases, to establish whether long-run movements in exchange rates matter for international trade in the agricultural sector.

In order to explore the effects of medium-to long-run exchange rate uncertainty at a more disaggregated level, in the present paper we construct a gravity model and apply it to two separate panels of US bilateral trade flows: fresh fruit for the period 1976-1999, and fresh vegetables for the period 1976-2006. We also apply an export gravity model to US exports of fresh vegetables for the same period. Based on data from the Economic Research Service (ERS) of USDA, by the early-2000s, fruit and vegetables accounted for 29% of US farm crop cash receipts, about 17% of consumer food expenditures, and 18% of export value (ERS/USDA, 2006). In addition, while the overall trend has been a widening of the gap between both US fruit and vegetable imports and exports, bilateral trade between the US and its largest trading partners has also exhibited a good deal of fluctuation, which, *inter alia*, may be a function of exchange rate movements. Interestingly, a recent report on trade in fruits and vegetables by the ERS (Huang, 2006) has highlighted that there has been very little research on the impact of exchange rates on horticultural commodity exports.[2]

Application of the gravity model to these data allows for cross-partner determinants of trade including income, distance, membership of free trade agreements, common borders, exchange rate uncertainty, and so on. While these factors are typically captured in cross-section models, e.g., Eichengreen and Irwin (1995), the use of panel data also captures changes in variables over time such as income and changes in exchange rate uncertainty. Clearly, the interest lies in whether exchange rate uncertainty has affected US bilateral fresh fruit and fresh vegetables trade, once we have controlled for these other factors.

The paper is organised as follows. First a review of key statistics relating to trade in fresh fruits and fresh vegetables is presented, followed by discussion of the specification and justification for the gravity model. Then variable construction and data are discussed, and the econometric specification and results are reported. The principal results and implications are then discussed, and the paper ends with a summary of the analysis and results.

II. Fresh Fruit and Vegetable Trade

Based on data presented by the Foreign Agricultural Service (FAS) of USDA, by 2003, world fresh fruit production reached 379 million metric tons, having grown by

[2] The recent paper by Karemera *et al*. (2010) extends the earlier work of Cho *et al*. (2002), by examining the impact of exchange rate uncertainty on vegetable trade for an OECD panel data set over the period 1996-2002.

over 30% since 1990 (FAS/USDA, 2004a). China was the world's largest and fastest growing producer of fresh fruit in 2003, accounting for 19% of global production, followed by the EU (14%), and India (12%). Other key producers in 2003 included Brazil, the US, Mexico, Chile and South Africa. Similarly, by 2003, world fresh vegetable production reached 842 million metric tons, having grown by nearly 40% since 1999 (FAS/USDA, 2009). Again, China was the world's largest and fastest growing producer of fresh vegetables in 2003, accounting for 48% of global production, followed by India (7%), and the US (4%).

In terms of international trade, the total value of fresh fruit exports was greater than $11 billion in 2003, having more than doubled since 1996 (FAS/USDA, 2004a), while the total value of fresh vegetable exports reached $7.5 billion in 2002, having risen by 19% since 1999 (FAS/USDA, 2004b). The increase in the value of world trade in fresh fruit and vegetables has been driven largely by changes in technology and patterns of food consumption (ERS/USDA, 2006b). With respect to technology, advances in transportation combined with developments such as controlled atmosphere technologies, have resulted in reduced delivery time, maintenance of product quality and lower shipping costs. Consequently, demand for a wide variety of fresh fruit and vegetables all year round can be met at affordable prices.

As for consumer demand, increased consumption of fresh fruit and vegetables is related to increasing per capita incomes, greater urbanization, as well as access to more information about its health and nutritional benefits. For example, Blisard *et al*. (2002) report that in the US, by 2001, annual fresh fruit consumption per capita had risen to 98 pounds, up by 11% since 1980. Similarly, annual fresh vegetables consumption per capita in the US had risen to 217.9 pounds by 2001, up 33% from 1980. In addition, the increase in US demand has also been associated with a demand for variety and convenience, and the willingness of consumers to pay for imported, out-of-season products. Growth in demand in other countries is also affecting international trade in fresh fruit and fresh vegetables. For example, wealthier middle-income countries have been shown to be most likely to include more fruits and vegetables in their diets as income levels rise (Regmi *et al*., 2001; Regmi and Dyck, 2001), and fresh fruit and vegetable consumption is generally greater in urban areas across all developing countries (FAO, 1993; 1994).

Even though the US has been a net importer of fresh fruit since the early-1980s, the deficit continuing to grow wider over the past twenty years, the US was still the world's largest exporter of fresh fruit in 2003, accounting for nearly 20% of the value of world exports. The US's primary export products are grapes, oranges and apples, its key export markets being Canada, Japan, Mexico, Hong Kong, the EU and South Korea (FAS/USDA, 2004a). Other major exporters of fresh fruit in 2003 in terms of value of world exports were the EU 15 (16%, excluding internal trade), Chile (11%), and Mexico (7%). In addition, exports from South Africa have been growing rapidly, and China is beginning to gain some importance in the world market for fresh fruit. Although the EU is not a direct competitor with the US, most of its external exports of fresh fruit going to Eastern Europe and Russia, Mexico has become a key competitor with the US in both the key markets of Canada and Japan.

While the US was also a net importer of fresh vegetables over the period 1993-2002, it was also the world's second largest exporter, accounting for 18% of the value of world exports in 2002, its two primary export products being lettuce and tomatoes, and its key export markets being Canada, Japan, Mexico, Taiwan and the EU 15 (FAS/USDA, 2004b). Other major exporters of fresh vegetables in 2002 in terms of value of world exports were Mexico (27%), the EU 15 (18%), China (10%), and Canada (7%).

Over the period 1999-2001, the top 30 exporters and importers of fresh fruit and vegetables accounted for over 92 to 95% of global trade in fresh fruit and vegetables (Huang, 2006). The shares of exports of fresh fruit were dominated by the EU (57%), NAFTA (18.8%) and Asia (10.8%), while shares of imports were dominated by the EU (31.4%), the banana-exporting countries (20.3%), Southern-Hemisphere countries (19.1%) and NAFTA (13.1%).[3] In the case of fresh vegetables, the share of exports, were dominated by the EU (56%), NAFTA (26.4%) and Asia (7.7%), while shares of imports were dominated by the EU (55.2%), NAFTA (23.4%), and Asia (7.4%).

Interestingly, the USDA/ERS report by Huang (2006) on trade in fruit and vegetables raises the issue of how exchange rate movements might affect US trade in individual horticultural commodities such as fresh fruit and vegetables, noting that there has been little research in this area. Shane, Roe and Somwaru's (2008) paper is a notable exception where they evaluate the impact of annual average exchange rate appreciation and trade partner income growth on aggregate US agricultural exports over the period 1972-2006. In particular, their commodity specific results show some evidence for a negative effect of trade-weighted real exchange rate appreciation on aggregate exports of both fresh fruit and vegetables, along with evidence for a positive effect of foreign income growth. This suggests it is useful important to examine in more detail, the effect of exchange rate uncertainty on US fresh fruit and vegetable trade.

[3] The banana-exporting countries include Colombia, Costa Rica, Côte d'Ivoire, Ecuador, Guatemala, Honduras and Panama, while Southern-Hemisphere countries consist of Argentina, Australia, Brazil, Chile, New Zealand, Peru and South Africa.

III. The Gravity Equation

Theory

The so-called gravity equation of trade predicts that the volume of trade between two countries will be proportional to their GDPs and inversely related to any trade barriers between them. Typically, bilateral trade flows between country *j* and country *k* have been explained by the following specification:

$$V^{jk} = \beta_0 (Y^j)^{\beta_1} (Y^k)^{\beta_2} (D^{jk})^{\beta_3} (A^{jk})^{\beta_4} u^{jk} \tag{1}$$

where V^{jk} is the value of exports (imports) by country *j* to *k* (*j* from *k*) Y^j (Y^k) is the value of nominal GDP in *j*(*k*), D^{jk} is the distance from *j* to *k*, A^{jk} is a vector of other factors that may positively or negatively impact trade between *j* and *k*, and u^{jk} is a log-normally distributed error term with $E(\ln u_{jk}) = 0$. This particular specification was originally used by Tinbergen (1962). The gravity equation, in fact, is probably one of the great success stories in applied economics, many studies being able to account for variation in the volume of trade across country pairs and over time (Leamer and Levinsohn, 1995). However, until fairly recently, the theoretical foundations for the gravity model were considerably less well understood.

Feenstra *et al*. (2001) note the gravity equation is not implied by the many-country, H-O model. However, with perfect specialisation an equation of this sort does arise, and can be derived from quite different theoretical models. This specialization can be due to an Armington demand structure (Anderson, 1979; Bergstrand 1985), increasing returns (Helpman, 1987; Bergstrand, 1989), technological and geographical differences (Davis (1995); Eaton and Kortum, 2002), and factor endowment differences (Deardorff, 1998; Evenett and Keller, 2002).

Grossman (1998) notes, "…Specialisation – and not new trade theory or old trade theory – generates the force of gravity…" (p. 29)[4]

Due to the emergence of a theoretical literature developing the micro-foundations for the gravity model, its application to explaining bilateral trade patterns has become popular again in recent years. As noted in the introduction, it has been used extensively in analysis of the effects of exchange rate uncertainty in country panel data sets, e.g., Rose (2000), De Grauwe and Skudelny (2000), Dell'Ariccia (2000), Rose and Wincoop (2001), and Glick and Rose (2001). In addition, tests of the different theoretical models underlying the gravity equation have become quite common, e.g., Helpman, 1987, Hummels and Levinsohn (1995), Rauch (1999), Head and Ries (2001), Baier and Bergstrand (2001), Feenstra *et al*. (2001), Chen (2002), Evenett and Keller (2002), and Rose (2004).

