Positive OCA criteria: Microfoundations for the Rose effect

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Abstract

Since Rose (2000), many scholars have found empirical evidence linking trade to exchange rate volatility and currency unions. Our paper takes a first step toward providing theoretical underpinnings for this "Rose effect". In our Melitz-like trade model, reduced volatility boosts trade by inducing existing exporters to export more and by inducing more firms to begin exporting. Specifically, volatility is a greater hindrance to export for small firms, so reduced volatility especially promotes small firms' exports. Because most firms are small, the extra exports induced by a marginal reduction in volatility may increase as the level of volatility falls – a result that can account for the convexity of the trade-volatility link implied by the Rose effect. We derive and test three new empirical hypothesis generated by our model. We find some support for two of them using data on Eurozone aggregate bilateral trade, but have insufficient data to test the third in a convincing manner.

1. INTRODUCTION

The euro is surely the largest and boldest economic policy innovation since WWII. The year 1999 saw the formation of a monetary union among nations that account for about a quarter of world GDP and two-fifths of world trade. In 2001, this became a currency union. Preliminary empirical studies show the euro has had a positive and statistically significant effect on trade and that this appeared surprisingly quickly.

This paper extracts a series of 'stylised facts' from the existing empirical literature on the euro's trade impact and uses these to formulate a theoretical model – what might be called the microfoundations of the Rose effect (the trade impact of a currency union is commonly named after Rose 2000). We then go on to test several of the model's implications with *de novo* empirical work.

As a side effect of our work, we identify a series of what might be called 'positive' optimal currency area (OCA) criteria; 'positive' in the sense of identifying gains.

Current thinking views a monetary union as a trade-off between macroeconomic *costs* and microeconomic *gains*. The existing "OCA criteria" provide rules of thumb for identifying groups of nations that are most likely to benefit from merging their monies, but these criteria are quite one-sided. They focus exclusively on the macro costs of monetary union. They say nothing about which nations are likely to enjoy the greatest micro gains from monetary union. Specifically, the literature starts by asserting that national monetary policies are useful in dealing with macro shocks, so the cost of foregoing national monetary policy autonomy depends on how asymmetric macro shocks will be among monetary union members. The OCA criteria identify national features that either reduce the likelihood of asymmetric shocks or allow the nations to adjust without a bilateral exchange rate. The three classic criteria are labour mobility, openness to trade, and diversified exports. Two political criteria are frequently added, namely homogeneous preferences regarding the aims of macroeconomic policies and tolerance for large intra-union fiscal transfers. These are "negative OCA criteria" since they identify nations for whom the costs of monetary union would be mild. We add two 'positive' OCA criteria.

Two positive OCA criteria

The theoretical and empirical results in this paper suggest two criteria for nations that are most likely to experience large micro gains from monetary union. The first concerns the initial level of integration among nations. As it turns out, the trade-boosting effects of monetary union are amplified by lower trade costs, so the gains from joining a monetary union are likely to be greatest for nations that are already tightly integrated on the real side. Since distance-related trade costs are so important, a corollary to this is that monetary union members should be geographically proximate. Second, our theoretical and empirical results suggest that monetary union boosts trade in sectors marked by imperfect competition and increasing returns more than trade in competitive sectors. Thus nations that have a good deal of bilateral trade in such sectors are more likely to gain more from monetary union. Again, a simple corollary is immediate. The most natural explanation for intra-industry trade is the existence of imperfect competition and increasing returns, so we can say that nations that engage in a great deal of bilateral intra-industry trade are more likely to gain.

Existing studies

While the theoretical literature linking exchange rate volatility and trade volumes has waxed and waned since the breakdown of Bretton Woods in early 1970s, there seems to be no formal model of how a currency union could boost bilateral trade volumes in a discrete fashion. A good deal of informal theorising can be found in the background studies to the European Commission's well-known "One Market, One Money" study (EC 1990), in particular Baldwin (1991). Moreover, almost all of the empirical papers on the Rose effect contain a few paragraphs of conjecture on how a currency union might boost trade. A related strand of the theoretical literature that is noteworthy combines modern trade and exchange rate models to examine the two-way interaction between trade pricing and exchange rate volatility. The results of the first formal models by Baldwin and Lyons (1993, 1994) have recently been reproduced and extended by Devereux and Engel (2002) and Borda and Romalis (2003).

Organisation of the paper

Section 2 identifies a set of stylised, empirical results that are used as a guide to our theoretical modelling in Section 3. Section 4 presents a list of testable predictions of the model that go beyond the stylised facts from Section 2. Section 5 presents our *de novo* empirical work aimed at testing these predictions and section 6 presents our concluding remarks.

2. SYNTHESIS OF EXISTING EMPIRICAL FINDINGS

For many years, the trade-inhibiting effects of exchange rate volatility were an article of faith among international economists with this folk wisdom based largely an a causal evaluation of the gold standard's pro-trade effects. This article of faith was also a key intellectual pillar of the Bretton Woods exchange rate system and various European currency arrangements. The breakdown of Bretton Woods and extreme volatility in Europe, however, did not have the anticipated trade effects. Indeed, despite extensive empirical efforts in the 1970s and 1980s, no one could convincingly demonstrate that volatility had a statistically significant impact on trade, either positive or negative.

The recent use of vast data sets and panel estimation techniques have turned this situation on its head. Nowadays, everyone finds negative, statistically significant effects of exchange rate volatility on trade. More spectacularly, a sequence of papers spearheaded by Rose (2000) has found large positive trade effects of currency unions. The cause and indeed existence of these large effects is still being debated. One persistent critique of Rose's findings turned on the fact that most of the currency unions in his data samples involved poor and very, very small nations. Recent empirical studies of the euro's trade impact have addressed this by finding a significant Rose effect even among large, advanced industrial nations.

Most of the literature on the 'currency union effect', or the Rose effect as we prefer to call it, has treated currency unions as magic wands – one touch and intra-currency union trade flows rise between 5%, 20% or 400%. The debate has been over how big the effect is, with the 'anti-Rose' crowd struggling to bring down the size, and Rose and co-authors struggling to keep it up. The flavour of this literature is best encapsulated by the titles of a pair of articles in the October 2001 issue of Economic Policy: Torsten Persson's paper was "Currency Unions and Trade: How Large is the Treatment Effect?" and Andy Rose's was "Currency Unions and Trade: the Effect is Large". The best title in literature, however, surely goes to Nitsch (2001) with his "Honey, I shrunk the currency union effect".

This literature has yet to settle firmly on a 'received wisdom' estimate, but it seems to us that the whole exercise is somewhat too blunt. Surely, the size of the trade effect depends upon the nature of the trade partners and the nature of the trade.

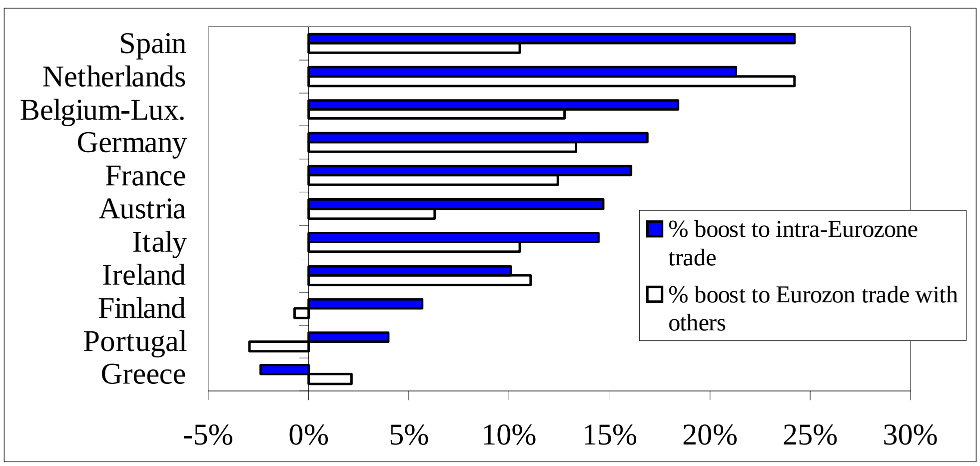
In this section, we distil stylised facts from the literature with the aim of identifying characteristics that are associated with large Rose effects. Since we are not sure how to deal with vast heterogeneity of currency unions used in the general literature, we limit ourselves to studies of the euro's trade impact.

2.1. ***The Micco, Stein and Ordonez findings***

To date, the best empirical study of the euro's trade effect is Micco, Stein and Ordonez (2003); MSO henceforth. The MSO study was the first to establish the existences of a Rose effect in the Eurozone. Following standard practice, they focus on finding 'the' number. As they write, "Controlling for a host of other factors, we find that the effect of EMU on bilateral trade between member countries ranges between 4 and 10 percent." This suggests that the "currency-union wand" is a good deal less magic than other papers indicate, but this is not much help to us in determining the types of trade and types of partners that are most likely to experience microeconomic gains from currency union membership. Fortunately, MSO report extensive robustness checks and deep within these are by-nation estimates the Rose effect for all Eurozone nations. We have converted MSO's raw coefficients into percent increases in trade and plotted the results by nation in Figure 1. The nations are ordered by decreasing Rose effect. Three features are particularly relevant. (Note that MSO also allow the euro to alter trade between euroland members and other nations.)

1. Apart from Spain, the nations with the highest Rose effects are those that are already the most tightly integrated: the Benelux nations and Germany. Two aspects of this group may be relevant in our search for positive OCA criteria.

Figure 1: euro's trade effect by nation



Source: Our calculations based on Micco, Stein and Ordenez (2003), Table 8.

