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# EVIDENCE FROM SECTORAL DATA

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In 2005 all ECB publications will feature a motif taken from the €50 banknote.



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## Abstract

This paper contributes to the literature on the impact of EMU on trade, adding two new elements. First, we propose a theoretical model for explaining how the euro could have increased trade by the large amounts found in the empirical literature. Second, we propose a sectoral dataset to test the insights from the theory. Our theoretical model shows that in a monopolistic competition set-up, the effect of exchange rate uncertainty on trade has non-linear features, suggesting that EMU and a standard measure for exchange rate uncertainty should be jointly significant. Our empirical results confirm this finding, with a trade creating effect between 108 and 140% in a pooled regression, and between 54 to 88% when sectors are estimated individually. Importantly, we find evidence for a trade creating effect also for trade with third countries.



Keywords: Rose effect, exchange rate volatility, monetary union, sectoral trade, gravity

JEL classification: F12, C33, E0

# Non-technical Summary

This paper contributes to the rapidly growing literature on the impact of Europe's monetary union on trade (hereafter referred to as 'Rose' effect), with a theoretical model explaining how the euro could have increased trade right from its creation and by the large amounts found in the empirical literature. It proposes, for the first time, a theoretical model explaining why the creation of a monetary union can have an effect even once the elimination of exchange rate volatility has been taken into account. In the empirical part of the paper, we propose a sectorally disaggregated dataset to test the insights from the theory.

In a monopolistic competition set-up, the effect of exchange rate uncertainty on trade has non linear features. We go beyond this finding, as our model predicts a convex relationship between trade volumes and exchange rate uncertainty, i.e. the marginal increase in trade as volatility falls gets progressively larger as volatility approaches zero. The intuitive explanation for the non-convexity of the trade-volatility link is that a reduction in exchange rate volatility raises both the sales per exporting firm and the number of exporting firms. This finding is crucial and at the same time new in the literature, as it suggests why the trade-exchange rate uncertainty relationship can be proxied by a linear volatility term along with a currency union dummy. Our model shows that the effect of volatility on trade depends on the marginal costs faced by exporting firms. This suggests the use of sectoral data, as the firm structure and hence the cost structure of firms tends to widely vary across sectors.

Our empirical section tests this model on a gravity type trade equation for bilateral trade flows between 12 countries since 1990. In our specification, we augment the standard gravity specification – with, as explanatory variables, size and bilateral distance and fixed effects to reflect time invariant trade resistance factors – two measures for exchange rate uncertainty and a dummy for the participation in EMU. A range of different specifications allows us to check the sensitivity of the results to the chosen specification for exchange rate uncertainty, for the size variable of the gravity equation and for different sectors. A first set of estimations pools data across countries and sectors while, in a second instance, data are pooled only across countries, allowing thereby for sectoral differences.

With our two exchange rate uncertainty measures, the variance of the nominal exchange rate return (VOL) and the absolute forecast premium (AFP), we test for backward and forward looking expectations, respectively. The results for both specifications show that the effect of exchange rate uncertainty is negative, significant and robust to changes in the specification. Furthermore, our overall finding of joint significance of exchange rate uncertainty and the EMU dummy is in line with the intuition from the theory pointing to non-linearities in the relationship between trade and exchange rate uncertainty.

The results indicate that the mere creation of EMU would increase trade by 70-112% according to the regression pooled both by country and industry, and by 21-108% when allowing for sector specific coefficients (taking into account only significant estimates). Although qualitatively similar, estimations using the two alternative uncertainty measures are different in size. The EMU effect is smaller when using AFP, the forward looking uncertainty measure, as proxy for exchange rate uncertainty. If the AFP is a more powerful proxy for exchange rate uncertainty, the bigger figures obtained for the EMU dummy when using the backward looking measure (VOL) can be read as reflecting the part of uncertainty impact that the VOL proxy is unable to depict. However, to reach firm conclusions, further investigation on this issue is required.

The results obtained when adding up the effects of the elimination of exchange rate uncertainty and of the creation of a currency union indicate a trade creation effect between 91 and 119%, according to the pooled regression and of 40 to 87% when sectors are estimated individually. Furthermore they signal potential convexities of the trade volatility link. Introducing higher order uncertainty terms into the pooled regression provides further evidence for the convex form of the trade-exchange rate uncertainty relationship.

It should be noted that the size of the EMU effect is also sensitive to the choice of the size variable (GDP or value added by sector). Measurement problems and the limited availability of sectoral value added data are possible sources of the observed discrepancies. Differences in results might stem from the fact that when dealing with sectoral data, the mapping between empirical and theoretical measures for the size variables of the gravity equation (endowment of factors and expenditures) is problematic. Both aggregate GDP and sectoral value added are imperfect approximations of real import demand and export supply, which take into account cross-sector elasticities. Hence, given the difficulties of precisely assessing the trade creation brought about by EMU, we suggest considering the figures provided by our estimations as possible ranges of the Rose effect.

Finally, tests on the impact of EMU on trade flows with non-EMU countries reveal no signs of trade diversion. In line with other authors, we find a significant and positive impact in most specifications, indicating that third countries tend to trade up to 27% more with EMU countries since the creation of EMU. This effect is also stronger for those sectors characterised by increasing returns to scale and imperfect competition features.