Specification

The gravity model explains the volume of trade between two countries. Consistent with the underlying micro-foundations, the product of the countries' GDPs is a positive stimulant to trade while distance, representing the impact of transport costs, has a negative influence.[5] As noted above, the standard gravity model also includes other variables that may affect the volume of trade between two countries including the existence of a common border, and whether the countries are members of a customs union/free trade agreement. Exchange rate variability can also influence the level of trade between two countries. The anticipated sign is negative, indicating

[4] See Sheldon (2006) for an extensive discussion of the theoretical foundations for the gravity model.
[5] More broadly, distance may capture other barriers to trade (Anderson and Wincoop, 2004)

that higher levels of uncertainty decrease trade.[6] Following discussion in Evenett and Keller (2002) and Feenstra (2004) , and recent empirical work by Dell'Ariccia (2000), Cho *et al*. (2002), and Rose (2004), the gravity model tested in this paper is specified as a simple reduced-form model:

$$\ln TRADE_{ij,t} = \alpha_{i,j} + \beta_1 \ln(Y_{it}Y_{jt}) + \beta_2 (Pop_{it}Pop_{jt}) + \beta_3 U_{ij,t} + \beta_4 dis_{ij} + \beta_5 Language_{ij} + \beta_6 FTA_{ij,t} + \mu_{ij,t} \quad (2)$$

where $TRADE_{ij,t}$ is gross bilateral trade (imports plus exports) between country *i*, the US, and a trading partner *j*, for either the fresh fruit sector, or the fresh vegetables sector; $Y_{it}Y_{jt}$ is the product of *i* and *j*'s GDP in period *t*, $Pop_{it}Pop_{jt}$ is the product of population between countries *i* and *j* in period *t*, $U_{ij,t}$ is a measure of exchange rate uncertainty, defined subsequently, dis_{ij} is a measure of distance between *i* and *j*, $Language_{ij}$ is a dummy variable which equals one if countries share a common language and is zero otherwise, and $FTA_{ij,t}$ is a dummy variable representing membership of a free trade agreement, equal to one if a member, zero otherwise. As noted in the introduction, the panel data nature of the gravity model has the attraction that it can explain cross-sectional variation in bilateral trade as well as changes in the level of bilateral trade over time.[7]

---

[6] While the expected sign is negative, De Grauwe (1999) shows that, if the utility function is sufficiently convex, firms may export more rather than less when uncertainty arises. Bachetta and Wincoop (2000) have forwarded similar arguments.

[7] See Egger and Pfaffermayr (2003) for a useful discussion of the econometric specification of the gravity equation.

IV. The Data

Bilateral Trade Data

The empirical gravity Equation (2) was estimated for annual US bilateral fresh fruit trade over the period 1976-1999, for a panel of 26 countries.[8] Initially, the panel consisted of the top 30 US trade partners based on the annual value of fruit trade, but in order to maintain a balanced panel, Belgium/Luxembourg, South Africa and Taiwan were eventually dropped from the sample due to missing data. On average, over the sample period, the panel of 26 countries accounted for over 80% of US bilateral fresh fruit trade. Equation (2) was also estimated for annual US bilateral fresh vegetable trade over the period 1976-2006, for a panel of 9 countries. Again, the initial panel was larger, consisting of the top 10 US trade partners based on the annual value of vegetable trade, but in order to maintain a balanced panel, Peru was eventually dropped from the sample due to missing data. On average, over the sample period, the panel of 9 countries accounted for between 80 and 90% of US bilateral fresh vegetable trade. The trade data are from the U.S. Census Bureau, using commodity classifications adopted from Foreign Agricultural Trade of the United States (FATUS), Economic Research Service. They consist of the real dollar value of US exports and imports of fresh fruit (fresh vegetables) to and from each of the 26 (9) trading partners.

The selection of trading partners with this high value of trade criterion introduces some variation into the sampling. In terms of fresh fruit trade, from a regional perspective, over the period 1976-1999, some regional partners were net importers from the US, while other regional partners were net exporters to the US, as

[8] Note that the fresh fruit trade sample is truncated at 1999 due to introduction of the Euro.

can be seen in Table 1. The US was a net importer from Latin America, and Australia and New Zealand, but was a net exporter to Asia, Canada and the EU. Within regions over the period, there was also variation in fresh fruit trade across countries, as shown in Table 2. Other than Brazil, all countries in the Latin American region were net exporters to the US, whereas all countries in the Asia region were net importers. In the case of the EU region, all countries with the exception of Italy and Spain were net importers of fresh fruit. As shown in Table 3, in the case of fresh vegetable trade over the period 1976-2006, while the US was a net importer from most countries, most notably Mexico, it was a net exporter to Canada, the US's bilateral trade being dominated by these two countries.

GDP and Population Data

Annual data on real GDP, real GDP per capita and population were taken from the Penn World Tables. Given the cross-sectional nature of the data, GDP for each country in the two samples has been converted into US dollar values after adjusting for the respective country's consumer price index. Equation (2) was specified in terms of the product of trading partners' real GDP's and also the product of their respective populations. However, many specifications of the gravity model often use the product of trading partners' GDP's per capita. Given the income elasticity of demand for fresh fruit and fresh vegetables, the product of real GDP's per capita may be the more appropriate definition in terms of explaining bilateral trade.[9]

[9] Correlation between real GDP per capita and trade was observed to be higher than the correlation between real GDP and trade. Furthermore, real GDP and population were found to be highly positively correlated with each other.

Distance, Border, and Free Trade Agreements

Distance was measured as the great circle distance between the two major cities of the respective trading partners. The data for distance were taken from Andrew Rose's website at the University of California, Berkeley.[10] The definition of the dummy variables for border and membership of free trade agreements were based on those of Rose.[11]

Exchange Rate Uncertainty

In terms of measuring exchange rate uncertainty, a variety of methods have been used previously in the literature, which probably reflects the fact that theory is not clear about the impact of exchange rate risk on firms (Clark *et al*., 2004). In a recent and comprehensive survey of the literature by Bahmani-Oskooee and Hegerty (2007), find that no dominant approximation for uncertainty has emerged 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. Given the time-series nature of the panel, such a measure has to be time varying. To do this, an *ex ante* measure of uncertainty can be derived using a moving standard deviation of the first differences in the exchange rate over the prior n years. Specifically:

$$U_{ij,t} \equiv s_{ij,t} = \sqrt{\frac{\sum_{l=1}^{n}(x_{ij,t-l} - \bar{x}_{ij,t})^2}{n-1}} \quad (3)$$

[10] http://faculty.haas.berkeley.edu/arose/RecRes.htm

[11] Information about common membership in free trade agreements was obtained from the website: http://www.dfait-maeci.gc.ca/nafta-alena/menu-en.asp

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 $\bar{x}_{ij,t} = \sum_{l=1}^{n} x_{ij,t-l} / n$ is the mean of $x_{ij,t}$ over the previous *n* years. As noted by Bahmani-Oskooee and Hegerty (2007), this measure of uncertainty is the most common, having been used in 32 previous studies, including Cho *et al*. (2002).

Of course, the impact of uncertainty may not be captured well by this measure, consequently in this paper for purposes of comparison, we also use the measure proposed by Perée and Steinherr (1989), and also applied by Cho *et al*. (2002) and Karemera *et al*. (2011) in their analyses of agricultural trade. The central feature of this measure 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. Specifically, they propose:

$$U_{ij,t} \equiv V_{ij,t} = \frac{\max X^{t}_{ij,t-n} - \min X^{t}_{ij,t-n}}{\min X^{t}_{ij,t-n}} + \left[1 + \frac{\left| X_{ij,t} - X^{p}_{ij,t} \right|}{X^{p}_{ij,t}} \right] \quad (4)$$

where max (min) $X^{t}_{ij,t-n}$ is the maximum (minimum) value of the absolute value of the real exchange rate over the previous *n* years.[12] The first term captures 'accumulated experience' rather than just variation on the basis that, even if the variation became smaller in recent periods, agents may still remember the (bad) experiences of the past. The second term adds more recent information, representing the level of misalignment, as measured by deviations of the exchange rate $X_{ij,t}$ from

[12] In constructing the exchange rate uncertainty measure there is a certain amount of arbitrariness involved concerning the choice of the measure and the time period covered. In this paper, *n* = 2, 3 or 5 years. The results are generally robust to the time period covered by the measure, the most important issue being the form the measure takes.

the 'equilibrium' exchange rate $X^{p}_{ij,t}$. There is no obvious way to measure the equilibrium exchange rate over the previous period, as most models of the exchange rate perform poorly (Mark, 1995). Consequently, in this paper, the mean of the exchange rate over the previous 2, 3 and 5 years respectively, is used as a proxy for $X^{p}_{ij,t}$. The Perée and Steinherr measure is re-calculated for each year of the data based on the experience of the preceding *n* years, and it is computed for all bilateral exchange rates in the sample. Annual data on real exchange rates between the US and the trade partners are taken from the series constructed by the Economic Research Service of USDA.[13] In Figs. 1 and 2, we plot the measure from (4) for one country from each region in the fresh fruit trade panel, r = 1 to 5, based on n = 2 and 5 years respectively. In Figs. 3 and 4, we plot these measures for three key countries in the fresh vegetable trade panel, c = 1 to 3, based again on n = 2 and 5 years.