These nations have been in an informal, but very tight exchange rate arrangement called the DM-bloc for decades. As Figure 2 shows, intra-DM bloc volatility was very low, so the euro had only a very small impact on the bilateral exchange rate variability among these nations. This is a bit puzzling since one might have thought that the trade effects would have been largest among nations that had the largest, pre-euro bilateral volatility.

2. These nations are geographically proximate, so we suppose that the natural trade costs among these nations are quite low; gravity model estimates in Europe suggest that each doubling of the

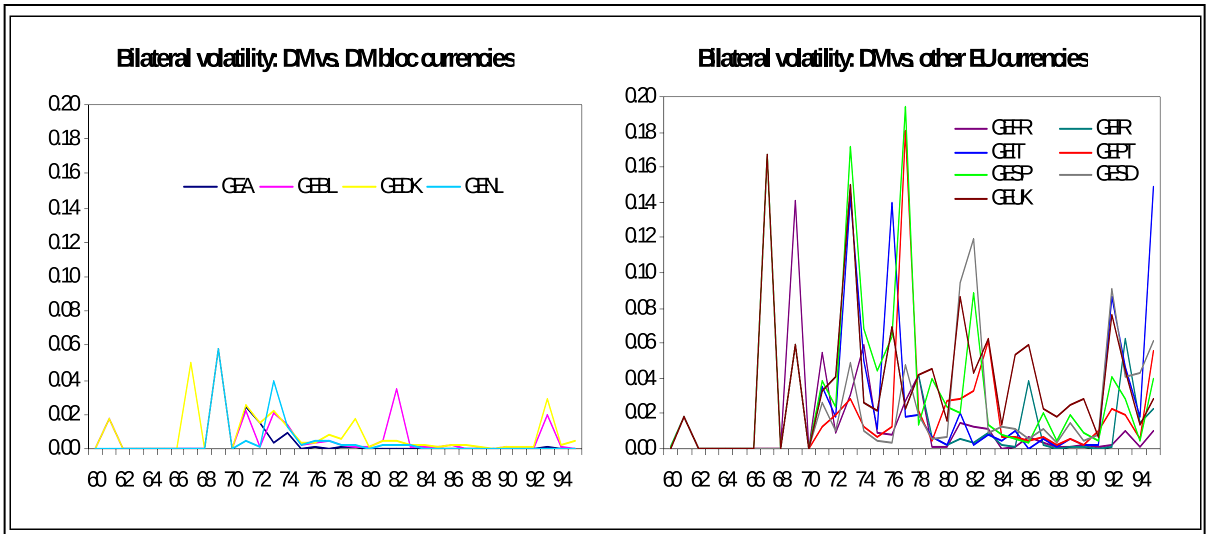
distance between capitals lowers trade by 70%.[1] Moreover, these nations are among the most avid integrationists in the EU and thus have embraced the EU's deep trade integration even more tightly than other members. For example, the Benelux nations formed a customs union even before the EU was founded in 1958, and Belgium and Luxembourg have shared a common currency since just after the war. As part of this distance-Rose-effect nexus, we note that the size of the euro's trade impact is lowest in the geographically peripheral euroland nations: Greece, Portugal, Finland and Ireland. Again this suggests a negative relationship between trade costs and the Rose effect.

3. Apart from Portugal, there is a positive correlation between individual euro member's EMU2 coefficients (the dummy on intra-euroland trade) and the importance of euroland in their trade pattern. This provides some support for the notion that the euro simply boosted trade with all nations since each nation's euroland trade share indicates the fraction of its trade that is influenced by the euro on both the sending and receiving ends of the trade flow.

2.1.1 Trade with non-Eurozone nations

Intriguingly, MSO also find that trade between Eurozone nations and other nations rose with the euro's introduction, but not quite as much. Specifically, they estimate what might be called a one-sided euro dummy; its value is unity for any trading pair that involves only one Eurozone member (the regular euro dummy, or two-sided dummy, is one only for trading pairs where both nations are in the Eurozone). The results, again translated into percent increase in trade, are shown as the light bars in Figure 1. Roughly speaking, the one-sided impact is lower than the two-sided effect, but the nations with large two-sided effects also seem to have large one-sided effects.

Figure 2: DM bloc exchange rate volatility, 1960-1994



Source: Anderton, Baldwin and Taglioni (2003).

This result is intriguing. It provides a very significant hint as to the microeconomics of the Rose effect, or at least as to what it is not. Informal discussion of the trade effects of a monetary union

[1] On the gravity model, see Anderson (1979).

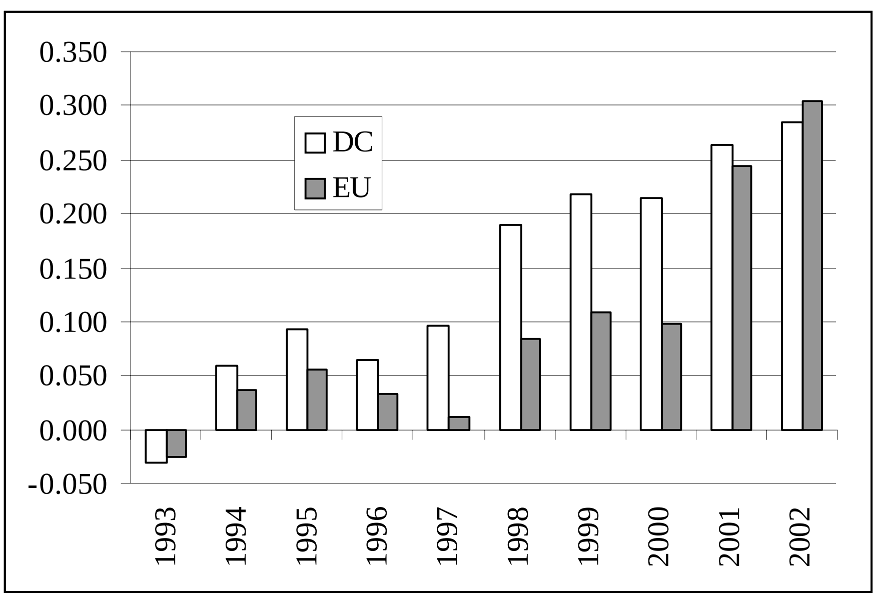
typically refer to 'transaction costs' of having different currencies. In standard trade policy terminology, having a common currency is like reducing bilateral, non-tariff barriers. The evidence on the one-sided dummy tends to reject this view. If one could model the trade-reducing effects of volatility as a frictional trade barrier, the one-sided dummy should have been negative. The euro would have been akin to a discriminatory liberalisation and this should have reduced the exports of non-euro nations to Euroland.

2.1.2 Speed of the effect

Monetary union in Europe was never a sure thing until it actually happened. Although the treaty that laid out the path to the euro was signed in 1992, the Treaty had several major difficulties in becoming law. Moreover, the treaty laid down a series of conditions – the famous Maastricht conditions – for membership in the monetary union, and most European nations had trouble meeting these. Right up to the announcement of the names of the inaugural members in 1998, sceptics doubted that the monetary union would ever become a reality.

Given this, the speed with which the euro's trade impact appeared is striking. Evidence for this comes from the MSO estimates of their gravity model that allows for year-by-year Rose effects. The results are illustrated in Figure 3, which shows the estimated year-by-year dummies for intra-Eurozone trade; the dark bars show the estimates for the sample that includes only EU nations and the light bars show the estimates for the sample that includes all industrialised nations The main points are that the Rose effect jumps up and becomes statistically significant in 1998. It jumps up again in 2001, especially for the EU sample, when the monetary union became a currency union.

Figure 3: euro's trade effect over time



Source: Micco, Stein and Ordenez (2003),

The rapid reaction of trade flows is quite remarkable since the MSO study controls – as usual in gravity model studies – for the main determinants of bilateral trade. The speed also provides us with an important hint as to what is *not* going on here. Such a rapid increase in trade would be very hard to explain if, for example, it was driven by the construction of new plants related to the unwinding of hedging-related foreign direct investment.

Hints from the sectoral results

While most studies of the euro's impact have focused on aggregate trade data, Baldwin, Skudelny and Taglioni (2003) run the standard gravity model using sectoral data. In addition to confirming the general findings of the aggregate studies when all the sectors are pooled, this paper also provides sector-specific estimates of the Rose effect. The results are shown in Table 1.

What these results show is a rough correlation between the size of the Rose effect and what we loosely call ICIR sectors (imperfect competition and increasing return sectors). At the bottom of the list, we have agriculture as well as mining and quarrying, while near the top, we have various types of machinery and highly differentiated consumer goods such as food products, beverages and tobacco. This finding opens the door to the possibility that ICIR like effects – for example, the impact of uncertainty on market structure – may be part of the story.