# 1. INTRODUCTION

Europe's monetary union provides a unique opportunity to observe the trade effects of exchange rate regime changes. Among the many important effects, the trade impact has attracted a great deal of attention from policy makers and scholars. Monetary union involves costs and benefits, the most commonly identified cost being the loss of monetary policy as a national stabilisation tool, and the most commonly identified benefit an increase in trade and investment that monetary union might foster. In short, the 'cons' are macro and the 'pros' are micro. For example, the recent debates in the UK and Sweden over potential membership in the euro area frequently turn on the euro's trade impact. At the heart of this discussion is the path-breaking empirical study, Rose (2000), which found that currency unions tended to hugely increase bilateral trade flows – by about 200% according to some of his estimates. Rose (2000) attracted a multitude of comments and critiques – mostly suggesting that Rose's first estimates were too high. While the general point that currency unions have a positive trade effect is now widely accepted, the applicability of Rose's results to the euro area remains difficult. Most of the studies in this literature rely on evidence from currency unions between nations that were typically poor and very small economically.

Fortunately, we now have enough data to directly test for the Rose effect on euro area data. For example, a recent paper, Micco et al. (2003), finds a statistically significant increase in euro area aggregate trade right from 1999, with their estimates suggesting a gain of between 5% and 20% depending on the sample and the statistical technique. This is roughly in line with the findings of other similar studies that include Barr et al (2003), Bun and Klaassen (2002), and De Nardis and Vicarelli (2003).

This paper adds two elements to the rapidly emerging literature on the euro's trade impact. First, we provide a theoretical framework for explaining how the euro could have increased trade. Second, we use bilateral import data for ISIC 2-digit and 3-digit manufacturing sectors for 18 industrialised countries to test for the presence of a Rose effect.

The main finding of this paper is that in a monopolistic competition set-up, the effect of exchange rate uncertainty on trade flows is non-linear, indicating that EMU should have some impact on top of the effect resulting from setting exchange rate uncertainty equal to zero. Our empirical models confirm this finding, both for a pool across countries and sectors, and for a pool only across countries, where we obtain sector specific estimates.

The paper is structured as follows. After the introduction, we review the most relevant literature in Section 2 and present the theoretical model in Section 3 before turning to the empirics in Sections 4 and 5. The final section presents our concluding remarks.

## 2. LITERATURE REVIEW: TRADE, EXCHANGE RATE VOLATILITY AND CURRENCY UNIONS

The literature distinguishes three types of exchange rate uncertainty: exchange rate misalignment, exchange rate volatility, and currency unions. While exchange rate misalignments – persistent departures of real exchange rates from their equilibrium values – have been conclusively shown to have a negative link with trade (see, inter alia, European Commission, 1995), empirical findings on the volatility-trade link are much more mixed. The currency-union-and-trade literature emerged only recently, but here again the empirical findings are mixed. Since the results on misalignment are clear and less relevant to our own work, we review only the volatility-trade studies in section 2.1 and the currency-union-trade studies in section 2.1.3.

### 2.1. *Exchange rate uncertainty*

The trade effect of exchange rate uncertainty has been widely discussed theoretically and empirically at least since the breakdown of the Bretton Woods system in the early 1970s.[1] We turn first to the theory.

#### 2.1.1 Theoretical literature

Theoretically, the volatility-trade relationship is ambiguous. The mainstay of the economic logic underpinning a negative link is the aversion of firms to engaging in a risky activity, namely trade. This was evident in the early post Bretton Woods literature (Clark (1973), Baron (1976a), Hooper and Kohlhagen (1978)).

A second wave of papers, sparked by the dollar's spectacular rise and fall in the 1980s, sought to account for the continual stream of negative results by modifying the assumption of risk aversion. Since standard profit-functions are convex in prices, removing risk aversion from firms' objective function directly led to theoretical predictions of an insignificant or even positive relationship between volatility and trade (see De Grauwe (1988) and Gros (1987)). A second line of models removed the presumption that exchange rate uncertainty would hamper trade risk by showing that hedging possibilities could lead risk averse firms to act in ways that made them seem risk neutral (see Ethier (1973) and Baron (1976b), Viaene and de Vries (1992)). A third line of papers argued that the inability to find a negative volatility-trade link stemmed from the fact that exchange rate risk was small relative to other risks incurred by the exporter (see Grauwe (2000), Gros (1987), Broll and Eckwert (1999), Bacchetta and Wincoop (1998)). A very different line of models studied the behaviour of risk neutral firms facing a sunk market-entry cost (see Baldwin (1988), Baldwin and Krugman (1989), Dixit (1989), Krugman (1989), Franke (1991), Sercu and Vanhulle (1992)).

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[1] For more extended literature reviews about the effect of exchange rate volatility on trade, see IMF (1984), Côté (1994), McKenzie (1999), Skudelny (2002) and Taglioni (2002).

These models introduced the possibility of trade hysteresis and, depending upon modelling details, could predict a negative, positive and no effect of exchange rate uncertainty on trade.

### 2.1.2 Empirical literature

Given the importance of the topic and the ready availability of the necessary data, it is not surprising to find a huge number of empirical studies on the volatility-trade link. For analytic purposes, it is useful to classify the studies according to the type of data used, namely times series, cross-section, or panel. A summary of all the studies is presented in Table 1, Table 2 and Table 3. Here we discuss the general conclusions.