V. Econometric Results

Bilateral Trade Estimation – Fresh Fruit and Vegetables

Given the panel data set, Equation (2) is initially written in the following form:

$$y_{ij,t} = \alpha + \boldsymbol{\beta}'\boldsymbol{x}_{ij,t} + \mu_{ij,t} \qquad (5)$$

where $\boldsymbol{x}_{ij,t}$ contains K regressors, $\boldsymbol{\beta}'$ is a 1xK vector of constants, α is a 1x1 scalar constant assumed to be the same over time t and across trading partners j, and the error term is $\mu_{ij,t} \sim i.i.d.(0, \sigma_{\mu}^{2})$. Given this, Equation (5) was estimated using Ordinary Least Squares (OLS), the results for fresh fruit trade being shown in

[13] The data can be found at the website: http://www.ers.usda.gov/data/exchangerates/

Tables 4-a and 5-a, where columns (i) to (iii) refer to *n* = 2, 3 and 5 years respectively for the measures of uncertainty $U_{ij,t} = s_{ij,t}$ and $U_{ij,t} = V_{ij,t}$. The results for both the moving standard deviation index of uncertainty, Table 4-a, and the Perée-Steinheer index of uncertainty, Table 5-a, are very similar, and quite typical for a gravity-type equation, with all of the key control variables having the expected signs: the product of real GDP per capita has a positive and statistically significant impact on bilateral trade flows, suggesting that demand for fresh fruit is highly income elastic, distance between trading partners has a negative and statistically significant impact on bilateral trade, common membership of free trade agreement has a positive and statistically significant impact on bilateral trade, while common language, has a positive and statistically significant effect. However, the impact of real exchange rate uncertainty on bilateral trade, while negative for *n* = 2 and 3 years for both indices of uncertainty, is not statistically significant.

Similarly, Equation (5) was estimated using OLS for fresh vegetable trade, the results being shown in Tables 6-a and 7-a, where again columns (i) to (iii) refer to *n* = 2, 3 and 5 years respectively for the measures of exchange rate uncertainty $U_{ij,t} = s_{ij,t}$ and $U_{ij,t} = V_{ij,t}$. These results are again very typical for a gravity-type equation, with all but one of the key control variables having the expected signs: the product of real GDP per capita has a positive and statistically significant impact on bilateral trade flows, suggesting that demand for fresh vegetables is highly income elastic, distance between trading partners has a negative and statistically significant impact on bilateral trade, while common membership of a free trade agreement has a positive and statistically significant impact on bilateral trade. However, the impact of real exchange rate uncertainty on bilateral trade is positive for *n* = 2, 3, and 5 years, for the respective indices, and statistically significant in three cases. In the case of common language, it has a negative and statistically significant effect as shown in Tables 6-a and 7-a.

In using OLS to estimate Equation (5), there is the possibility of an omitted variables problem. One way of dealing with this is to use a fixed effects model, whereby dummy variables are introduced to account for the effects of those omitted variables specific to each trading partner *j*, but which stay constant over time *t* (Hsiao, 1986). A dummy variable γ_t specific to each time period *t*, but the same across all trading partners *j* is also introduced. Therefore, Equation (5) becomes:

$$y_{ij,t} = \alpha_{ij} + \gamma_t + \boldsymbol{\beta}'\boldsymbol{x}_{ij,t} + \mu_{ij,t} \qquad (6)$$

Equation (6) was estimated using OLS, the results for fresh fruit trade being shown in Tables 4-b and 5-b, where again, columns (i) to (iii) refer to n = 2, 3 and 5 years respectively for the measures of uncertainty $U_{ij,t} = s_{ij,t}$ and $U_{ij,t} = V_{ij,t}$. The product of real GDP per capita again has a positive and statistically significant impact on bilateral trade flows, while the impact of real exchange rate uncertainty on bilateral trade is negative and statistically significant for n = 2, 3 and 5 years, and also for both measures of uncertainty $U_{ij,t} = s_{ij,t}$ and $U_{ij,t} = V_{ij,t}$. The results for membership of a free trade agreement are positive but not statistically significant. Due to the almost perfect collinearity between trading partner fixed effect(s) and the distance and common language variables, these variables are dropped from this regression. In addition, the time dummy γ_t was also dropped from the estimation, as it proved to be highly correlated with the real GDP per capita variable, the parameter on the latter becoming statistically insignificant.

Similarly Equation (6) was estimated using OLS for fresh vegetable trade, the results being shown in Table 6-b and 7-b, where again columns (i) to (iii) refer to n =

2, 3 and 5 years respectively for the measures of uncertainty $U_{ij,t} = s_{ij,t}$ and $U_{ij,t} = V_{ij,t}$. The product of real GDP per capita again has a positive and statistically significant impact on bilateral trade flows, while the impact of real exchange rate uncertainty on bilateral trade has mixed effects: it is negative but not statistically significant for n = 5 years for $s_{ij,t}$, and positive and statistically significant for n = 5 years for $V_{ij,t}$,but it is not statistically significant for *n* = 2 and 3 years for either $s_{ij,t}$ or $V_{ij,t}$. The results for membership of a free trade, albeit showing a positive effect on bilateral trade flows, are not statistically significant. Again due to the almost perfect collinearity between trading partner fixed effect(s) and the distance variable, it was dropped from this regression. In addition, the time dummy γ_t was also dropped from the estimation, as it proved to be highly correlated with the real GDP per capita variable, the parameter on the latter becoming statistically insignificant.[14]

In order to establish whether the results for fresh fruit trade are common to all of the US's trading partners, or whether the impact of exchange rate uncertainty is restricted to certain regions, we also estimated the fixed effects model with an interactive dummy on exchange rates for the five regions listed in Table 1, Equation (6) becoming:

$$y_{ij,t} = \alpha_{ij} + \psi_r U_{ij,t}.\partial_r + \boldsymbol{\beta}'\boldsymbol{x}_{ij,t} + \mu_{ij,t} \quad (7)$$

where $U_{ij,t}$ is the index of real exchange rate uncertainty, and ∂_r is the interactive dummy, where *r* = regions 1 to 5. The results shown in Table 8 for the Perée-Steinherr measure of uncertainty $U_{ij,t} = V_{ij,t}$ clearly indicate that the impact of real

[14] In both the case of both fresh fruit and vegetable trade, an alternative to estimating Equation (6) by fixed effects is to estimate it via random effects. In doing the latter, while the results for exchange rate uncertainty were found to be robust across the fixed and random-effects estimates, application of the Hausman test concluded in favour of the fixed effects model, so we do not report the random effects results in the paper. See Egger (2000) for a discussion of fixed versus random-effects estimation of the gravity equation.

exchange rate uncertainty on bilateral trade in fresh fruit is dominated by region r = 2, Latin America, the estimated parameter being negative and statistically significant for n = 2, 3 and 5 years.[15]

Export Estimation – Fresh Vegetables

A puzzle in the results is that, while we find statistically significant evidence for a negative effect of exchange rate uncertainty on bilateral trade in fresh fruit based on fixed effects estimation and two different measures of exchange rate uncertainty, the results for bilateral fresh vegetable trade provide no statistically significant evidence for exchange rate uncertainty. In order to investigate this further, and to compare our results with the previous work of Shane *et al*. (2008), we chose to estimate a separate export $X_{ij,t}$ gravity equation for fresh vegetables using the following reduced form equation based on used by McCallum (1995)[16]:

$$\ln X_{ij,t} = \alpha_{i,j} + \beta_1 \ln(YC_{it}) + \beta_1 \ln(YC_{jt}) + \beta_3 U_{ij,t} + \beta_4 dis_{ij} + \beta_5 Language_{ij} + \beta_6 FTA_{ij,t} + \mu_{ij,t} \quad (8)$$

where $X_{ij,t}$ are exports of fresh vegetables from country i, the US, to a trading partner j; YC_{it} and YC_{jt} are GDP per capita of i and j respectively in period t, and the other variables are as defined for Equation (2).

Based on the OLS estimating Equation (5), and the fixed effects estimating Equation (6), the results for fresh vegetables are presented in Tables 9 and 10 for both measures of exchange rate uncertainty, where again columns (i) to (iii) refer to

[15] In the case of the moving standard deviation measure of uncertainty, $U_{ij,t} = s_{ij,t}$, when adjusting for group-wise heteroscedasticity in the results, while still finding that the estimated parameter on region r = 2, Latin America, was negative for n = 2, 3 and 5 years it was statistically insignificant, so we do not report those results here.

[16] Based on Bahmani-Oskooee and Hegerty's (2007) survey, we chose to estimate an export rather than an import gravity equation, based on the fact that this has been by far the most common approach in the empirical literature on exchange rate volatility.

n = 2, 3 and 5 years respectively for the measures of uncertainty $U_{ij,t} = s_{ij,t}$ and $U_{ij,t} = V_{ij,t}$.

The OLS results for both the moving standard deviation index of uncertainty, Table 9-a, and the Perée-Steinheer index of uncertainty, Table 10-a, are very similar, and again very typical for a gravity-type equation, with all of the key control variables having the expected signs: the exporter and importer real GDP per capita have a positive and statistically significant impact on exports, distance between trading partners has a negative and statistically significant impact on exports, common membership of free trade agreement has a positive and statistically significant impact on exports, while common language has a positive and statistically significant effect on exports. Importantly, the impact of real exchange rate uncertainty on exports of fresh vegetables is negative for both indices of uncertainty and is statistically significant in all cases.