Table 1: Rose effect and volatility impact by sector.

isic	industry	Rose effect	t-stat	Volatility	t-stat
40-41	electricity, gas and water supply	1.64	4.47	-15.78	-1.87
351	……building and repairing of ships and boats	0.57	2.00	-15.87	-2.42
15-16	food products, beverages and tobacco	0.40	2.64	-7.78	-2.23
25	….rubber and plastics products	0.35	2.25	-10.73	-3.04
35	….other transport equipment	0.34	1.84	-17.72	-4.23
30	……office, accounting and computing machinery	0.32	1.91	-5.77	-1.50
34	….motor vehicles, trailers and semi-trailers	0.31	1.81	-13.78	-3.53
32	……radio, television and communication equipment	0.27	1.68	-14.06	-3.74
36-37	manufacturing nec; recycling	0.27	1.76	-6.25	-1.76
353	……aircraft and spacecraft	0.27	1.09	-16.89	-2.98
33	……medical, precision and optical instruments	0.27	1.76	-7.75	-2.22
31	……electrical machinery and apparatus, nec	0.26	1.64	-14.13	-3.94
28	….fabricated metal products	0.25	1.66	-9.78	-2.85
17-19	textiles, textile products, leather and footwear	0.25	1.54	-12.00	-3.25
24	….chemicals and chemical products	0.25	1.52	-8.80	-2.38
20	wood and products of wood and cork	0.23	1.41	-7.78	-2.08
29	….machinery and equipment, n.e.c.	0.23	1.44	-9.29	-2.54
27	….basic metals	0.19	1.16	-14.23	-3.70
26	other non-metallic mineral products	0.19	1.24	-10.29	-2.91
271+2731	……iron and steel	0.14	0.74	-13.25	-3.08
2423	……pharmaceuticals	0.13	0.70	-8.04	-1.90
272+2732	……non-ferrous metals	0.12	0.63	-20.52	-4.72
01-05	agriculture, hunting, forestry and fishing	0.09	0.50	-7.59	-1.91
23	….coke, refined petroleum products and nuclear fuel	0.03	0.12	-7.83	-1.33
352+359	……railroad equipment and transport equipment n.e.c.	-0.05	-0.23	-14.09	-2.96
10-14	mining and quarrying	-0.21	-1.15	-9.84	-2.37
Source:	Adapted from Baldwin, Skudelny and Taglioni (2003)				

3. A MICRO MODEL OF THE ROSE EFFECT

A monetary union or currency union could affect trade through many economic channels. The range, however, is greatly narrowed by one important clue from the empirical work we surveyed above. The effect happened very quickly, far too quickly for the new trade to be explained by important changes in production structures. Moreover, given the very small size of the likely transactions cost reductions entailed in monetary union (even smaller than the one linked to currency union), the size of the effect seems to be too large to be explained by a standard export supply curve model using a reasonable export supply elasticity. One way to explain these facts – the way adopted in this paper – is to assert that monetary union leads to a big increase in the number of firms engaged in trade.

The basic intuition is simple. Most European firms are not engaged in trade; they sell only in their local markets due to a variety of reasons – one of which is aversion to exchange rate uncertainty. Our story is that monetary union eliminated this uncertainty and thus increased the number of firms in the Eurozone that are engaged in exporting to other Eurozone markets. A sudden and permanent reduction of bilateral volatility within the Eurozone thus led to an increase in exports with little change in the basic production structure. (See Bernard and Jensen 2002 for an empirical analysis of the importance of new exporters versus export-expansion by existing exporters in the 1987-1992 US export boom).

3.1. *Basic Model*

The essential elements of the model are dictated by our basic story – reduced volatility induces more firms to export – and by the stylised facts we wish to capture. The particular model we present may be thought of as a ‘new trade’ trade model (Helpman and Krugman 1985) with a few modifications, the main ones being the inclusion of exchange rate volatility, a Baldwin (1988)-like sunk cost of exporting to a new market, a Melitz (2003)-like monopolistic competition that allows for heterogeneous firms. Since inclusion of exchange rate uncertainty in a market-clearing trade model involves a host of complex issues that are tangential to the core logic of our model, we work in partial equilibrium (see Ghironi and Melitz 2003 for the sort of complexity that is necessary to endogenous exchange rate fluctuation in a general equilibrium model of this type).

Our model allows for two traded goods sectors. One is perfectly competitive (the C sector, where C is a mnemonic for commodity) and one imperfectly competitive (the M sector, where M stands for manufacturing).

The C-sector is meant to represent the non-ICIR sectors that did not seem to experience a Rose effect. Following Davis (1995), we assume the sector is marked by perfect competition and constant returns to scale. Davis-style intra-industry trade arises in the sector because the two nations have complementary technology in C-sector varieties. Specifically, we assume the following technological complementarity. The varieties of the C-good that Home can make cannot be made in Partner; Partner simply does not know how to make them. Likewise, Partner produces a distinct set of varieties that it alone knows how to make. As in Davis (1995), these differences are assumed not derived.[2] For simplicity’s sake, C-varieties are symmetric in

[2] Davis (1995) assumes technological complementarity that is much less extreme.

production; production of any C-variety that a nation knows how to make requires a_C units of labour (a_C is infinite for the varieties a nation does not know how to make). As we shall see, these assumptions on technological complementarities produce intra-industry trade with a minimum of complication.

Heterogeneous firms M-sector firms

The M-sector reflects the ICIR sectors that did experience a Rose effect. To keep the modelling as simple as possible, we assume that the M-sector is marked by monopolistic competition and increasing returns. Production of each variety of the M good involves a variable cost of 'm' units of labour per unit of output and a fixed cost of F units of labour.

The core logic of our model of the Rose effect turns on firms' decisions to export, but in the standard monopolistic trade model, all active firms export, so our model requires an additional element. Following the 'beachhead model' of Baldwin (1988), we assume that firms must incur market-entry cost in order to sell in a market (i.e. to establish a 'beachhead' in that market). A second element in our model helps us link export behaviour to exchange rate volatility. Since the heart of our story is volatility's impact on small firms' export behaviour, we cannot adopt the standard simplifying assumption of identical firms. Rather, we follow Melitz (2003) in allowing for firm-level productivity differences. Specifically, M-sector firms are assumed to have heterogeneous technology in the sense that the marginal cost 'm' varies across firms. We arrange firms according to their marginal cost, with marginal cost ranging from zero to a maximum of m_0; m_χ denotes the marginal cost of firms with index χ (chi is a mnemonic for cost). Since firms with low marginal costs will charge a lower price and thus sell more, we often also refer to the firms as being heterogeneous in terms of size. We note in passing that heterogeneity in firm size is one of the most firmly established results in empirical industrial organisation (Cabral and Mata 2001).

As we show more formally below, the natural outcome of heterogeneous marginal costs and sunk market-entry costs is that only sufficiently large firms export, and crucially, the cut-off size varies with exchange rate volatility.

Timing of the exchange rate uncertainty and firms' risk aversion

Any model with uncertainty must make assumptions concerning the timing of decisions relative to the realization of the uncertainty (Helpman and Razin 1978). In our model, we assume that the market-entry decision is taken by firms *before* any particular realization of the exchange rate is known (entry decisions are based on expectations that are informed by firms' knowledge of the exchange rate's stochastic process). Firms that have entered choose their level of sales, again without knowing the realisation of the exchange rate. This is meant to reflect the fact that production and sales decisions are taken only occasionally, but the exchange rate fluctuates continuously. To summarise, the order of decision-making is:

1. Enter each market, or not,
2. Set sales per market entered.
3. Observe exchange rate and realize operating profits.

All steps are repeated each period, ad infinitum.

At all moments, firms take the exchange rate's stochastic process as given. As such, changes in the process's volatility, including a shift to a common currency, are unanticipated.

Firms in our model are risk averse.[3] To focus sharply on the essential logic of the mechanism under study, we adopt the simplest form of risk aversion – firms discount revenue streams by a risk premium that is related to the stream's variance and a risk-aversion parameter. Formally, the firm maximizes utility of profits. The utility function is:

(1) $$U = E\Pi - R[\sigma^2]$$

where Π is pure profit (this includes operating profit and fixed costs), σ^2 is the variance of the exchange rate and R is the function that defines the risk premium.

3.1.1 Short run equilibrium expressions

We first work out prices and quantities in the short run, i.e. taking the number of active firms per market as given (see Melitz 2003 for the additional assumptions that are necessary to endogenise this number).

M-sector short-run results

Standard monopolistic competition trade models assume that varieties compete indirectly with each other in the sense that the sales of one variety depends upon the prices of other varieties. While this interaction is interesting and important for many issues, it is irrelevant to the core logic of the model. More to the point, allowing for this strategic interaction renders our model analytically intractable, so we opt for tractability by making assumptions that eliminate the interaction. In particular, we assume that demand for each variety enters consumers' preferences symmetrically, quadratically and in an additively separate manner. This means that each M-sector firm faces a demand function in each market that is given by:

(2) $$p(i) = a - q(i)$$

where a>0. Firms play Cournot market by market, which, as usual, is tantamount to assuming that markets are segmented. Since each variety is distinct yet patented, each firm is a monopoly for its variety in each market.

As we shall demonstrate, some firms will sell only locally. These firms, called D-type firms, face no exchange rate uncertainty since their costs and revenue are in the same currency. This means that the risk adjustment term, R, in (1) is zero, so these firms engage in standard profit maximisation. Using the well-known fact that the operating profit of a monopolist facing linear demand is its optimal sales squared, a typical D-firm's pure profit is:

(3) $$\Pi = \left(\frac{a - m(\chi)}{2}\right)^2 - F$$

where $m(\chi)$ is the firm's particular marginal cost.

Home-based firms that export face exchange rate risk directly since the level of the exchange rate affects their marginal cost of selling to Home. In particular, their operating profit is:

[3] There is an extensive industrial organization literature on justifying this assumption, see Asplund (2002).

(4) $\pi \equiv (p - sm_{\chi}\tau)q$

where p is the price in the Partner market, q is per-firm export, m is the marginal cost, ‘s’ is the spot rate (Partner currency price of Home currency), and $\tau \geq 1$ is the ad valorum tariff equivalent of all trade barriers, both natural and man-made (more on this below).