Most studies employed time series techniques and found no significant relationship between volatility and trade. The few that found a link, suggested that the effect was very small (see Koray and Lastrapes (1989), Bélanger and Gutierrez (1988), Bini-Smaghi (1991), Kenen and Rodrik (1986) and Sekkat (1998)

More recently, some studies implemented co-integration analysis, as for example Arize (1997, 1998a and b), Fountas and Aristotelous (1999) and Koray and Lastrapes (1989). An empirical review of this strand of literature is reported in Flam and Jansson (2000). The results of the studies taking into consideration the trend characteristics of the time-series appear to be more clear-cut; most suggest a significant negative effect of exchange rate uncertainty on the trade variables. However, at least three studies employing the above-mentioned techniques, among which the one from Flam and Jansson, report significantly positive or mixed results[2]. Moreover, the choice between OLS regressions and co-integration analysis depends on the stationarity properties of the trade variable and of the proxy for exchange rate uncertainty.

---

[2] Flam and Jansson find that the long run relations between exchange rate volatility and exports are mostly negative and in several cases insignificantly different from zero. McKenzie (1998) analyses Australian imports and exports at the sectoral level and obtains mixed results. Daly (1998) analyses bilateral trade between Japan and seven other industrialised countries, finding significantly positive results for seven import and five export flows out of fourteen.

## Table 1: Empirical literature using time series techniques

| Authors[1)] | Period | Region[2)] | Proxy for uncertainty[3)] | Dependent variable[4)] | Results[5)] |
|---|---|---|---|---|---|
| **Time series studies** | | | | | |
| Arize (1997) | 73-92 | G7 | Moving average σ [RER] | X | all var I(1) and co-int |
| Arize (1998a) | 73-93 | US | Moving average σ [RER] | M | all var I(1) and co-int |
| Arize (1998b) | 73-95 | BL, DK, FI, FR, GR, NL, SP and SD | σ [REER] from predicted value (fitting 4th order auto-regressive process) | M | all var I(1) and co-int |
| Bailey and Tavlas (1988) | 75-86 | US | abs [REERR] σ [REER] and σ [FEER] | Aggr. X | n.s. |
| Bélanger and Gutierrez (1988) | 76-87 | CAN-US | squared forcast error | X, 5 sectors | s. neg. in 2 sectors |
| Bini-Smaghi (1991) | 76-84 | GE, FR, IT, intra EMS | VEERR | X | s. neg. |
| Cushman (1988) | 74-83 | US | MA σ [RERR] E[RER] E [FER] | Bil. X | s./n.s., pos./neg. |
| Fountas and Aristotelous (1999) | 73-96 | FR, GE, IT, UK | MA σ [NEERR] Dummy ERM | Bil. X | σ [NEERR] mostly s. neg. Dummy n.s. |
| Gagnon (1993) | 60-88 | US | based on regression of the RER | Bil. X | n.s. |
| Kenen and Rodrik (1986) | 75-84 | 11 indus | σ [RERR] different forecast errors | M | s. neg. |
| Klaassen (2000) | 78-96 | US-G7 | MA VNERR | Bil. X | Mostly n.s. |
| Koray and Lastrapes (1989) | 61-71, 75-85 | US-UK, GE, FR, JP, CAN | VRERR | Bil. M | s. neg. (small) |
| Kumar (1992) | 62-88 | US, GE, JP | σ (RERR) | Intra-industry X+M | Mixed |
| Lastrapes and Koray (1990) | 75-87 | US | VRERR and VNERR | Aggr. X and M | s. neg. (weak) |
| McKenzie (1998) | 69-95 | AUS | ARCH | ΔX ΔM | Mixed results |
| McKenzie and Brocks (1997) | 73-92 | GE-US | ARCH | ΔX ΔM | s. pos. |
| Perée and Steinherr (1989) | 60-85 | US, JP, UK, GE, BL | LT uncertainty | Aggr. and bil. X | Aggr n.s., often s. neg. in bil equ |
| Sekkat (1998) | 75-94 | FR, IT, GE, UK and BL) | σ [NERR] misalignment | X vol and P 3SLS, ECM | ERV has ST effect, misalignment LT effect |

[1)] A star designates authors using gravity type trade models
[2)] indus: industrialised countries; WT: world trade (trade from different regions, sample depending on data available).
[3)] (V)N(R)E(E)R(R): (variance of the) nominal (real) (effective) exchange rate (return); MA: moving average; σ: standard deviation
[4)] M: imports, X: exports, Δ: variable in first difference
[5)] (n.)s.: coefficient on the exchange rate uncertainty term is (non-)significantly different from zero at 5%.

Cross sectional studies were more likely to find a link, but again the effect was in most cases relatively small (see Hooper and Kohlhagen (1978), De Grauwe (1987), Brada and Méndez (1988), De Grauwe and Verfaille (1988), Savvides (1992), Frankel and Wei (1993), Sapir et al. (1994) and Eichengreen and Irwin (1995)).