The fixed effects results for both the moving standard deviation index of uncertainty, Table 9-a, and the Perée-Steinheer index of uncertainty, Table 10-a, are also very similar, and once again typical for a gravity-type equation, with all of the key control variables having the expected signs: the exporter and importer real GDP per capita have a positive and statistically significant impact on exports, distance between trading partners has a negative and statistically significant impact on exports, while common membership of a free trade agreement has a positive and statistically significant impact on exports. Importantly, the impact of real exchange rate uncertainty on exports of fresh vegetables is negative for both indices of uncertainty and is statistically significant in all cases.[17]

[17] We also estimated the export equation using a random effects specification. Application of the Hausman test could not discriminate between a fixed or random effects specification. We chose to

VI. Discussion

The motivation for this paper is the hypothesis, originally put forward by, *inter alia*, De Grauwe and de Bellefroid (1986), that it is not the short-run variability of exchange rates that is relevant to considering trade, but instead long-run variability, due to the fact that it is difficult to hedge the latter uncertainty at low cost (Perée and Steinherr, 1989; Obstfeld, 1995).

Cho *et al*. (2002) using a gravity model approach and panel econometric methods found evidence for a negative impact of long-run exchange rate uncertainty on aggregate agricultural trade. In this paper, the objective has been to extend this type of analysis to trade in specific agricultural commodities, specifically fresh fruit and vegetables. Using country panels of bilateral trade data, for both fresh fruit and vegetables, we find strong support for a commonly specified gravity equation, in particular the product of GDP per capita and distance have a positive and negative impact respectively on bilateral trade, and country fixed effects do the job of accounting for the unobservable characteristics of the trading partners. This is what one would expect from applying a gravity model.

In terms of the variable of interest, exchange rate uncertainty, we find statistically significant evidence that it has a negative effect on bilateral fresh fruit trade, especially that between the US and Latin America. Interestingly, this effect is found to be robust across a commonly used index of exchange rate uncertainty, the moving standard deviation, as well the Perée and Steinherr (1989) index, the latter designed specifically to account for long-run exchange rate uncertainty. In addition, the results indicate that long-run exchange rate uncertainty holds up over one-year,

report only the fixed effects results, but the random effects results are available from the authors on request.

three-year and five-year time horizons, reinforcing the notion that it is likely difficult to hedge against this type of exchange rate risk.

In the case of bilateral fresh vegetable trade, even though the gravity model specification works as predicted for the gravity-type variables, we are unable to find a statistically significant negative effect for exchange rate uncertainty using either index. This seems somewhat surprising in light of the previously published results of Shane *et al*. (2008), which indicate that US exports of fresh vegetables are negatively affected by appreciations in the real value of the dollar. To explore this further we estimate an export gravity equation using the fresh vegetable country panel data set. In this case we find a very clear and statistically significant negative effect for exchange rate uncertainty on US exports of fresh vegetables, especially using fixed effects estimation. This result is robust across both indices of uncertainty, and again the result holds up over one-year, three-year and five-year time horizons.

The overall conclusion to be drawn from the empirical analysis is that at a specific commodity level, there is evidence that long-run exchange rate uncertainty negatively affects agricultural trade. This result is important in the light of the broader literature on the importance of the link between agricultural trade and exchange rates, pioneered by Schuh (1974) and others such as Orden (1999). This literature highlighted that macroeconomic factors, including monetary policy, can work through exchange rates, thereby affecting agricultural commodity prices and trade flows, which in turn can affect domestic agricultural policies and hence the competitiveness of agriculture in the world market.

In the context of this paper, if long-run exchange rate uncertainty reflects the movement of exchange rates away from purchasing power parities, then there may real effects in the agricultural sector, as resources move in or out of a specific commodity sector such as fresh fruit and fresh vegetables, based on whether a currency is over or under-valued for a significant period of time. Importantly, there may be a political economy effect as producers in a particular sector lobby for either protection from import competition or support for maintaining and developing export markets (De Grauwe, 1988). In the case of the US horticultural sector, compared to other sectors such as grains, oilseeds and cotton, there is very little in the way of direct farm subsidies. This suggests that US fruit and vegetable exporters may actually be quite significantly exposed to exchange rate risk, for which there are no cheaply available hedging-instruments, and that available crop insurance is not designed to cover. As global integration of markets increase, traders in these types of agricultural commodity may become more exposed to uncertainty beyond that due to movements in relative prices and aggregate demand, which has potential implications for the structure of federal funding of farm programs.

VII. Summary

In this paper, we explore whether exchange rate uncertainty has negatively affected US bilateral trade in fresh fruit and vegetables. We constructed two bilateral trade matrices, one involving fresh fruit trade flows between the US and 26 other countries for the period 1976-99, and one involving fresh vegetable trade flows between the US and 9 other countries for the period 1976-2006. Using a standard gravity model, and both the moving standard deviation and Perée and Steinherr (1989) measures of exchange rate uncertainty, the results of panel estimation indicate that for fresh fruit, US bilateral trade has been negatively affected by medium- to long-run uncertainty in real exchange rates, a result that is robust across the two measures of uncertainty. In addition, we find that the exchange rate between the US dollar and the currencies of Latin American trading-partners accounts for most of the impact of exchange rate uncertainty on bilateral trade flows in fresh fruit. For fresh vegetables, we find little or no statistically significant evidence for any negative effect of exchange rate uncertainty in the bilateral trade data. Therefore, in order to extend the analysis, we also estimated an export gravity equation for fresh vegetables, the results showing a statsitically significant negative effect of exchange rate uncertainty on fresh vegetable exports using both measures of exchange rate uncertainty.

Table 1. Region-wise average real value of US fresh fruit imports and exports ($ million)

Region	Years	Average Imports	Average Exports	Average Trade Balance
EU[a]	1976-84	4.2	76.7	72.5
	1984-94	12.9	126.6	113.7
	1994-99	56.0	135.9	79.9
Latin America[b]	1976-84	154.1	14.2	-139.9
	1984-94	930.2	50.8	-879.4
	1994-99	2235.7	148.0	-2087.7
Asia[c]	1976-84	1.7	248.1	246.4
	1984-94	7.9	453.1	445.2
	1994-99	7.5	653.7	646.2
Australia/New Zealand	1976-84	16.7	6.7	-10
	1984-94	53.9	12.7	-41.2
	1994-99	83.7	21.5	-62.2
Canada	1976-84	31.1	229.2	198.1
	1984-94	59.1	356.8	297.7
	1994-99	93.8	602.2	-508.4

Notes: [a] Denmark, Finland, France, Germany, Ireland, Italy, Netherlands, Spain, Sweden, the UK.

[b] Brazil, Chile, Colombia, Costa Rica, Ecuador, Guatemala, Honduras, Mexico.

[c] China, Hong Kong, Japan, Korea, Malaysia.

Table 2. Country-wise average real value of US fresh fruit imports and exports ($ million)

Country	Years	Average Imports	Average Exports	Average Trade Balance[a]
Canada	1976-84	31.1	229.2	198.1
	1984-94	59.1	356.8	297.7
	1994-99	93.8	602.1	508.3
Brazil	1976-84	0.1	1.3	1.2
	1984-94	2.3	2.8	0.5
	1994-99	8.1	13.9	5.8
Chile	1976-84	53.1	0.3	-52.8
	1984-94	71.1	0.01	-71.1
	1994-99	420.6	0.3	-420.3
Columbia	1976-84	0.06	3.2	3.1
	1984-94	101.9	2.3	-99.6
	1994-99	175.6	6.9	-168.7
Costa Rica	1976-84	0.8	0.5	-0.3
	1984-94	179.1	2.7	-176.4
	1994-99	421.3	6.4	-414.9
Ecuador	1976-84	0.5	0.4	-0.1
	1984-94	154.1	0.8	-153.3
	1994-99	295.5	2.5	-293.0
Guatemala	1976-84	0.6	1.01	0.41
	1984-94	76.5	1.6	-74.9
	1994-99	180.9	9.1	-171.8
Honduras	1976-84	5.5	0.9	-4.6
	1984-94	93.9	1.2	-92.7
	1994-99	149.5	2.4	-147.1
Mexico	1976-84	93.4	6.6	-86.8
	1984-94	251.2	39.4	-211.8
	1994-99	584.1	106.4	-477.7
China	1976-84	0.008	0.01	0.002
	1984-94	0.1	0.2	0.1
	1994-99	1.1	3.4	2.3
Hong Kong	1976-84	0.004	76.3	76.3
	1984-94	0.07	108.7	108.6
	1994-99	0.1	176.9	176.8
Japan	1976-84	1.1	165.1	164.0
	1984-94	6.2	326.4	320.2
	1994-99	2.2	420.3	418.1
Korea	1976-84	0.5	0.2	-0.3
	1984-94	1.6	5.5	3.9
	1994-99	4.1	26.3	22.2
Malaysia	1976-84	0.001	6.4	6.4
	1984-94	0.05	12.3	12.2
	1994-99	0.03	26.8	26.8

Table 2 continued

Australia	1976-84	2.4	2.2	-0.2
	1984-94	4.7	6.4	1.7
	1994-99	22.2	9.3	-12.9
New Zealand	1976-84	143.9	4.5	-139.4
	1984-94	492.6	6.2	-486.4
	1994-99	615.6	12.2	-603.4
Denmark	1976-84	0.003	0.5	0.5
	1984-94	0.005	0.8	0.8
	1994-99	0.03	0.9	0.8
Finland	1976-84	0.001	2.3	2.3
	1984-94	0.0008	3.4	3.4
	1994-99	0.0	2.4	2.4
France	1976-84	2.3	23.2	20.9
	1984-94	2.9	28.7	25.8
	1994-99	0.4	23.7	23.3
Germany	1976-84	0.04	5.9	5.8
	1984-94	0.04	8.5	8.4
	1994-99	0.06	11.4	11.3
Ireland	1976-84	0.003	0.7	0.7
	1984-94	0.0	1.2	1.2
	1994-99	0.002	1.1	1.1
Italy	1976-84	0.2	0.4	0.2
	1984-94	0.6	2.4	1.8
	1994-99	4.4	0.9	-3.5
Netherlands	1976-84	0.1	22.9	22.8
	1984-94	0.1	27.9	27.8
	1994-99	0.1	27.6	27.5
Spain	1976-84	1.45	0.02	-1.4
	1984-94	8.9	0.6	-8.3
	1994-99	50.8	1.1	-49.7
Sweden	1976-84	0.01	7.9	7.9
	1984-94	0.09	10.7	10.6
	1994-99	0.2	7.2	7.0
UK	1976-84	0.1	12.7	12.6
	1984-94	0.1	42.2	42.1
	1994-99	0.007	59.4	59.4

Notes: [a] Average trade balance values have been rounded.