In expected value terms, π is $(p\text{-}s^e m_{\chi}\tau)q$, the superscript ‘e’ denotes the expectation of s. The variance of this is $\sigma^2(m_{\chi}\tau q)^2$, where σ^2 is the variance of the spot rate ‘s’. Taking the R function in (1) to be the simplest possible function, namely $\alpha\mathrm{Var}(\pi)$ where α measures risk aversion, a typical exporting firm’s problem is to choose its sales to the Partner market, q, to solve:

(5) $\max_q (p - s^e \tau m_{\chi})q - \alpha\sigma^2(\tau m_{\chi} q)^2$

Using the demand function and solving the first order condition, we see that any firm that has entered the Partner market will export an amount given by:

(6) $$q = \frac{(a - s^e \tau m_{\chi})}{2(1 + \alpha\tau^2 m_{\chi}{}^2 \sigma^2)}$$

With our mean-variance objective function, (1), and linear demand, the risk adjusted operating profit is the square of optimal sales times $(1\text{-}\alpha(\tau m_{\chi})^2\sigma^2)$. To see this, note that the first order condition for export sales is $p\text{-}\tau ms^e - q - 2\tau^2 m^2\sigma^2 q$, where all variables are evaluated at equilibrium. Thus the payoff function, $(p\text{-}\tau ms^e)q - \alpha\tau^2 m^2\sigma^2 q^2$, evaluates to $q^2(1\text{-}\alpha(\tau m_{\chi})^2\sigma^2)$, normalizing $s^e=1$ for convenience. Given this, plugging the optimal export level from (6) back into the objective function, (5), the risk adjusted reward to exporting for a firm with marginal cost i is:

(7) $$U = \frac{(a - \tau m_{\chi})^2}{4(1 + \alpha\tau^2 m_{\chi}{}^2 \sigma^2)}$$

Here we normalised $s^e=1$ to reduce clutter in the expressions.

C-sector short-run results

Demand for each C-variety is linear in prices. The inverse demand function for a typical C-variety is:

(8) $p_C(j) = a - C_C(j)$

where $C_C(j)$ is the total consumption/sales of variety-j in a particular market and $p_C(j)$ is the corresponding price. When it comes to local sales (i.e. non-export sales), firms face no risk, so they price at marginal cost; equilibrium consumption/supply follows directly from the demand function.

When C-goods are exported, however, perfect competition does not mean marginal-cost pricing. Due to the presence of exchange rate uncertainty, firms supply the good up to the point where risk adjusted profit is zero, i.e. where price equals the risk-adjusted marginal cost. More specifically, firms supply each variety up to the point where (1) is zero. Modelling atomistic C-sectors firms as producing 1 unit of C each, the per-firm profit from exporting is

(9) $\pi_C = (p_C - s a_C \tau_C)$

where 's' is the spot rate, and $\tau_C \geq 1$ is the ad valorem tariff equivalent of all trade barriers. The variance of π_C is $\sigma^2(a_C\tau_C)^2$, where σ^2 is the variance of the exchange rate. The value of a typical C-firm's objective function is, therefore, $(p_C - s^e a_C\tau_C) - \alpha\sigma^2(a_C\tau_C)^2$, where s^e is the expected value of s. Perfect competition drives this to zero, so the price of each variety is $p_C = a_C\tau_C(1+\alpha\sigma^2 a_C\tau_C)$. Here we think of $a_C\tau_C(1+\alpha\sigma^2 a_C\tau_C)$ as the risk-augmented marginal cost. Using this price in the demand function, the volume of exports per variety will be:

(10) $q_C = a - a_C\tau_C(1+\alpha a_C\tau\sigma^2)$

3.1.2 Long-run equilibrium: Free entry

Having worked out the optimal actions and pay-offs for the second and third stages, we turn to the first stage market-entry decision, i.e. the decision of whether to export at all.

The objective of M-sector Home firms is to maximise risk-adjusted profit denominated in Home currency. This means that we must translate both the operating profit and the fixed entry costs – both of which have hereto been denominated in Partner currency units – into Home currency units when considering the entry decision, i.e. Home firms care about s^e(U-F)-$\sigma_2$var(U-F). From (7) we see that the variance of U-F is zero, so the entry criteria is just s^e(U-F)=0. It is obvious that this is positive, if and only if (U-F) is positive. This shows that the currency of denomination has no impact on the entry decision.

Minimum export size

Using (3) and (7), we see that the minimum class-sizes for D-types and E-types are defined by the cut-off levels of marginal cost, namely:

(11) $m_D = a - 2\sqrt{F}, \qquad m_E = \dfrac{a - 2\sqrt{F(1+\alpha\sigma^2(a^2-4F)}}{\tau(1-\alpha\sigma^2 4F)}$

where m_D and m_E are the minimum viable class-size for D-types and E-types, respectively. By inspection, we see that there is a range of firms with marginal cost between m_D and m_E who will sell in the local market without exporting.

The expression for optimal export sales makes it clear that firms with high marginal costs will sell less. This will also be true of their Home market sales, regardless of whether they export. In particular, firms get bigger (in terms of home market sales) as their marginal cost falls.

3.2. *The volume of trade*

Having determined the cut-off m_E, we know which class sizes will be exporting and how much a typical firm in each size class will sell. This, however, is not sufficient for determining the overall volume of exports. We also need the distribution of firms across size classes.

A well-known fact in the empirical industrial organisation literature is that the size distribution of firms is skewed heavily towards small firms. Indeed, the actual distribution is usually approximated with a Pareto distribution (see Cabral and Mata 2001 for recent findings and a history of the literature). In other words, the number of firms per size class is:

(12) $n[size] = B(size)^{-\rho}$

where size is measured in a variety of ways (number of employees, sales, assets, etc.), ρ measures the skewness of the distribution, and B is a constant.

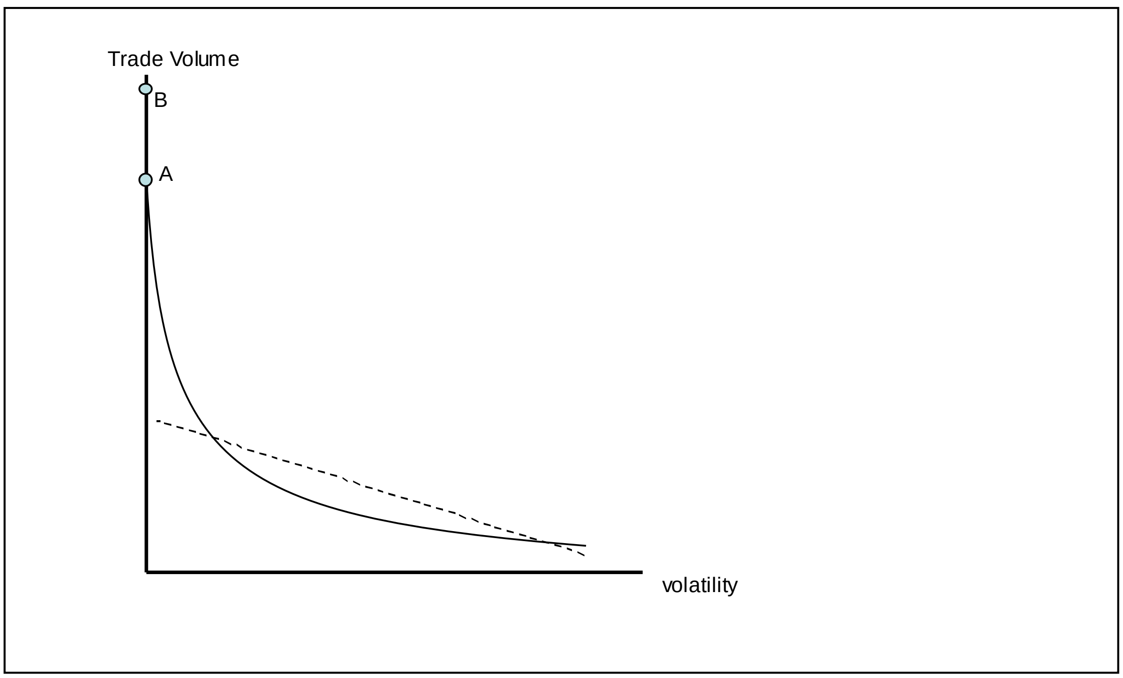
As it turns out, calculations are simplified by taking a very specific measure of size. That is, we measure firm-size by the number of units they would export with zero volatility. This is certainly not the only measure of size one could think of, but it simplifies calculations and the argumentation below makes it clear that other measures would lead to qualitatively equivalent results.

The volume of Home exports in the M-sector is the number of firms in each size class times the export sales per firm integrated over all exporting size classes. Using (6) and (12), the volume of trade is:

(13) $$VT_M = \int_0^{m_E} \frac{(a - m\tau)^{1-\rho}}{4(1+\alpha\tau^2 m^2\sigma^2)} dm; \qquad VT_M \Big|_{\rho=1} = \frac{\arctan(\tau m_E \sqrt{\alpha\sigma^2})}{\tau\sqrt{\alpha\sigma^2}}$$

where m_E is given by (11). The integral in the first expression cannot be solved for general values of ρ, but it is easily solved for ρ=1 or 2; the solution for ρ=1 is shown by the second expression.