## Table 2: Empirical literature using cross-section techniques

| | | | | | |
|---|---|---|---|---|---|
| **Cross-sectional analysis** | | | | | |
| Brada and Méndez (1988)* | 73-77 | WT | dummy ER regime | Bil. X | Effect float pos. |
| De Grauwe (1987) | 73-84 | EU | σ [R(N)ERR] | Bil. X | s. neg. |
| De Grauwe and Verfaille (1988) | 79-85 | 15 indus | VRERR | Bil. X | Trade in EMS > outside EMS |
| Eichengreen and Irwin (1995)* | 30s | WT | VNERR | X | s. neg., small |
| Frankel and Wei (1993)* | 80, 85, 90 | WT | σ [N(R)ERR] | Bil. trade | s. neg. in 80, s. pos. in 90, small |
| Hooper and Kohlhagen (1978) | 65-75 | 6 indus | σ NER<br>σ (FER)<br>abs[FER(-1)-NER] | X prices and volumes | P: s. neg.<br>Vol: n.s. |
| Sapir et al. (1994) | 73-92 | GE-EC<br>GE-non EC | NERR | Bil. M | s. neg., small |
| Savvides (1992) | 73-86 | WT | σ (REERR) | ΔX | only unanticipated RER vol. s. neg. |
| Wei (1999)* | 75, 80, 85, 90 | 63 countries | σ [N(R)ERR]<br>Dummy hedging instruments | Bil. trade | s. neg.<br>dummy ns |

[1] A star designates authors using gravity type trade models
[2] indus: industrialised countries; WT: world trade (trade from different regions, sample depending on data available).
[3] (V)N(R)E(E)R(R): (variance of the) nominal (real) (effective) exchange rate (return); MA: moving average; σ: standard deviation
[4] M: imports, X: exports, Δ: variable in first difference
[5] (n.)s.: coefficient on the exchange rate uncertainty term is (non-)significantly different from zero at 5%.

The reason for this difference in using a cross sectional or a time series analysis relies in the fact that a volatility term in a time series analysis may capture the volatility of other variables in the model. The effect of the latter might differ from what we expect from exchange rate volatility, so that the total outcome is uncertain. The problem of cross sectional studies is that their outcome may be heavily dependent on the selected countries. A heterogeneous sample of industrial and less developed countries could lead to an estimation bias due to omitted variables driving trade flows in the different countries. The only practical solution to these shortcomings was to use fixed-effects estimators on panel data.

Studies that used panel data and estimation methods find a significant and negative effect of exchange rate uncertainty on the volume of trade, with the magnitude of the impact being quite large; reaching levels of around 10% in the long run. (See Abrams (1980), Thursby and Thursby (1987), Dell'Ariccia (1998), Pugh et al. (1999), Rose (2000), De Grauwe and Skudelny (2000) and Anderton and Skudelny (2001) who all use panel data econometrics.

## Table 3: Empirical literature using panel techniques

| | | | | | |
|---|---|---|---|---|---|
| **Panel techniques** | | | | | |
| Abrams (1980)* | 73-76 | 19 indus | VNER and VNERR | Bil X | s. neg. |
| Anderton and Skudelny (2001) | 89-99 | EMU | VNERR | Bil M | s. neg. |
| De Grauwe and Skudelny (2000) | 61-95 | EU | VNERR | Bil. X | s. neg. |
| Dell'Ariccia (1998)* | 75-94 | Western Europe | σ [ERR]<br>abs [FER(-1)-NER]<br>max[NER]/min[NER] | X+M | s. neg.;<br>strong effect (ca 10-12%) |
| Pugh et al. (1999)* | 80-92 | 16 OECD | σ [NERR] | M demand growth; X (level) | s. neg., big; bigger for non-ERM countries |
| Rose (2000)* | 70, 75, 80, 85, 90 | WT | MA σ [NERR]<br>MA max[abs(NERR)]<br>MA 90th percentile univariate distribution of ERR<br>MA σ [ER]<br>σ [ERR]<br>dummy for currency union | X | vol: s. neg. ;<br>CU: s. pos.<br>big effect of both |
| Thursby and Thursby (1987)* | 74-82 | 17 indus | VNER around predicted trend | Bil. X | s. neg. |

[1)] A star designates authors using gravity type trade models
[2)] indus: industrialised countries; WT: world trade (trade from different regions, sample depending on data available).
[3)] (V)N(R)E(E)R(R): (variance of the) nominal (real) (effective) exchange rate (return); MA: moving average; σ: standard deviation
[4)] M: imports, X: exports, Δ: variable in first difference
[5)] (n.)s.: coefficient on the exchange rate uncertainty term is (non-)significantly different from zero at 5%.

In summary, there seems to be a clear superiority of panel techniques in a situation involving substantial cross-nation variation in unobserved variables as well as substantial time-series variation. Therefore, the profession has progressively come to downgrade the importance of the slew of non-findings in the early literature. The empirical assertion that uncertainty reduces trade in a first-order manner should hence be taken seriously. The remaining question is by how much uncertainty reduces trade.

### 2.1.3 Currency unions and trade

An important subset of the empirical works on exchange rates and trade concerns what we call the *Rose effect*. Rose (2000) started the debate by finding that countries participating in a currency union seemed to trade three times more than expected – even when one controlled for the impact of exchange rate volatility. In his seminal paper, Rose (2000) uses a gravity model of trade flows for a panel over five year intervals spanning 1970 to 1990 for 186 countries, dependencies, territories, overseas departments, colonies, etc. On top of the standard variables for a gravity model, he introduces a volatility measure and a dummy variable for trading partners using the same currency (330 in his sample of 31000 observations in total). Rose (2000) finds a significant positive effect for this dummy with a coefficient of 1.21, implying that countries within a currency union traded 2.3 times more with the other members of the currency union than with third countries. Rose conducts some sensitivity analysis, excluding some countries, changing the measurement of monetary regime (the currency union dummy), using alternative measures for distance and adding possible omitted variables, and always finds a significant and substantial effect.