Table 3. Country-wise average real value of US fresh vegetable imports and exports ($ million)

Country	Years	Average Imports	Average Exports	Average Trade Balance[a]
Honduras	1976-85	0.25	0.2	-0.7
	1986-95	2.1	0.1	-1.9
	1995-06	5.9	0.3	-5.5
Canada	1976-85	43.5	194.1	150.6
	1986-95	109.7	489.3	379.7
	1995-06	481.4	912.8	431.4
China	1976-85	0.3	0.004	-0.3
	1986-95	3.6	0.06	-3.6
	1995-06	23.6	2.1	-21.5
Costa Rica	1976-85	2.8	0.04	-2.7
	1986-95	17.3	0.1	-17.2
	1995-06	44.8	0.8	-43.9
Dominican Republic	1976-85	13.5	0.4	-13.0
	1986-95	11.1	0.3	-10.7
	1995-06	16.9	2.4	-14.6
Guatemala	1976-85	5.8	9.6	-5.8
	1986-95	11.4	0.07	-11.4
	1995-06	11.6	0.2	-11.3
Israel	1976-85	0.3	0.03	-0.3
	1986-95	1.5	0.1	-1.4
	1995-06	20.9	0.2	-20.7
Jamaica	1976-85	1.9	0.2	-1.7
	1986-95	6.8	0.2	-6.6
	1995-06	10.9	1.2	-9.8
Mexico	1976-85	348.5	4.0	-344.4
	1986-95	697.9	19.8	-678.1
	1995-06	1,703.5	62.3	-1,641.2

Notes: [a] Average trade balance values have been rounded.

Table 4. Results bilateral trade gravity equation – fresh fruit trade - $U_{ij,t}$ = s_{ijt}

	a – OLS			b - Fixed Effects		
	(i) *n*=2	(ii) *n*=3	(iii) *n*=5	(i) *n*=2	(ii) *n*=3	(iii) *n*=5
Intercept	10.12	10.13	9.82	-34.30	-33.94	-33.89
GDPPC	0.68 (6.52)***	0.69 (6.52)***	0.69 (6.54)***	2.57 (17.56)***	2.56 (17.41)***	2.55 (17.22)***
Distance	-0.89 (5.29)***	-0.89 (5.31)***	-0.88 (5.23)***			
Common language	0.56 (2.49)***	0.56 (2.48)***	0.59 (2.61)***			
RFTA	2.36 (4.07)***	2.36 (4.08)***	2.37 (4.16)***	0.07 (0.20)	0.11 (0.31)	0.13 (0.39)
Uncertainty						
2years	-0.24 (0.50)			-0.95 (3.33)***		
3 years		-0.48 (0.70)			-1.40 (3.50)***	
5 years			0.39 (0.43)			-1.43 (2.66)***
Adjusted R^2	0.17	0.17	0.17	0.36	0.36	0.36
Individual effect				Yes	Yes	Yes
Time effect				No	No	No

Notes: t-statistics in parentheses.
*** 99% level of confidence.
$U_{ij,t}$ = s_{ijt} moving standing deviation index of uncertainty.

Table 5. Results for bilateral trade gravity equation – fresh fruit trade - $U_{ij,t} = V_{ij,t}$

	a – OLS			b - Fixed Effects		
	(i) *n*=2	(ii) *n*=3	(iii) *n*=5	(i) *n*=2	(ii) *n*=3	(iii) *n*=5
Intercept	10.23	10.18	9.81	-33.51	-33.51	-34.08
GDPPC	0.67 (6.31)***	0.68 (6.33)***	0.69 (6.54)***	2.53 (17.28)***	2.53 (17.26)***	2.56 (17.25)***
Distance	-0.88 (5.27)***	-0.89 (5.27)***	-0.89 (5.28)***			
Common language	0.58 (2.59)***	0.58 (2.58)***	0.58 (2.58)***			
RFTA	2.37 (4.09)***	2.37 (4.09)***	2.37 (4.09)***	0.15 (0.45)	0.15 (0.45)	0.17 (0.51)
Uncertainty						
2years	-0.01 (0.62)			-0.04 (4.33)***		
3 years		-0.01 (0.53)			-0.04 (4.22)***	
5 years			0.01 (0.52)			-0.01 (2.59)***
Adjusted R^2	0.17	0.17	0.17	0.37	0.37	0.36
Individual effect				Yes	Yes	Yes
Time effect				No	No	No

Notes: t-statistics in parentheses.
*** 99% level of confidence.
$U_{ij,t} = V_{ij,t}$ Perée-Steinherr index of uncertainty.

Table 6. Results for bilateral gravity trade equation – fresh vegetable trade - $U_{ij,t} = s_{ijt}$

	a – OLS			b - Fixed Effects		
	(i) *n*=2	(ii) *n*=3	(iii) *n*=5	(i) *n*=2	(ii) *n*=3	(iii) *n*=5
Intercept	5.92	5.65	6.33	-29.23	-29.36	-28.62
GDPPC	1.11 (9.21)***	1.12 (9.29)***	1.10 (8.87)***	2.37 (19.45)***	2.37 (19.53)***	2.34 (17.83)***
Distance	-1.44 (9.12)***	-1.43 (9.09)***	-1.43 (9.09)***			
Common language	-0.62 (2.50)***	-0.63 (2.56)***	-0.63 (2.56)***			
RFTA	2.94 (8.72)***	2.95 (8.75)***	2.95 (8.75)***	0.16 (0.77)	0.16 (0.78)	0.16 (0.76)
Uncertainty						
2years	0.57 (1.16)			0.21 (0.80)		
3 years		1.12 (1.60)#			0.44 (1.06)	
5 years			0.17 (0.19)			-0.10 (0.18)
Adjusted R^2	0.63	0.63	0.63	0.62	0.62	0.62
Individual effect				Yes	Yes	Yes
Time effect				No	No	No

Notes: t-statistics in parentheses.

\# 90% level of confidence, *** 99% level of confidence.

$U_{ij,t} = s_{ijt}$ moving standing deviation index of uncertainty.

Table 7. Results for bilateral trade gravity equation – fresh vegetable trade - $U_{ij,t} = V_{ij,t}$

	a – OLS			b - Fixed Effects		
	(i) *n*=2	(ii) *n*=3	(iii) *n*=5	(i) *n*=2	(ii) *n*=3	(iii) *n*=5
Intercept	5.78	5.50	5.18	-29.14	-29.48	-30.28
GDPPC	1.11 (9.19)***	1.12 (9.25)***	1.14 (9.33)***	2.36 (19.56)***	2.37 (19.56)***	2.41 (19.82)***
Distance	-1.46 (9.26)***	-1.45 (9.09)***	-1.46 (9.30)***			
RFTA	2.94 (8.68)***	2.93 (8.68)***	2.91 (8.65)***	0.15 (0.76)	0.16 (0.76)	0.14 (0.71)
Common Language	-0.64 (2.57)***	-0.65 (2.61)***	-0.67 (2.68)***			
Uncertainty						
2years	0.37 (0.97)			0.11 (0.59)		
3 years		0.37 (1.38)#			0.15 (1.08)	
5 years			0.34 (1.74)*			0.23 (2.20)**
Adjusted R^2	0.63	0.63	0.63	0.62	0.62	0.62
Individual effect				Yes	Yes	Yes
Time effect				No	No	No

Notes: t-statistics in parentheses.
90% level of confidence,* 95% level of confidence, ** 97.5% level of confidence, *** 99% level of confidence.
$U_{ij,t} = V_{ij,t}$ Perée-Steinherr index of uncertainty.

Table 8. Results for bilateral trade gravity equation with regional interactive dummy $U_{ij,t} = V_{ij,t}$ - fresh fruit trade

	Fixed Effects (i) n=2	(ii) n = 3	(iii) n = 5
Intercept	-33.25	-32.90	-33.31
GDPCC	2.52 (16.83)***	2.50 (16.79)***	2.52 (16.66)***
RFTA	0.14 (0.41)	0.17 (0.49)	0.17 (0.49)
Uncertainty			
r = 1	0.13 (0.06)	0.38 (0.14)	0.45 (0.12)
r = 2	-1.46 (3.77)***	-2.19 (4.22)***	-2.67 (3.78)***
r = 3	-0.48 (0.86)	-0.69 (0.78)	-0.84 (0.65)
r = 4	1.42 (1.02)	1.96 (0.34)	0.92 (0.34)
r = 5	-0.69 (0.87)	-0.28 (0.26)	0.99 (0.82)
Adjusted R^2	0.37	0.37	0.97
Individual effect	Yes	Yes	Yes

Notes: t-statistics in parentheses.
*** 99% level of confidence.
$U_{ij,t} = V_{ij,t}$ Perée-Steinherr index of uncertainty.