Figure 4: Convexity of the volume-volatility link



Trade including C-sector varieties

The total volume of Home exports includes trade in C-sector varieties. Taking the fixed number of C-sector varieties as n_C, the export per variety equation (10) implies that C-sector exports are:

(14) $$VT_C = n_C\left(a - a_C\tau_C(1+\alpha a_C\tau\sigma^2)\right)$$

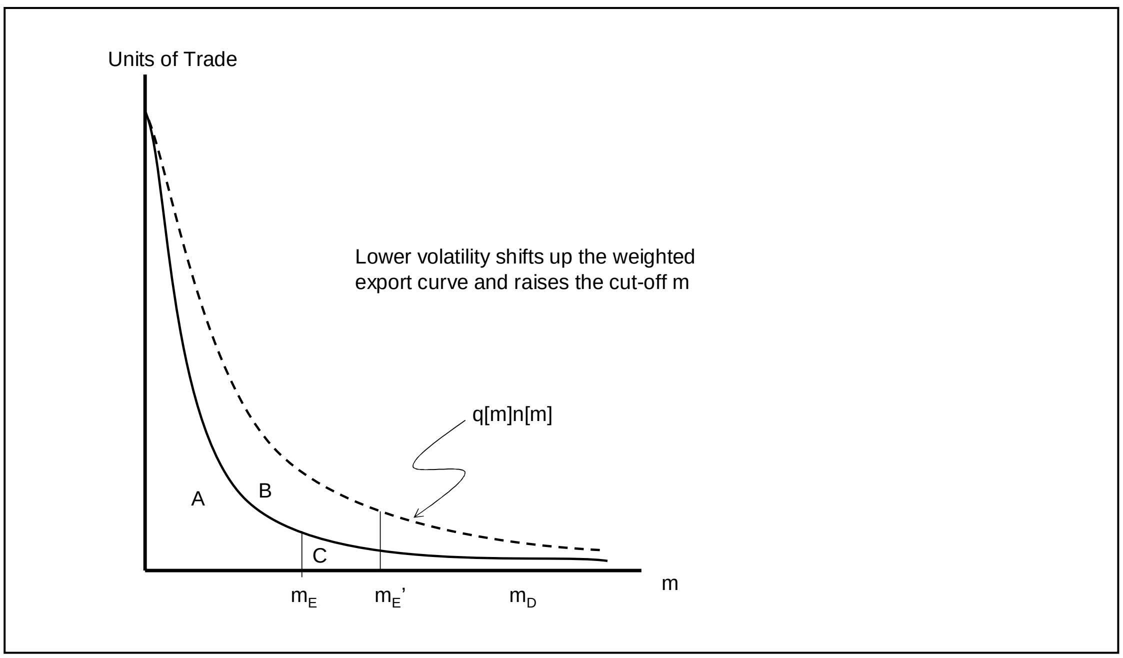
3.3. *Demonstrating the stylised facts*

We turn now to showing that the model reflects the key features of the empirical literature it was designed to account for. We start with the two most dominant results in the empirical literature: 1) higher volatility reduces the trade volume, and 2) regressions that include a linear volatility term still find a Rose effect, namely that a zero-volatility dummy is positive and significant.

3.3.1 Trade impact of exchange rate volatility

We begin the discussion by making a simple point that has not been clearly recognised in the literature: the Rose effect is nothing more than a convex relation between volatility and trade. To see this, suppose the true relationship between volatility and trade is convex and continuous, as illustrated by the solid curve in Figure 4. An empirical model that assumed a linear link between volatility and trade (as illustrated by the dashed line), but also allowed a dummy for monetary union (i.e. zero volatility), would estimate the dummy to be positive and significant. Importantly, if the link were sufficiently convex, then adding a finite number of higher order volatility terms to the regression would not be enough; a currency dummy would still be significant. Moreover, notice that there does not need to be a discrete jump in the trade volume at zero volatility (A to B in the diagram) for the Rose effect dummy to be positive. The convexity can be continuous, ending at point A. To summarise, a necessary and sufficient condition for the finding of a significant linear volatility effect *and* a Rose effect is that the volatility-trade relationship is convex.

Figure 5: Deriving the slope of the volume-volatility link



To show that our model predicts a negative, convex volatility-volume link, it is sufficient to show that the first derivative of the link is negative and the second is positive. Taking these tasks in order, we note that $dVT/d\sigma^2<0$ can be illustrated for a general ρ using the indirect analysis in Figure 5. The volume of trade is the integral of the density-weighted export-per-firm curve from m=0 to the cut-off m, m_E. The solid curve in the diagram shows the weighted export curve for a given σ^2, and the cut-off m_E that corresponds to it. The volume of trade for this given σ^2 is the area under the curve up to m_E, namely area A.

As inspection of (6) shows, a reduction in volatility raises the exports per firm regardless of size class (as measured by m) and this raises the entire density-weighted export-per-firm curve, as shown by the dashed curve in the diagram. As inspection of (11) shows, the lower volatility also raises the maximum cost at which firms find exporting interesting, i.e. it raises m_E to m_E' as shown in the diagram. The new integral, which is the new volume of trade, is larger than the old volume by the areas B and C. This formally demonstrates that the volume-volatility link is negative, i.e. $dVT/d\sigma^2<0$.

By inspection of (13), the M-sector trade volume is diminishing in the level of trade barriers τ and we have just shown that it is diminishing in σ^2. Inspection of (14) shows that C-sector exports are also diminished by volatility and trade costs. Thus we write:

Result 1:

> ***The volume of trade declines as exchange rate volatility and as trade-barriers rise.***

While the impact of volatility on trade is clear, it is useful to decompose the effects. The elimination of exchange rate uncertainty, i.e. setting $\sigma^2=0$, will affect exports in two ways. First, the level of exports per exporting firm will increase. This is seen immediately by inspection of the optimal sales level (6). Second, the number of Partner firms exporting to the Home market will increase. This can be seen by inspection of (11) because a reduction in σ^2 reduces the minimum class-size that is required to make exporting profitable. We summarise this as:

Result 2:

> ***A reduction in exchange rate volatility raises both the sales per exporting firm and the number of firms that export.***

3.3.2 Convexity of the trade-volatility link

We turn next to the shape of the trade-volatility link, considering C-sector exports and then M-sector exports.

Linearity of the C-sector trade-volatility link

Inspection of (14) reveals that the volume of trade is linear in the exchange rate variance. The importance of this linearity accounts for the lack of a Rose effect in non-ICIR sectors. That is, once one controls for a linear trade-volatility link, there should be no Rose effect.

Convexity of M-sector trade-volatility link

The expression for M-sector exports, (13), shows that the trade-volatility link is not a simple one in this ICIR sector. Even when we take $\rho=1$, the expression is difficult to manipulate. The deep reason for this is clear enough. As we showed in Figure 5, a reduction in volatility increases the cut-off m_E and shifts up the export by size-class curve, but the shift is greater for small firms. To sign the second derivative of the σ^2 on the term VT (volatility) involves working out whether these shifts are larger when σ^2 is higher.

There is an easy part of this task and a hard part. The easy part is showing that the upward shift in the weighted export-per class-size curve is greater when volatility is lower. The reason in that the impact on volatility is greater on smaller firms and that there are more small firms in operation when volatility is low. The hard part is to see whether the increase in VT due to the volatility-induced rise in m_E will also be larger when the initial level of σ^2 is smaller. We have been unable to show that VT is convex in σ^2 for the general case, but it is simple to do when evaluating the second derivative, $d^2VT/d(\sigma^2)^2$, at $\sigma^2=0$. Specifically:

(15) $$\lim_{\sigma^2 \to 0} \frac{d^2VT}{d(\sigma^2)^2} = \frac{\alpha^2(4a^2 + 9a\sqrt{F} + 6F)(a - 2\sqrt{F})^3}{10\tau} > 0$$

We can establish the sign since we know that $(a-2(F)^{1/2})=m_D>0$.

For the general case, we rely on numerical analysis. For the simple case where $\rho=1$, the relationship between trade and volatility is convex for a wide range of parameters.[4] This leads to:

Result 3:

> ***In ICIR industries, the marginal increase in trade as volatility falls gets progressively larger as volatility approaches zero, i.e. the volume-volatility link is convex. In perfectly competitive industries, the trade-volatility link is linear.***

There are two sources of the convexity. First, a reduction in volatility affects the sales of small firms more than that of large firms, and there are more small firms exporting when the volatility is initially low. Second, each reduction in volatility brings more firms into the exporting business. Given that the distribution of firms is so heavily skewed to small firms, a reduction in volatility brings more exporters into the market when the initial level of volatility is low.

3.3.3 Interaction effect between trade costs and the volume-volatility link

Another stylised result from the empirical literature concerns the interaction between the size of the trade effect of monetary union and trade costs. In particular, the nation-by-nation estimates of the Rose effect could be interpreted as showing that the effect was largest for nations that were close to the economic core of Europe and smallest for nations that were on the periphery. The MSO regressions that found this effect did not include a linear volatility term. We shall want to correct for this omission in our empirical work below, but in the meantime, we can show that the predictions of our model are consistent with the MSO findings.

To facilitate the task, we define a metric for the 'unconditional Rose effect', i.e. the total change in the volume of trade when volatility falls from some positive level to zero. In symbols this is $RE = VT\big|_{\sigma^2=0} - VT$, where RE stands for the Rose effect. In the $\rho=1$ case, the expression for VT with $\sigma^2=0$ is $(a-2(F)^{1/2})/\tau$. Using this and the definition of VT from (13), we have:

(16) $$RE = \frac{a - 2\sqrt{F}}{\tau} \quad - \quad \frac{\arctan(\tau m_E \sqrt{\alpha\sigma^2})}{\tau\sqrt{\alpha\sigma^2}}$$

where m_E is given by (11).