Several studies have built upon this framework and provide support for the thesis of Rose (2000) pointing to a very substantial effect of a currency union on trade flows. Rose and van Wincoop (2001) control for the effect of multilateral trade resistance. Rose and Engel (2002) construct a gravity model with similar control variables as Rose (2000), but use a cross sectional approach, with a sample of 150 countries (or territories, etc.) in the year 1995, and do not have, among the explanatory variables, a proxy for exchange rate volatility. The study of Glick and Rose (2002) is based on a panel of 217 countries (or territories, etc.) with annual observations from 1948 to 1997. The estimation is based on a gravity equation as in Rose (2000), excluding however the volatility variable. Moreover, Glick and Rose use the random effects, the fixed effects, the between and the maximum likelihood estimators for panel data. Nitsch (2002) makes the following main changes to the estimates of Rose (2000), thereby entailing significant changes in the coefficient of the currency union dummy: First, he uses cross-sectional estimates over 5 years rather than pooling the data across time and country pairings. Second, he corrects the data set which apparently contained some misclassifications. It then introduces different language dummies, and separate dummies for each currency. Finally, it uses a regression method correcting for the missing observations of Rose's sample. Persson (2001) argues that non-linearity of the relationship might partly explain the surprisingly large results for the currency union dummy found by Rose (1999). The reply by Rose (2001) includes a new set of consistency checks and suggests that countries participating in currency unions trade 1.1 times more than other countries. In his reply, Rose is cautions against the applicability of his finding to the EMU, because most countries within currency unions in his sample are "small, poor or both, unlike most of the Euro-11." Honohan (2001) argues that the sample of Rose covers mostly colonial countries. For this sort of countries the currency dummy measures rather whether the abolition of a common currency reduces trade, so that no inference can be made regarding the effect of the creation of a monetary union, as for example EMU.

Although the modifications to the original empirical results are quite substantial, the general finding is that countries belonging to the same currency union trade substantially more with each other.

Micco et al. (2003) analyse the impact of a currency union on trade flows for the specific case of EMU. They use data for 22 industrial countries including the EMU countries and introduce, on top of the standard variables a dummy for membership in EMU. Their estimates suggest a gain of between 5% and 20% depending upon the data sample and statistical technique. Barr et al. (2003) estimate a gravity model for European countries, including both EMU and non-EMU countries. Their estimates for the period 1978 to 2002 indicate the currency union effect amounts to 29%. They also control for exchange rate volatility and find a trade reduction through exchange rate volatility by 12%.

Klein and Shambaugh (2004) estimate not only the impact of exchange rate volatility and of a currency union dummy, but also include the possibility of fixed exchange rates. They find for a dataset starting in the 1970s for more than 10.000 country pairings that fixed exchange rate regimes also have a strong effect on trade, though a smaller than currency unions. We will however not distinguish between fixed exchange rate regimes and currency unions in this paper, as this distinction doesn't apply to the European case.

With this review of the literature in hand, we turn to theoretical considerations that should help guide our empirical work in Section 4.

## 3. THEORETICAL FOUNDATIONS

### 3.1. *Theorizing about the theory: not only more exports per firm*

A drop in exchange rate volatility can increase the volume of trade in two not mutually exclusive ways – by producing more exports per firm, and by increasing the number of firms that are engaged in exporting. Given the magnitude of the impact of monetary union on trade volume found in the typical Rose-effect study and the rather small size of transaction costs that are eliminated by a currency union, it seem impossible that the rise in the exports-per-firm allowed could sufficiently explain the volume response.

For example, De Grauwe (1994) reports that the buying and selling spreads between the Belgian Franc and various industrial country currencies were quite low, approximately 500 basis points. For Europe as a whole, Emerson et al (1992) estimated all the costs involved in currency exchanging (this includes the salaries of all forex market participants) to be only about 0.5 percent of GDP, with much of this related to the massive turnover associated with asset trade rather than goods trade. For smaller, more open member countries with less liquid currency markets, they found the cost to be as high as 1% of GDP.

Taking the high end of these estimates and conservatively approximating the trade to GDP ratio to be 50% in Europe, we see that a high-side estimate of transaction cost would be something like 2%. Now consider the impact of a monetary union reducing trade cost by 2%. Even if the cost reduction were fully passed on to consumers, the aggregate import demand elasticity would have to be unreasonably large to explain the 20% to 40% rise that has been estimated in the Rose-effect literature on the euro area. Indeed, it is rare to find estimated aggregate import demand elasticities that exceed 2.[3] This is especially true since all the existing studies use data that pre-dates the currency union (the euro area was only a monetary union up to

[3] Since the euro affects all trade, not just a specific product, the relevant elasticity is for aggregate trade. Elasticity estimates for specific sub-sectors are much higher, but these implicitly assume that all other import prices are held constant.

2001), so many multi-currency related costs had not yet been eliminated in their sample and thus could not be responsible for the trade gain.