Table 9. Results for export gravity equation– fresh vegetable trade - $U_{ij,t}$ = s_{ijt}

	a – OLS			b - Fixed Effects		
	(i) *n*=2	(ii) *n*=3	(iii) *n*=5	(i) *n*=2	(ii) *n*=3	(iii) *n*=5
Intercept	-12.46	-12.63	-10.97	-41.94	-41.85	-42.05
GDPPC1	2.33 (3.08)***	2.35 (3.11)***	2.20 (2.84)***	3.72 (6.95)***	3.71 (6.96)***	3.50 (6.27)***
GDPPC2	1.23 (5.98)***	1.23 (5.95)***	1.23 (5.93)***	1.90 (4.28)***	1.90 (4.31)***	2.17 (5.77)***
Distance	-1.28 (5.43)***	-1.28 (5.42)***	-1.29 (5.44)***			
Common language	1.20 (3.50)***	1.24 (3.59)***	1.18 (3.43)***			
RFTA	3.76 (7.89)***	3.76 (7.89)***	3.70 (7.87)***	0.10 (0.33)	0.09 (0.30)	0.18 (0.73)
Uncertainty						
2years	-1.20 (1.77)*			-1.94 (4.63)***		
3 years		-1.84 (1.69)*			-3.17 (4.87)***	
5 years			-2.19 (1.57)#			-1.97 (2.23)**
Adjusted R^2	0.62	0.62	0.62	0.52	0.52	0.48
Individual effect				Yes	Yes	Yes
Time effect				No	No	No

Notes: t-statistics in parentheses.

90% level of confidence, * 95% level of confidence, ** 97.5% level of confidence, *** 99% level of confidence.

$U_{ij,t}$ = s_{ijt} moving standing deviation index of uncertainty.

Table 10. Results for export gravity equation – fresh vegetable trade - $U_{ij,t} = V_{ij,t}$

	a - OLS			b - Fixed Effects		
	(i) *n*=2	(ii) *n*=3	(iii) *n*=5	(i) *n*=2	(ii) *n*=3	(iii) *n*=5
Intercept	-12.99	-12.99	-12.94	-42.63	-42.10	-42.14
GDPPC1	2.41 (3.19)***	2.38 (3.15)***	2.38 (3.14)***	3.68 (6.75)***	3.71 (6.85)***	3.73 (6.87)***
GDPPC2	1.25 (6.06)***	1.25 (6.05)***	1.23 (5.97)***	2.13 (4.71)***	2.03 (4.52)***	1.98 (4.34)***
Distance	-1.26 (5.31)***	-1.26 (5.34)***	-1.25 (5.31)***			
Common Language	1.24 (3.58)***	1.25 (3.60)***	1.26 (3.65)***			
RFTA	3.77 (7.87)***	3.77 (7.88)***	3.79 (7.90)***	0.14 (0.44)	0.12 (0.40)	0.14 (0.47)
Uncertainty						
2years	-0.75 (1.31)#			-1.07 (3.28)***		
3 years		-0.56 (1.37)#			-0.93 (3.91)***	
5 years			-0.39 (1.33)#			-0.64 (3.70)***
Adjusted R^2	0.62	0.62	0.62	0.49	0.50	0.50
Individual effect				Yes	Yes	Yes
Time effect				No	No	No

Notes: t-statistics in parentheses.

[#] 90% level of confidence, *** 99% level of confidence.

$U_{ij,t} = V_{ij,t}$ Perée-Steinherr index of uncertainty.

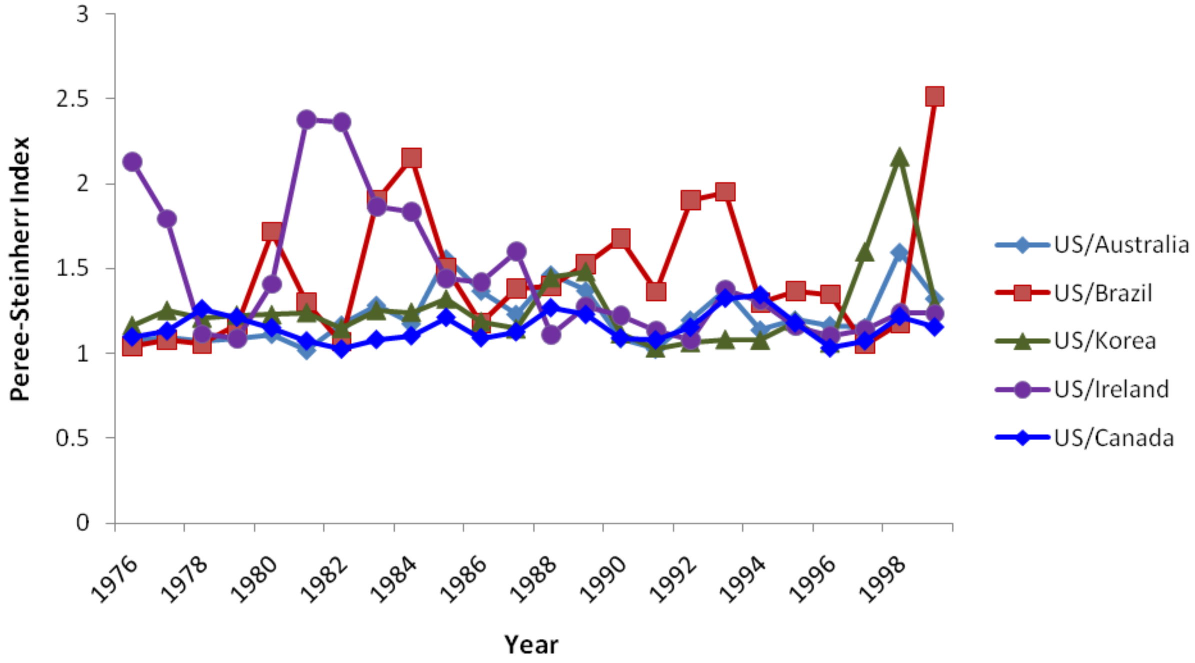

Fig.1. Index of exchange rate uncertainty (n=2)

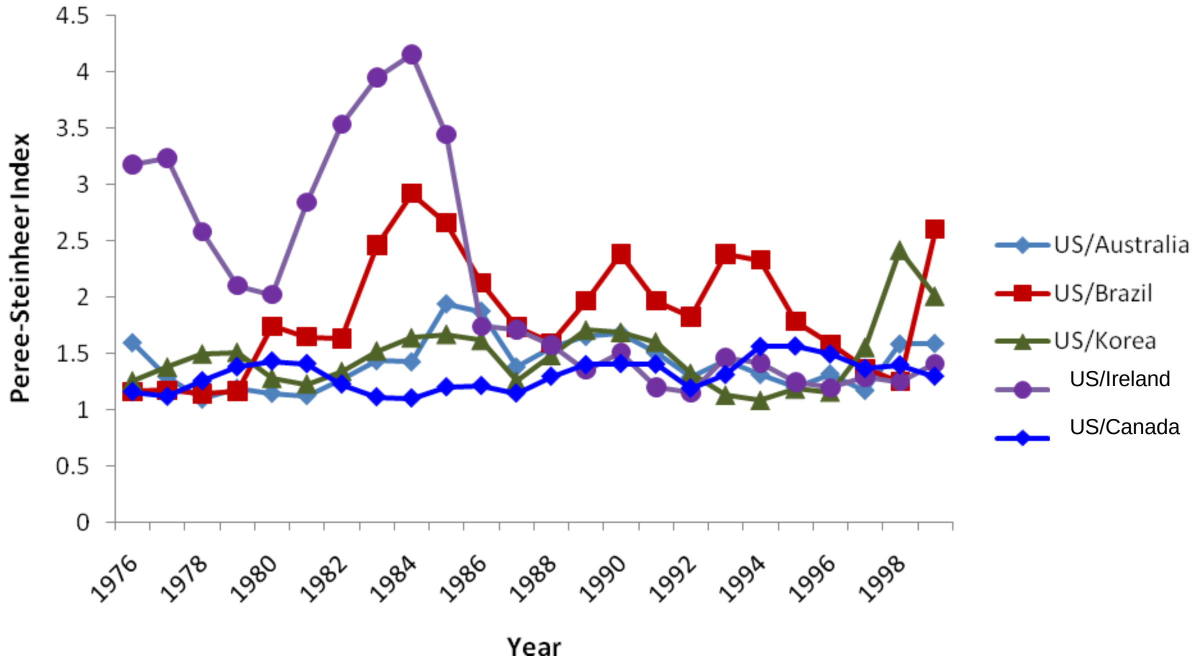

Fig.2. Index of exchange rate uncertainty (n=5)