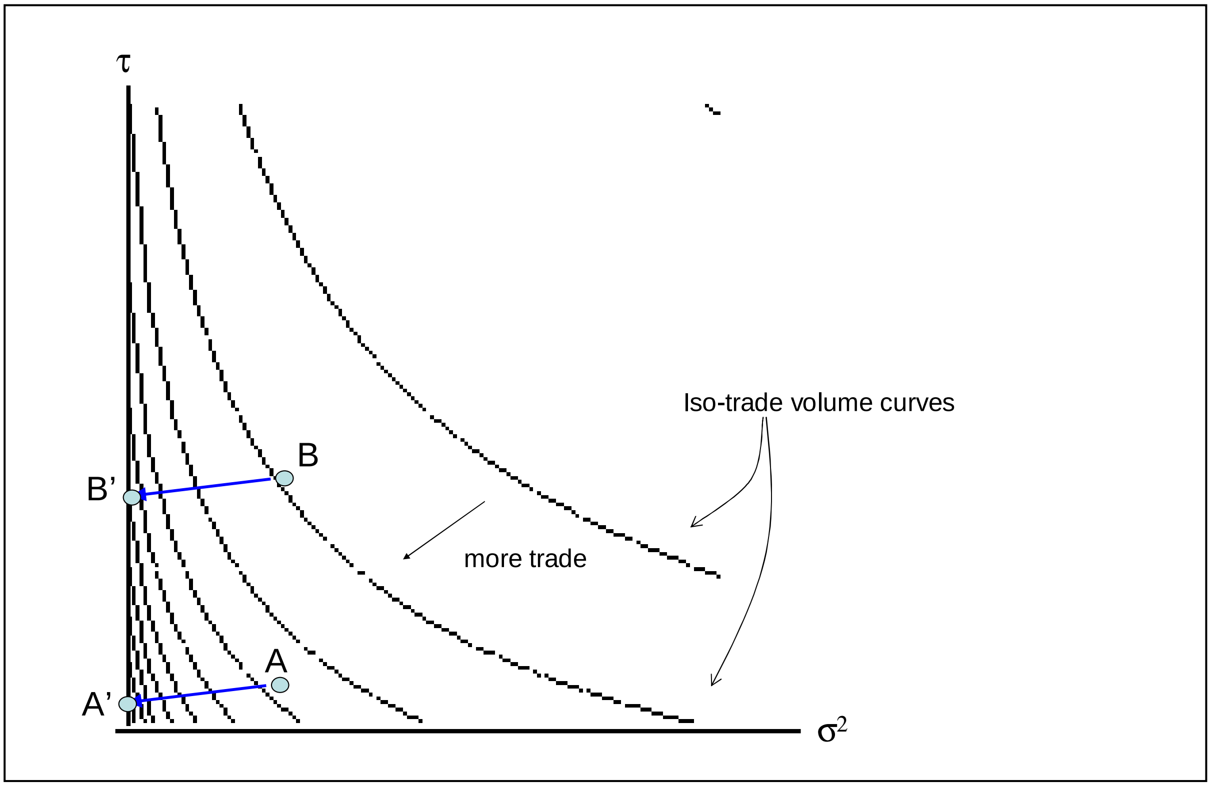
---

[4] Indeed, we have yet to find parameters where this is not true, although we cannot prove convexity.

Noting that τ enters the denominator of m_E in a multiplicative fashion, we see that τ cancels out of the argument of the arctan function, so RE equals $1/\tau$ times a term that is constant with respect to τ. Given this, it is obvious that the size of the Rose effect rises as trade barriers fall. Moreover, the relationship is hyperbolic – the increase in the Rose effect with each marginal reduction of τ is larger as τ falls. This allows us to write:

Result 4:

The unconditional Rose effect is larger when trade costs are low. In other words, the Rose



effect should be larger among nations that start with lower trade barriers, and given the important impact of distance on trade costs, this predicts that the Rose effect should be greatest between nearby nations. Error! Reference source not found.**Figure 6: Trade volume against trade costs and volatility**

Low volatility and low trade costs

In our discussion of the empirical results, we noted that some of the nations that started with very low bilateral volatility and very low trade costs seemed to have larger Rose effects than nations with high pre-euro volatility and high trade costs. To make sense of this, it helps to have a map, like in Figure 6.

The diagram, which shows the iso-VT curves, indicates the relative importance of volatility reduction and trade costs (the figure is plotted for ρ=1, α=1, F=1, and a=10). For example, the DM bloc nations may have started out at point A, with low volatility and trade costs, while a more peripheral nation (such as Portugal) started with higher trade costs and higher volatility. The monetary union would take volatility to zero in both cases, but trade would increase more from point A to A' than it would from B to B' because the A arrow crosses more iso-VT lines that the B arrow. This possibility arises because to the interaction between trade costs and volatility reduction.

3.3.4 The impact of risk aversion and financial market development

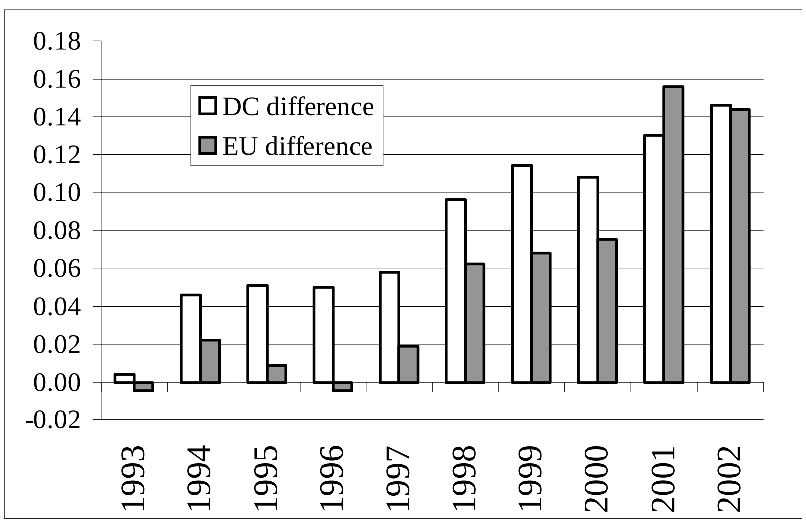
Although the existing empirical work has not explored the connection between the size of the Rose effect and the extent of risk aversion, we can do this easily in the model.

Given that our measure of risk aversion, α, always enters the expression for VT together with σ^2, it is clear that our demonstration in Result 1 applies to α. This allows us to write:

Result 5:

> ***The trade-reducing effect of volatility is larger when firms act in a more risk averse manner. Equating risk aversion with financial market imperfection, this suggests a positive correlation between the size of the Rose effect and the backwardness of a nation's financial markets.***

Figure 7: Intra- and extra-Eurozone Rose dummies, DC and EU samples



Source: MSO (2003).
Note: DC sample includes 22 developed nations, EU sample includes only EU members.

3.3.5 Transaction cost reduction of monetary union and currency union

Two of the stylised results from the empirical literature suggest that formation of the monetary union in 1999 and the currency union in 2001 had an impact on transaction costs in addition to their impact on volatility. First, trade between the Eurozone and non-euro nations jumped up in 1999 even though the bilateral volatility between these nations did not go to zero. Second, the intra-Eurozone dummy jumps up again in 2001 when the monetary union became a currency union. Moreover, the *difference* between the intra-euroland trade dummy and the extra-euroland trade dummy becomes greater in 2001. This suggests that the elimination of the currency exchange had a favourable effect (see Figure 7).

Why would monetary and currency union lower transaction costs?

The classic optimal currency area reasoning applies to currency unions, not monetary unions. While it is obvious that adopting a common currency eliminates some of the costs involved in trade, the impact of adopting a common monetary policy without a common money is less clear.

One approach is to focus on the cost of exchanging currencies, measuring this as the bid-ask spread in the relevant foreign exchange market. The thinking here is that monetary union led to changes that lowered the bid-ask spread both between Eurozone nations and between Eurozone nations and others. For example, Hartmann (1999) shows that the bid-ask spread is positively related to unpredictable trading volumes, and more directly, Naranjo and Nimalendran (2000) find that the bid-ask spread increases with unexpected government intervention. To the extent that the Euro eliminated the need for European central banks to intervene in their currency markets, all speculation became stabilising speculation (so the bilateral rates enforced themselves). The elimination of risk among euro-legacy currencies may also have stimulated competition in the forex market, especially for small currencies such as the Belgian franc. Here we note that Huang and Masulis (1999) found the deutsche mark spread to diminish as dealer competition rose. Contrary evidence, however, can be found in Hau, Killeen, and Moore (2002). These authors find that the euro spreads increased (compared to DM-dollar spreads) in 1999.

Could a currency union reduce transaction costs for trading partners that are not part of the monetary union? The evidence in Figure 7 certainly suggests this, so we explore economic channels that might produce this result. Note that this reasoning is entirely outside of our model.

Begin with a mental picture of the foreign exchange market for most euro-legacy currencies. With the sole exception of the DM and the French franc, the euro-legacy currencies were quite unimportant on the foreign exchange market. For example, the most recent Bank of International Settlement’s 3-yearly survey of the forex market showed that none of the euro-legacy currencies other than the French franc and the deutschemark were traded in any significant amounts (the 1998 survey lists currencies down to those that represented two-tenths of one percent of the market). With such low levels of trade, it seems likely that adoption of the euro radically increased the amount of relevant competition. Before the euro, only a few banks would trade Belgian francs, so exporting to Belgium was particularly expensive. After the euro, exporting to Belgium involved a forex transaction in the second largest currency in the world. It thus seems plausible that the introduction of the euro in 2001 lowered transaction costs even for non-Eurozone nations.