#### 3.1.1 The basic logic of our model

This pair of observations directs the theory towards a story that turns on the decision of firms to enter the foreign market, in other words, towards models in the spirit of the 'beachhead model' of Baldwin (1988).[4] Our basic story is simple. It is a well-known fact that most firms in European economies are small, and that the vast majority of them do not export. One factor that keeps them from exporting is the uncertainty involved in trade. In our model, a reduction in uncertainty induces more firms to export and this raises the trade volume.

While this accounts for a negative volatility-trade link, it does not address the Rose effect, namely the impact of currency union controlling for a linear (or log-linear) volatility-trade link. To get this, we must also explain why the volatility-trade link is *convex*. Figure 1 helps explain the argument.

Suppose the true relationship between volatility and trade is convex, as illustrated by the solid curve in the diagram. 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 is sufficiently convex, then adding a finite number of higher order volatility term to the regression would not be enough. There would still be room for a significant currency dummy.[5]

We focus on two sources of convexity. First, it is often asserted that volatility affects small firms more than it affects large ones. Consequently, the marginal impact of lower volatility will be large when the initial set of exporting firms includes more small firms (as predicted by the negative level relationship between minimum firm size and exporting). Second, the empirical distribution of firms in European nations is heavily skewed towards smaller firms. Thus each reduction in the minimum size-class necessary for exporting brings forth an ever larger number of new exporters.

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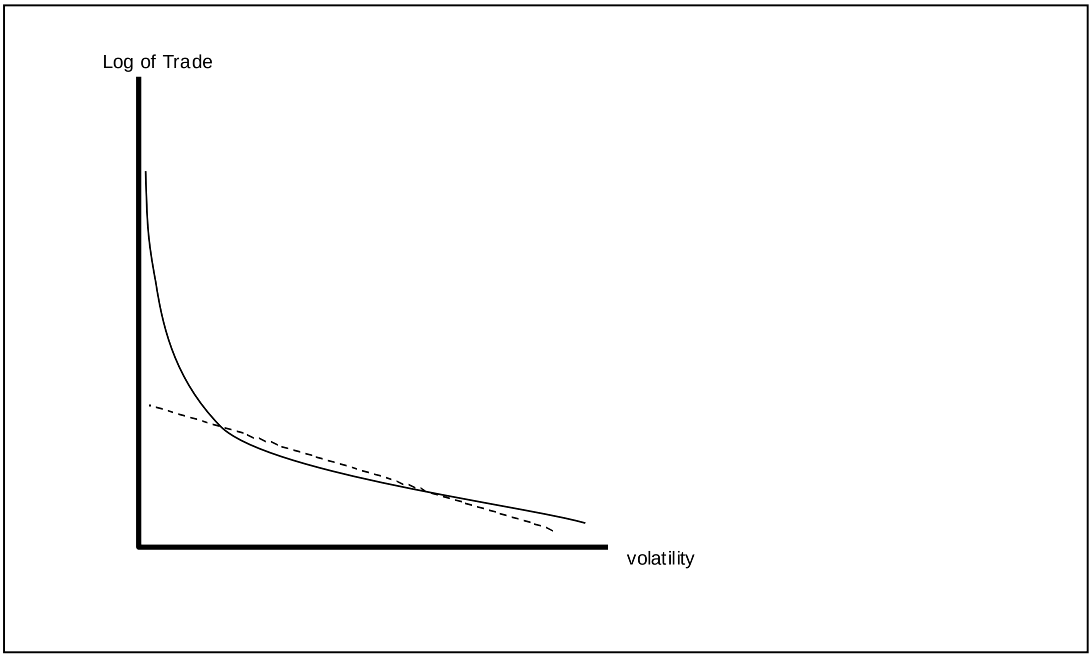
[4] For empirical support for the beachhead model see, e.g., Tybout and Roberts (1997)

[5] Any continuous function can be perfectly approximated by a polynomial of a sufficiently high order, however, some convex functions have an infinite number of non-zero higher-order derivatives, so one would need an infinite polynomial to capture the true relationship.

**Figure 1: Convexity of the volume-volatility link**




We turn now to presenting a very simple model to illustrate the economic logic of a convex link between exchange rate volatility and trade volumes.

## 3.2. *A stylised model: impact of volatility on trade*

The goal of this model is to provide a concrete example of how a reduction in uncertainty can raise the volume of trade in a convex manner by altering the range of firms engaged in exporting.

### 3.2.1 Basic set up

We shall need, at a minimum, two nations (Home and Foreign) and two types of firms. One type sells only locally, while the other type sells both locally and abroad. The fulcrum of the analysis will be firms' market-entry decision, i.e. a typical firm's decision to begin exporting when the exchange rate is uncertain. To keep the model as simple as possible, we assume that there is a fixed range of Home-based firms in existence and then focus on their decisions to entry the Foreign market. In particular, we assume that entering the Foreign market, i.e. beginning to export, involves a market-specific sunk cost as in Baldwin (1988). As we shall see, the key trade-off facing potential exporters is the uncertain revenue from exporting versus the deterministic sunk cost of market entry.

### 3.2.2 Technology, market structure and timing

Again to keep reasoning as streamlined as possible, we work with a partial equilibrium model, assume segmented markets with Cournot conjectures in each market. Since we take the number of Home firms that are active in the Home market as given, we can, without further loss of generality, focus only on the Foreign-market entry decision, i.e. Home firms' export decision.