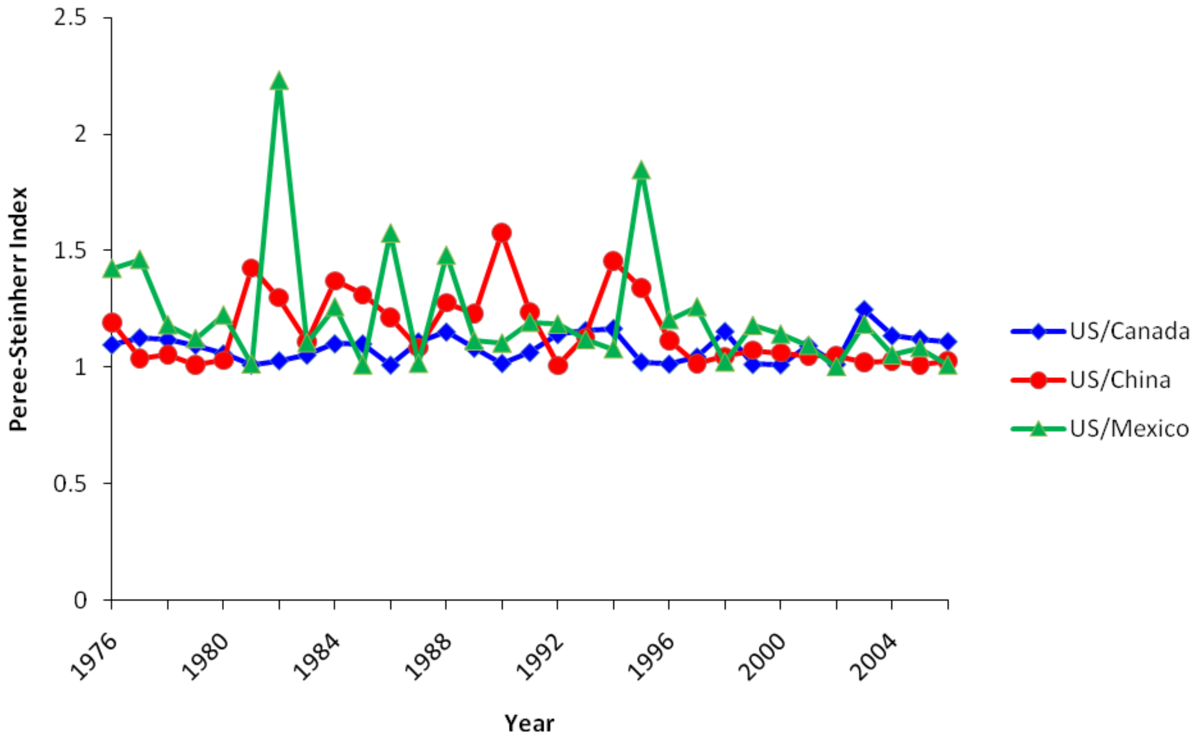

Fig.3. Index of exchange rate uncertainty (n=2)

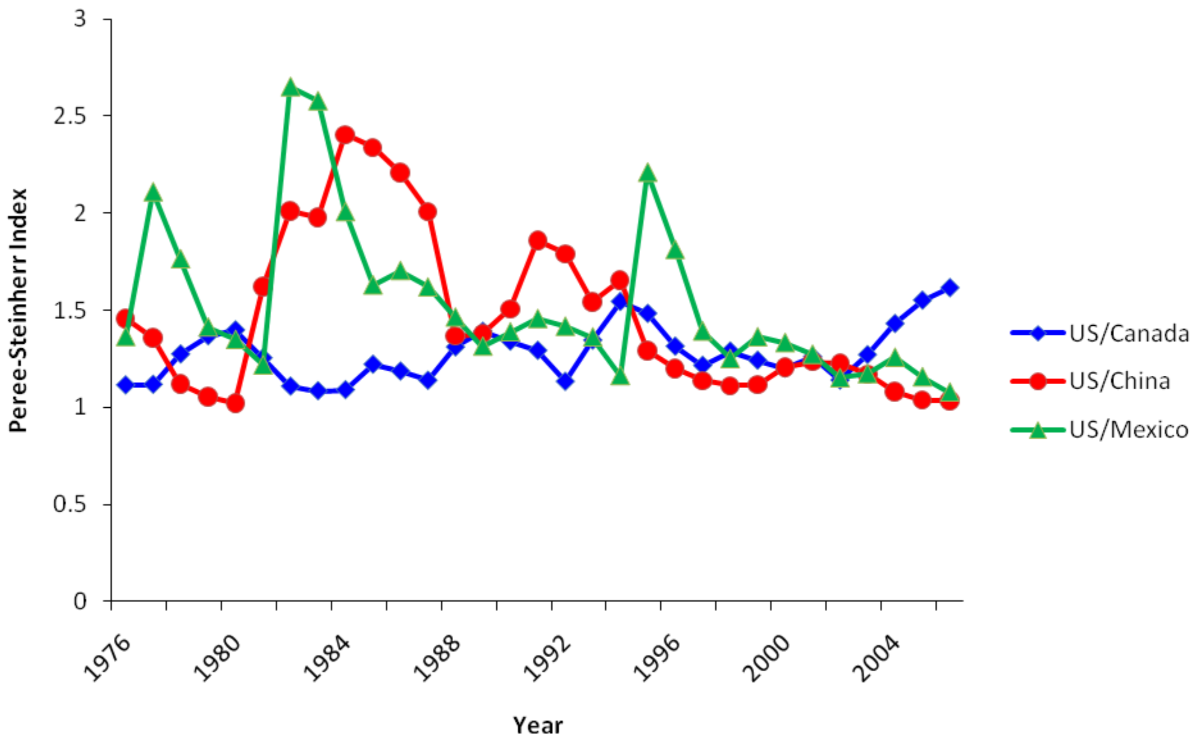

Fig.4. Index of exchange rate uncertainty (n=5)

References

Adler, M. and Lehman, B. (1983) Deviation from purchasing power parity, *Journal of Finance*, **38**, 1471-83.

Anderson, J. (1979) A theoretical foundation for the gravity equation, *American Economic Review* **69**, 106-16.

Anderson, J.E. and van Wincoop, E. (2004) Trade costs, *Journal of Economic Literature* **42**, 691-751.

Anderson, M. and Garcia, P. (1989) Exchange rate uncertainty and the demand for U.S. soybeans, *American Journal of Agricultural Economics* **71**, 721-29.

Bachetta, P. and van Wincoop, E. (2000) Does exchange rate stability increase trade and welfare?, *American Economic Review* **90**, 1093-1109.

Bahmani-Oskooee, M. and Hegerty, S.W. (2007) Exchange rate volatility and trade flows: a review article *Journal of Economic Studies* **34**, 211-255.

Baier, S.L. and Bergstrand, J.H. (2001) The growth of world trade: tariffs, transport costs, and income similarity, *Journal of International Economics* **53**, 1-27.

Baldwin, R, Skudelny, F., and Taglioni, D. (2005) Trade effects of the Euro: evidence from sectoral data, Working Paper No. 446, European Central Bank, Frankfurt.

Batten, D.S. and Belongia, M.T. (1986) Monetary policy, real exchange rates and U.S. agricultural exports, *American Journal of Agricultural Economics* **68**, 422-27.

Bessler, D. A. and Babula, R.A. (1987) Forecasting wheat exports: do exchange rates matter?, *Journal of Business and Economic Statistics* **5**, 397-406.

Bergstrand, J. (1985) The gravity equation in international trade: some microeconomic foundations and empirical evidence, *The Review of Economics and Statistics* **67**, 474-81.

Bergstrand, J. (1989) The generalized gravity equation, monopolistic competition and the factor-proportions theory of international trade, *Review of Economics and Statistics* **71**, 143-53.

Blisard, N., Lin, B.H., Cromartie, and Ballenger, N. (2002) America's changing appetite: food consumption and spending to 2020, *Food Review* **25**, 2-9.

Chen, N. (2002) Intra-national versus international trade in the European Union: why do borders matter?, Working Paper 3407, CEPR, London.

Cho, G, Sheldon, I.M. and McCorriston, S. (2002) Exchange rate uncertainty and agricultural trade, *American Journal of Agricultural Economics* **84**, 931-42.

Clark, P., Tamirisa, N., Wei, S-J., Sadikov, A. and Zeng, L. (2004) *Exchange Rate Volatility and Trade Flows – Some New Evidence*, International Monetary Fund, Washington DC.

Cushman, D.O. (1988) US bilateral trade flows and exchange risk during the floating period, *Journal of International Economics* **24**, 317-30.

Davis, D.R. (1995) Intra-industry trade: a Heckscher-Ohlin-Ricardo approach, *Journal of International Economics* **39**, 201-26.

De Grauwe, P. (1988) "Exchange rate variability and the slowdown in growth of international trade," *IMF Staff Papers* **24**, 317-30.

De Grauwe, P. (1999) *International Money*, Clarendon Press, Oxford.

De Grauwe, P. and de Bellefroid, B. (1986) Long-run exchange rate variability and international trade, in *Real-Financial Linkages among Open Economies*, (Eds) S. Arndt and J.D. Richardson, MIT Press, Cambridge, MA pp.?

De Grauwe, P. and Skudelny, F. (2000) The impact of EMU on trade flows, *Weltwirtschaftliches Archiv* **136**, 383-402.

Deardorff, A. V. (1998) Determinants of bilateral trade: does gravity work in a neoclassical world?, in *The Regionalization of the World Economy*, (Eds) J.A. Frankel, Chicago University Press, Chicago, IL.

Dell'Arricia, G. (2000) Exchange rate fluctuations and trade flows, *IMF Staff Papers* **46**, 293-314.

Dornbusch, R. (1986) Flexible exchange rates and excess capital mobility, *Brookings Papers on Economic Activity* **1**, 209-26.

Dornbusch, R. (1987) Exchange rates and prices, *American Economic Review* **77**, 1-8.

Eaton, J. and Kortum, S. (2002) Technology, geography and trade, *Econometrica* **70**, 1741-79.