Taking as given that lower transactions costs did fall for all Eurozone nations, we note that this would tend to stimulate trade between the Eurozone and all nations. Specifically, our model predicts that the trade-enhancing effect of lower transaction costs is greater when volatility is lower. This is, in fact, just a restatement of Figure 6. This allows us to write:

Result 6:

Assuming that formation of the monetary union and, separately, formation of the currency union lowered foreign exchange transaction costs, we should observe an increase in all trade with Eurozone nations in 1999 and 2001. However, the size of the effect should be larger between Eurozone nations since a given transaction cost reduction will have a larger trade-boosting effect when bilateral volatility is low.

Our model was designed to match the basic facts in the existing literature, but it can be used to formulate more precise, empirically testable, hypotheses.

4. NEW, EMPIRICALLY TESTABLE HYPOTHESES

The most obvious hypothesis concerns the nature of the volatility-trade link. Our model's main explanation of the Rose effect is the convexity of the volatility-trade link (see Figure 4). We render this as:

Hypothesis 1:

The relationship between bilateral exchange rate volatility and the volume of imports of a Eurozone nation should be convex, at least for ICIR goods.

Perhaps the least obvious implication of our model concerns the interaction between trade costs and volatility. Given that the close link between distance and trade costs has been firmly established by gravity model studies, we can test this implication using distance as a proxy for trade costs. In particular, this suggests:

Hypothesis 2:

Inclusion of an interaction term involving distance (as a proxy for trade costs) and volatility should enter the gravity equation positively, i.e. higher trade costs make volatility's trade impact less negative.

A related prediction involves the impact of the transaction cost reduction that accompanied formation of the currency union in 2001.

Hypothesis 3:

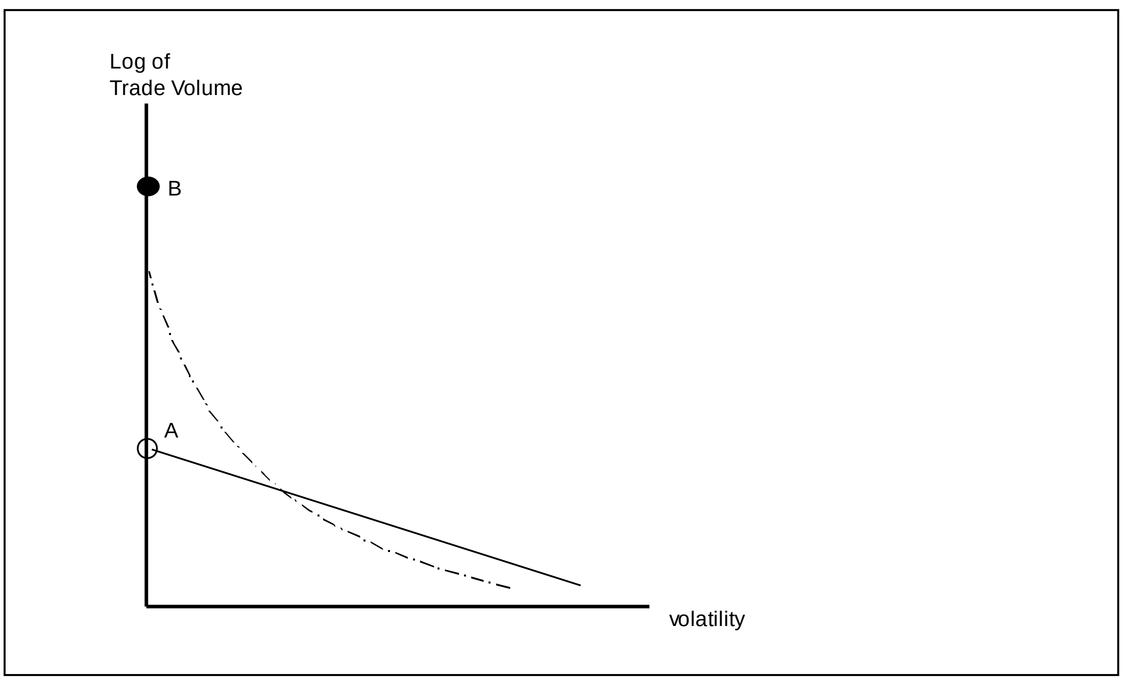
To the extent that currency union reduced trade costs (mainly foreign exchange transaction costs), the Rose effect should increase in 2001. Our model is silent on whether this transaction cost drop is significant, but the model predicts that if it does occur, it should be greater for intra-Eurozone trade relationships than it is for Eurozone nations' trade with other nations.

5. EMPIRICAL TESTS OF THE NEW HYPOTHESES

We turn now to testing the new hypotheses. To allow comparability with the existing literature, we work with the a dataset from the MSO paper, namely the dataset that MSO call the 'developed country' sample (this includes aggregate trade data from all countries listed as 'industrial countries' in the IMF's Direction of Trade Statistics database). These consist of the 15 nations that were EU members in 2002 (Belgium and Luxembourg's trade data are merged so there are only 14 EU observations) plus three non-EU Europeans (Norway, Switzerland and Iceland), three 'Asian' nations (Japan, New Zealand, Australia) and two North American nations (Canada and the US). The second MSO data set includes only the EU members. The sample cover the 1992 to 2002 period.

Again for comparability, we take MSO's preferred specification as our point of departure. Their dependent variable is the log of bilateral exports plus bilateral imports deflated by the US CPI (the focus on this variable is fairly standard in the literature, having been introduced by Glick and Rose 2001). Their explanatory variables consist of the log-product of the origin and destination nations' real GDP's, three trade integration dummies, real exchange rates for both importers and exporters, and two euroland dummies. The first trade integration dummy reflects membership in the EU to account for the preferences implicit in single market membership. The second accounts for non-EU free trade agreements to allow for trade preferences in agreements such as the North American Free Trade agreement between Canada and the US, and the Closer Economic Relationship between Australia and New Zealand. The third is a time trend for bilateral trade between EU members (MSO motivate this by saying that it allows for deepening of the single-market integration over the sample period). MSO also include the real exchange rate for both origin and destination nation to account for the possibility of what they call 'valuation effects.' That is, the euro's large swings in the foreign exchange market against both the US dollar and the yen. Finally, the two euro dummies are, as explained above, a dummy that is one for bilateral flows involving two euroland nations (called EMU2), and another that is one when only one partner is a euroland member (called EMU1).

Figure 8: Types of trade volume-volatility convexity



MSO did not include volatility in their regressions at all, allowing only zero volatility to have any effect at all on trade. Since this may bias the results, we add a volatility term as in Baldwin, Skudelny and Taglioni (2003). Specifically, our volatility measure is the moving average (over 5 years) of pairwise, annual variance of the weekly nominal exchange rate "return', that is:

$$VOL_{ij,t} = \frac{1}{52}\sum_{w=1}^{52}\left(\frac{S_{ijw}}{S_{ij,w-1}} - \frac{1}{52}\sum_{w=1}^{52}\left(\frac{S_{ijw}}{S_{ij,w-1}}\right)\right)^2$$

where S_{ij} is the nominal exchange rate between currencies i and j in week w. The relevant measure is used for each country pair.

Table 2: Testing for convexity using MSO aggregate data

	(1)		(2)		(3)		(4)		(5)	
emu2 (both use euro)	**0.054**				**0.036**				**0.022**	
	3.67	***			*2.34*	**			*1.31*	
volatility	**-3.004**		**-2.964**		**-2.929**		**-2.766**		**-2.746**	
	-6.94	***	*-6.86*	***	*-6.78*	***	*-6.30*	***	*-6.25*	***
volatility squared			**6.E+03**		**5.E+03**		**3.E+04**		**3.E+04**	
			4.77	***	*3.83*	***	*2.96*	***	*2.51*	**
volatility cubed							**-4.E+07**		**-4.E+07**	
							-2.41	**	*2.07*	**
emu1 (only one uses euro)									**-0.014**	
									-1.22	
Real GDP	0.458		0.457		0.447		0.457		0.465	
	26.66	***	*27.02*	***	*25.71*	***	*27.06*	***	*21.01*	***
Real exchange rate country 1	-0.327		-0.310		-0.332		-0.316		-0.323	
	-8.26	***	*-8.08*	***	*-8.41*	***	*-8.22*	***	*-7.97*	***
Real exchange rate country 2	-0.427		-0.410		-0.411		-0.409		-10.690	
	-11.58	***	*-11.05*	***	*-11.11*	***	*-11.04*	***	*-10.65*	***
Observations	2520		2520		2520		2520		2520	
R-squared: within	0.380		0.382		0.384		0.384		0.385	
between	0.603		0.601		0.604		0.601		0.603	
overall	0.600		0.597		0.600		0.597		0.599	
Country Pair Dummies	yes		yes		yes		yes		yes	

Note: T-statistics in italics; * significant at 10%; ** significant at 5%; *** significant at 1%
Developed nation sample from MSO (21 most developed nations); volatility measures with a 5-year moving average zeroed from 1999 onward.

Hypothesis 1: Convexity of the volatility and volume link

The first pass at testing the convexity hypothesis is to see if we find a Rose effect when a linear volatility term is included using the MSO data set on aggregate trade. If the volatility term turns out negative and the monetary union dummy turns out positive, we have evidence of a very simple form of convexity – that volatility reduces trade in a log-linear fashion right up to zero volatility and an extra increase in trade only appears when the volatility reaches zero. Figure 8 illustrates this convexity. The linear volatility term predicts a steady rise in the log volume of trade; the dummy, which equals one when both nations use the euro, predicts a jump in trade just as volatility reaches zero.