Each monopolistically competitive Home firm produces a differentiated good and all of these enter the foreigners' preferences symmetrically in the sense that the demand function for each Home variety in the Foreign market is identical and equal to:

$$(1) \qquad p(j) = a - q(j) - b\int_0^{i'} q(i)di$$

for all Home varieties $i \in \{0,\ldots,i'\}$ that are sold in the Foreign market (i' indicates the upper range of the goods sold).

Firms play Cournot (Nash in quantities) market by market, which, as usual, is tantamount to assuming that markets are segmented; in other words, firms can engage in third degree price discrimination. Since each variety is distinct, each firm is a monopolist for its variety in each market but it competes indirectly with all other varieties as shown by the last term in the demand equation.

#### *Timing of the exchange rate uncertainty*

Models with uncertainty require assumptions concerning the timing of decisions. We want a situation where the market-entry decision is taken with the long run perspective in mind, i.e. where the entry decision is taken by firms before the exact future exchange rates are known. Thus, firms use their knowledge of the stochastic process generating the exchange rate in order to formulate expectations of the level and volatility of profits. Any firm that enters a market then chooses its 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. At all moments, firms take the exchange rate's stochastic process as given. In particular, changes in the process's volatility, including a shift to a common currency, are unanticipated.

Firms in our model are risk averse. To focus sharply on the essential logic of the mechanism under study, we adopt the simplest form of risk aversion. Namely, we assume that the firm discounts an uncertain stream of revenue using a risk premium that is related to the stream's variance and a risk-aversion parameter. Formally, the firm maximizes utility of profits, where the utility function is:

(2) $$U = E\Pi - \sigma^2$$

Here Π is pure profit (this includes operating profit and fixed costs), E is the expectations operator, and $\sigma^2$ is the variance of the exchange rate.

### 3.2.3 Short-run equilibrium conditions

As usual, we solve the model backward, which in our case, means we solve for prices, quantities and operating profits, taking the range of exporting firms as given.

### *Exporting firms problems*

Home 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 in Foreign currency units is:

(3) $$\pi \equiv (p - sm_i\tau)q$$

where p is the price, q is per-firm export, m is the marginal cost, 's' is the spot rate (Foreign currency price of Home currency), and $\tau \geq 1$ is the ad valorem tariff equivalent of trade barriers.

Although Home firms produce varieties that are symmetric in terms of consumption, they have heterogeneous technology, a la Melitz (2003). In particular, firms have different marginal production costs and we arrange firms according to decreasing marginal cost, with marginal cost ranging from zero to a maximum of $m_0$; these costs are in Home currency units; $m_i$ denotes the marginal cost of firms with index i; below, we discuss the density of firms along the i range.

In expected value terms, π is $(p-s^e m_\chi \tau)q$, the superscript 'e' denotes the expectation of s. The variance of this is $\sigma^2(m_\chi \tau q)^2$, where $\sigma^2$ is the variance of the spot rate 's' (for simplicity, we take σ to be time-invariant).

The typical exporting firm's problem is to choose its sales to the Foreign market, q, to maximise:

(4) $$V = \max_q (p - s^e \tau m_i)q - \sigma^2(\tau m_i q)^2$$

For first-order condition implies:

(5) $$q_i = \frac{a - bQ - s^e \tau m_i}{2 + b + \sigma^2 \tau^2 m_i^2}; \qquad Q \equiv \int_0^{i'} q(i)di$$

To solve for the integral in this expression, we integrate over q(i) for all i, but we find it convenient to switch variables of integration from 'i' to m. To do this, however, we must weight the $q_i$ by the mass of firms that have the same marginal cost, m, and are thus selling that amount. Specifically:

$$(6)\qquad Q=\int_{m=0}^{m_C} n(m)\frac{a-bQ-s^e\tau m}{2+b+\sigma^2\tau^2m^2}dm$$

where n(m) gives the mass of firms with marginal cost ‘m’, and $m_C$ is the maximum marginal cost at which firms find it worthwhile selling to this market (we identify $m_C$ below).

To get an explicit solution for Q requires an explicit functional form for n(m). For simplicity we assume that $n(m)=m^2$. Note that this reflects the well-known fact that the size distribution of firms is skewed heavily towards small firms (Cabral and Mata 2001). Given this, the closed-form solution for (6) is:

$$(7)\qquad Q=\frac{(2a\arctan(D/A)A-2aD)v+(\tau 2\ln(A)-\tau\ln(A^2+D^2))A^2+\tau D^2)}{2v(-D+\arctan(D/A)A-v^2};\quad A\equiv\sqrt{v(2+b)},\ D\equiv vm_C, v\equiv\sigma^2$$

where we have taken $s^e=1$ to reduce clutter in the expression.