Economic Research Service. Fruit and Vegetable Backgrounder. Available at http://www.ers.usda.gov/publications/vgs/apr06/vgs31301/vgs31301.pdf (accessed December 28, 2009).

Egger, P. (2000) "A note on the proper econometric specification of the gravity equation, *Economics Letters* **66**, 25-31.

Egger, P. and Pfaffermayr, M. (2003) "The proper panel econometric specification of the gravity equation: a three-way model with bilateral interaction effects, *Empirical Economics* **28**, 571-80.

Eichengreen, B. and Irwin, D.A. (1995) Trade blocs, currency blocs and the reorientation of trade in the 1930s, *Journal of International Economics* **38**, 1-24.

Evenett, S.J. and Keller, W. (2002) On theories explaining the success of the gravity equation, *Journal of Political Economy* **110**, 281-316.

FAO. (1993) Compendium of food consumption statistics from household surveys in developing countries, vol. 1, Asia, FAO Economic and Social Development Paper 116/1, FAO, Rome.

FAO. (1994) Compendium of food consumption statistics from household surveys in developing countries, vol. 2, Africa, Latin America and Oceania, FAO Economic and Social Development Paper 116/2, FAO, Rome.

Feenstra, R.C., Markusen, J.R. and Rose, A.K. (2001) Using the gravity equation to differentiate among alternative theories of trade, *Canadian Journal of Economics* **34**, 430-447.

Feenstra, R.C. (2004) *Advanced International Trade: Theory and Evidence*, Princeton University Press, Princeton, NJ.

Fisher, E. and Park, J.Y. (1991) Testing purchasing power parity under the null hypothesis of co-integration, *Economic Journal* **101**, 1-8.

Flood, R.P. and Taylor, M.P. (1996) "Exchange rate economics: what's wrong with the conventional macro approach?, in *The Microstructure of Foreign Exchange Markets*, (Eds) J.A. Frankel, G. Galli, and A. Giovannini, Chicago University Press, Chicago, IL.

Foreign Agricultural Service. (2004a) The World Fresh Fruit Market. Available at http://www.fas.usda.gov/htp/Presentations/2004/World%20Fresh%20Fruit%20Market%20(08-04).pdf (accessed December 28, 2009).

Foreign Agricultural Service. (2004b) World Trade Highlights in Fresh Vegetables. Availabler at http://www.fas.usda.gov/htp/ITRs/2004/02-24-04%20ITR%20-%20Fresh%20Veg%20Trade.pdf (accessed December 28, 2009).

Foreign Agricultural Service. (2009) Vegetables and Melons Outlook. Available at http://www.ers.usda.gov/Publications/VGS/Tables/World.pdf (accessed December 28, 2009).

Frankel, J.A. (1996) Recent Exchange-Rate Experience and Proposals for Reform, *American Economic Review* **86**, 153-158.
Frankel, J.A. and Rose, A.K. (1996) A panel project on purchasing power parity: mean reversion within and between countries, *Journal of International Economics* **40**, 209-224.
Glick, R. and Rose, A. K. (2002) Does a currency union affect trade? The time series evidence, *European Economic Review* **46**, 1125-1151.
Grossman, G.M. (1998) Comment, in *The Regionalization of the World Economy*, (Eds) J.A. Frankel, Chicago University Press, Chicago, IL.
Head, K. and Ries, J. (2001) Increasing returns versus national product differentiation as an explanation for the pattern of US-Canada trade, *American Economic Review* **90**, 858-876.
Helpman, E. (1987) Imperfect competition and international trade: evidence from fourteen industrial countries, *Journal of the Japanese and International Economies* **1**, 62-81.
Hooper, P. and Kohlhagen, S.W. (1978) The effect of exchange rate uncertainty on the prices and volume of international trade, *Journal of International Economics* **8**, 483-511.
Hsiao, C. *Analysis of Panel Data*, Cambridge University Press, Cambridge, 1986.
Huang, S.W. (2006) *Global Trade Patterns in Fruits and Vegetables*, Agriculture and Trade Report WRS-04-06, USDA/ERS, Washington DC.
Hummels, D. and Levinsohn, J. (1995) Monopolistic competition and international trade: reconsidering the evidence, *Quarterly Journal of Economics* **110**, 799-836.
Kandilov, I. (2008) Exchange rate volatility and agricultural trade, *American Journal of Agricultural Economics* **90**, 1028-43.
Karemera, D., Managi, S., Reuben, and Spann, O. (2011) The impacts of exchange rate volatility on vegetable trade flows, *Applied Economics* **13**, 1607-1616
Klein, M.W. (1990) Sectoral effects of exchange rate volatility on United States exports, *Journal of International Money and Finance* **9**, 299-308.
Kristinek, J.J., and Anderson, D.P. (2002) Exchange rates and agriculture: a literature review, AFPC Working Paper, Agriculture and Food Policy Center, Texas A&M University, College Station, TX.
Langley, S.V., Guigale, M., Meyers, W.H. and Hallahan, C. (2000) International financial volatility and agricultural commodity trade: a primer, *American Journal of Agricultural Economics* **82**, 695-700.
Leamer, E.E. and Levinsohn, J. (1995) International trade theory: the evidence, in *Handbook of International Economics*, (Eds.) G.M. Grossman and K. Rogoff, Elsevier, Amsterdam.
Lothian, J.R. and Taylor, M.P. (1996) Real exchange rate behavior: the recent float from the perspective of the past two centuries, *Journal of Political Economy* **104**, 488-509.
MacDonald, R. (1999) Exchange rate behavior: are fundamentals important?, *Economic Journal* **109**, 673-91.
Mark, N.C. (1990) Real and nominal exchange rates in the long run: an empirical investigation, *Journal of International Economics* **28**, 115-36.
Mark, N.C. (1995) Exchange rates and fundamentals: evidence on long-horizon predictability, *American Economic Review* **85**, 201-218.
Maskus, K. (1986) Exchange rate risk and U.S. trade: a sectoral analysis, *Federal Reserve Bank of Kansas Economic Review* **3**, 16-28.

McCallum, J. (1995) National borders matter, *American Economic Review* **85**: 615-623.
McKinnon, R.I. (1988) Monetary and exchange rate policies for international financial stability, *Journal of Economic Perspectives* **2**, 83-103.
Meese, R.A. and Rogoff, K. (1983) Empirical exchange rate models of the seventies: do they fit out of sample?, *Journal of International Economics* **14**, 3-24.
Mundell, R. (1992) The global adjustment system, in *Global Disequilibrium in the World Economy*, (Eds.) M. Baldassari, J. McCallum and R. Mundell, St. Martin's Press, New York.
Obstfeld, M. (1995) International currency experience: new lessons and lessons relearned, *Brookings Papers on Economic Activity* **1**, 119-96.
Orden, D. (1999) Exchange rate effects on agricultural trade and trade relations, in *Policy Harmonization and Adjustment in the North American Agricultural and Food Industry*, Proceedings of the 5th Agricultural and Food Policy System Information Workshop, Farm Foundation, Oak Brook, IL.
Perée, E. and Steinherr, A. (1989) Exchange rate uncertainty and foreign trade, *European Economic Review* **33**, 1241-64.
Pick, D.H. (1990) Exchange rate risk and U.S. agricultural trade flows, *American Journal of Agricultural Economics* **72**, 694-700.
Pick, D.H. and Vollrath, T.L. (1994) Real exchange rate misalignment and agricultural export performance in developing countries, *Economic Development and Cultural Change* **42**, 555-71.
Rauch, J.E. (1999) Networks versus markets in international trade, *Journal of International Economics* **48**, 7-35.
Regmi, A., Deepak, M.S., Seale, J.L., and Bernstein, J. (2001) Cross-country analysis of food consumption patterns, in *Changing Structure of Global Food Consumption and Trade*, (Ed.) A. Regmi, Agriculture and Trade Report WRS01-1, USDA/ERS, Washington DC.
Regmi, A. and Dyck, J. (2001) Effects of urbanization on global food demand, in *Changing Structure of Global Food Consumption and Trade*, (Ed.) A. Regmi, Agriculture and Trade Report WRS01-1,USDA/ERS, Washington DC.
Rogoff, K. (1996) The purchasing power parity puzzle, *Journal of Economic Literature* **34**, 647-68.
Rose, A. K. (2000) One money, one market: the effect of common currencies on trade, *Economic Policy* **30**, 7-46.
Rose, A. K. and van Wincoop, E. (2001) National money as a barrier to international trade: the real case for currency union, *American Economic Review, Papers and Proceedings* **91**, 386-90.
Rose, A.K. (2004) Do we really know that the WTO increases trade?, *American Economic Review* **94**, 98-114.
Schuh, G.E. (1974) The exchange rate and US agriculture, *American Journal of Agricultural Economics* **56**, 1-13.
Shane, M., Roe, T., and Somwaru, A. (2008) Exchange rates, foreign income, and US agricultural exports, *Agricultural and Resource Economics Review* **37**, 160-175.
Sheldon, I.M. (2006) Monopolistic competition and trade: does the theory carry any empirical weight?, *Journal of International Agricultural Trade and Development* **2**, 1-31.

Tinbergen, J. (1962) *Shaping the World Economy: Suggestions for and International Economic Policy*, The Twentieth Century Fund, New York.

Vianne, J.M. and de Vries, C.G. (1992) International trade and exchange rate volatility, *European Economic Review* **36**, 1311-21.

Williamson, J. (1985) *The Exchange Rate System*, Institute for International Economics, Washington DC.