To test for this form of convexity, we add a linear volatility term to a standard fixed-effects Rose regression where the log of bilateral trade is regressed on real GDP, bilateral exchange rate volatility and various dummies (the fixed effect includes country-pair dummies and year dummies). The result is shown in column 1 of Table 2. The results provide some support for this type of convexity since the coefficients on the monetary union dummy and the linear volatility terms have the expected signs and are statistically significant.

Our model predicts an alternative form of convexity that is much smoother – one that resembles the dashed line in Figure 8. The precise form of the convexity will depend upon functional forms, so we cannot make a robust prediction from the theory as to the exact form of the convexity. It is well known, however, that any continuous function, y=f(x), can be well approximated by a polynomial in x of a sufficiently high order. Using this result, we test for a smoother form of convexity in the trade-volatility link by dropping the EMU2 dummy and introducing a squared volatility term in addition to the linear term. The results, shown in column 2 of the table, provides direct support for the convexity hypothesis and some support for the smooth-form of the convexity since the linear term is negative and the quadratic term is positive; both are statistically significant. We note however, that when we include the monetary union dummy, EMU2, in addition to the linear and quadratic volatility terms, the dummy is positive and significant; see column 3.

The fact that EMU2 is significant even when the quadratic volatility term is included, suggest a couple of possibilities. First, the trade-volatility link may look like a combination of the smooth and discrete forms illustrated in Figure 8; that is that trade falls according to the curved line right up to zero volatility but then it jumps up to point B. Second, it could be that there is no discrete jump at zero volatility but that the true relationship is more non-linear that can be captured by a second order approximation. To pursue this line of thinking, we include a cubic volatility term and higher order terms. We report only the cubic term since STATA drops the 4^{th} and 5^{th} order automatically. The results are mildly encouraging, as column 4 shows. When the EMU2 term is excluded, as suggested by the smooth form of convexity, all three volatility terms are individually significant and of the expected sign. The second order term is positive and the third order term is negative.

It is interesting and perhaps important that when we include linear, quadric and cubic volatility terms, the EMU2 and EMU1 dummies are insignificant; see column 5. This suggests that there may be no pure Rose effect in the sense of a discrete jump in trade when volatility reaches zero.

In conclusion, these tests confirm our first hypothesis, namely a convex relationship between volatility and trade.

Hypothesis 2: Distance-volatility interaction

To test Hypothesis 2 – the notion that the bilateral trade costs reduce the trade dampening effect of bilateral exchange rate volatility – we introduce an interaction term between distance (as a proxy for trade costs) and our volatility measure into the base-case specification. Our model predicts that this should be positive since higher trade costs make the impact of volatility less negative. Columns 1 and 2 of **Table 3** show the results for the MSO baseline specification (only EMU2) and the same with a linear volatility term. In both cases, the interaction term is positive and statistically significant. When we include higher order volatility terms, however, the interaction term becomes insignificant, sometimes positive and sometimes negative. This may be due to particular geography of Europe's monetary union. Although it is not perfect, there is a clear correlation between Euroland membership and bilateral distance. Moreover, since many of Euroland's current members, specifically the deutschmark bloc, also had very low bilateral volatility even before the euro, the volatility*distance term is not too dissimilar from the squared volatility term. In this case, it not surprising that the interaction term and the squared term on both imprecisely estimated.

Table 3: Testing for interaction between trade costs and volatility

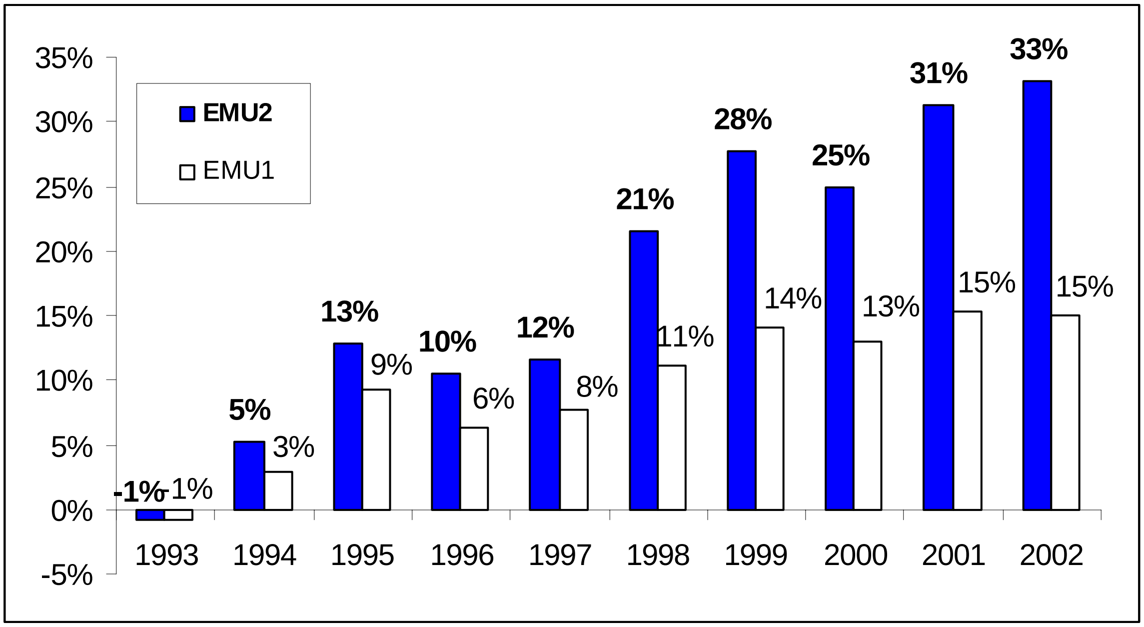
	(1)		(2)		(3)		(4)		(5)	
volatility*distance	**0.365**		**0.308**		**0.218**		**0.196**		**-0.037**	
	4.69	***	*3.97*	***	*1.64*		*1.46*		*-0.19*	
emu2 (both use euro)	**0.038**		**0.036**				**0.034**			
	2.43	**	*2.36*	**			*2.22*	**		
volatility			**-2.811**		**-2.870**		**-2.847**		**-2.765**	
			-6.48	***	*-6.59*	***	*-6.54*	***	*-6.29*	***
volatility squared					**3.E+03**		**2.E+03**		**3.E+04**	
					1.30		*1.03*		*1.94*	*
volatility cubed									**-5.E+07**	
									-1.78	*
Real GDP	0.486		0.450		0.457		0.448		0.457	
	29.41	***	*26.12*	***	*28.81*	***	*25.75*	***	*27.04*	***
Real exchange rate country 1	-0.393		-0.335		-0.314		-0.334		-0.316	
	-10.14	***	*-8.47*	***	*-9.44*	***	*-8.46*	***	*-8.21*	***
Real exchange rate country 2	-0.437		-0.416		-0.411		-0.413		-0.408	
	-11.78	***	*-11.27*	***	*-10.98*	***	*-11.14*	***	*-11.02*	***
Observations	2520		2520		2520		2520		2520	
R-squared: within	0.373		0.384		0.383		0.384		0.384	
between	0.592		0.603		0.601		0.604		0.601	
overall	0.589		0.600		0.597		0.600		0.597	
Country Pair Dummies	yes		yes		yes		yes		yes	

Note: Robust s t-stat;istics in italics * significant at 10%; ** significant at 5%; *** significant at 1%

Hypothesis 3: monetary vs currency union

Hypothesis 3 concerns the impact of monetary union and currency union on intra-Eurozone trade and Eurozone nations' trade with other non-members. The hypothesis is that both monetary union and currency union should boost both types of trade, but the boost should be greater for trade within the Eurozone. To test this, we re-do the MSO basic regression allowing for year-by-year Rose dummies (intra and extra-Eurozone), but we also control for volatility as our model suggests. Our findings, shown graphically in **Figure 9**, confirm the basic effect. In future drafts, when we have another year of data, we will test more directly for an independent effect of the currency union.

Figure 9: Year by year estimates of the Rose effect, MSO developed nations aggregate data



6. CONCLUSIONS

Since Rose (2000), a large number of scholars have found empirical evidence for an important link between bilateral exchange rate volatility and the bilateral volume of trade. An additional, more surprising result is that most of these studies also find that a currency union *per se* boosts trade. While many of these findings may be criticised for relying on currency unions that involve small and poor nations, recent studies of on the Eurozone confirm the existence of a 'Rose effect' in nations that have very good data and whose economies and currency union are well understood.

Our paper takes a first step toward providing theoretical underpinnings for the so-called Rose effect. In our model, a reduction in exchange rate volatility boosts trade in two ways. First, it induces existing exporters to export more since exporting becomes a less risky business. Second, it induces more firms to begin exporting their goods. In particular, we show that exchange rate volatility naturally hinders exporting by small/high-cost firms, so reduced volatility tends to especially promote exports from small firms. This is important since it is a well-known fact that most firms in modern economies are small; indeed, the standard assumption is that the number of firms is a Pareto distribution related to firm size. What this means is that the extra exports that are induced by a marginal reduction in volatility may increase as the level of volatility falls. Because of this, the relationship between volatility and trade volume can be convex – a result that is implied by the Rose effect.

Our paper derives and tests three new empirical hypothesis generated by our model. We find some support for two of them using data on Eurozone aggregate bilateral trade, but have insufficient data to test the third in a convincing manner.

In conclusion, we view our paper as a first stab at working out microfoundations for the Rose effect. There are, of course, many other possible accountings for the Rose effect, and indeed, different models will probably be necessary to explain different aspects of the phenomenon. We believe this may prove a promising direction for future theoretical and empirical research.

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