### *Expected operating profit*

As is well known, operating profit is the square of optimal sales with linear demand. With our mean-variance objective function, the risk adjusted operating profit is only slightly more complex, namely $q^2(1+(\tau m_\chi)^2\sigma^2)$. To see this, note that the first order condition for export sales is $p-\tau ms^e-q-2\tau^2m^2\sigma^2q$, where all variables are evaluated at equilibrium. Thus the pay off function, which is, $(p-ms^e)q-\tau^2m^2\sigma^2q^2$, equates to $(q+2\tau^2m^2\sigma^2q)q-\tau^2m^2\sigma^2q^2$. Given this, plugging the optimal export level from (5) with (7) back into the objective function, (4), gives the risk-adjusted reward to exporting, i.e.:

$$(8)\qquad U_i=\left(\frac{a-bQ-\tau m_i}{2+b+\sigma^2\tau^2m_i^2}\right)^2(1+\tau^2m_i{}^2\sigma^2)$$

where we have normalised $s^e=1$ to reduce clutter in the expressions. Note that this implicitly assumes that the exchange rate is iid, (the mean is independent of past realisations).

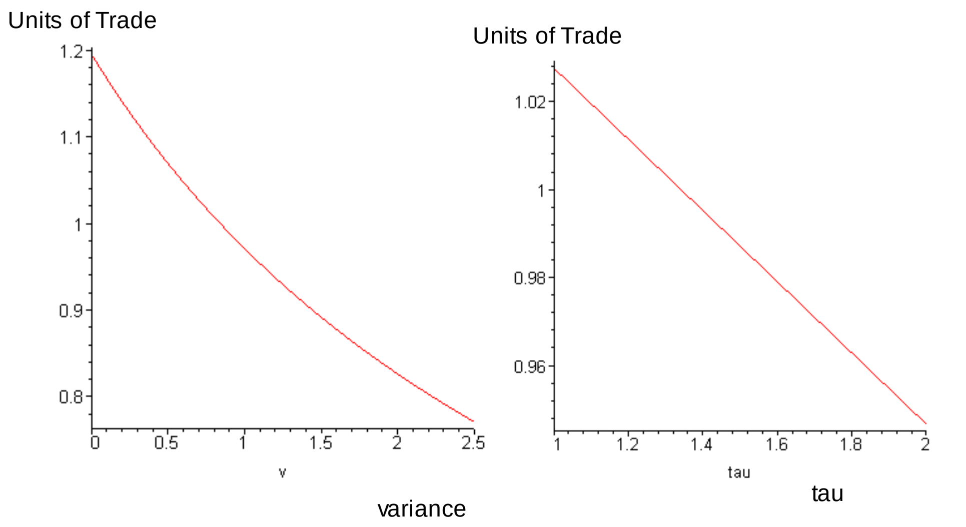
### 3.2.4 Long-run equilibrium: free entry

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.

Home firms plainly care about profit denominated in Home currency. For this reason, we must translate both the operating profit and the fixed entry costs – both of which have hereto been denominated in Foreign currency units – into Home currency units when considering the entry decision. To that end, we assume that Home firms make the discrete entry decision on the basis of the risk-adjusted return to market entry, namely

$s^e$(U-F)-var(U-F). From (8) we see that the variance of U-F is zero, so the entry criteria is just $s^e$(U-F). It is obvious that this is positive, if and only if (U-F) is positive. In short, the currency of denomination has no impact on the entry decision.

**Figure 2: The volume-volatility and volume-trade cost links**




Note: This left panel is drawn for a=10., b=.1 and tau=1.7; the right panel is drawn for a=10., b=.1 and v=1; sensitivity analysis reveals that the negative slopes holds for all parameter values tried.

Since the per-firm level of exports falls with a firm's "m", and the pay-off function rises with the square of export sales, it is plain that there exists a critical value of m that partitions the range of firms into exporters and non-exporters. Formally, the cut off is defined in terms of the highest m that would permit firms to cover the entry cost. The equation that determines the 'cut-off m' is:

$$(9) \qquad U = F \quad \Leftrightarrow \quad \left( \frac{a - bQ - \tau m_C}{2 + b + \sigma^2 \tau^2 m_C^2} \right)^2 (1 + \tau^2 m_C{}^2 \sigma^2) = F$$

where $m_C$ is cut-off m and Q is given by (7). Firms with m's less than this will export. Given the complexity of Q, however, this expression cannot be solved analytically for $m_C$. There is no difficulty, however, in solving it numerically. Having shown how $m_C$ is determined, we can plug the solution back into (7) to get the total value of exports.

### 3.3. *Trade impact of exchange rate volatility*

Given the lack of an explicit solution for the volume of trade, Q, we simulate the volatility-volume and $\tau$-volume links; Figure 2 shows the results. This allows us to 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 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 active firm will increase. This is seen immediately by inspection of the optimal sales level in (5). Second, the number of Foreign firms active in the Home market will increase since it lowers the cut-off $m_C$. In other words, lower volatility drops in the minimum class size that engages in exporting.

**Result 2:**

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

#### 3.3.1 Convexity of the volume-volatility link

Simulation of our model shows that the relationship between trade and volatility is convex for a wide range of parameters, as shown schematically in Figure 1. This leads to:

**Result 3:**

The marginal increase in trade as volatility falls gets progressively larger as volatility approaches zero, i.e. the volume-volatility link is convex for a wide range of parameters.

#### *Sources of nonlinearity in the volume-volatility link*

To provide intuition for the convexity of the link, we illustrate the two sources of nonlinearity discussed above. The first is that exchange rate uncertainty systematically affects small firms more than it affects large firms. The second stems from the fact that the empirical distribution of firms is skewed heavily towards small firms.

To see the first point, recall that the objective function is $(p-s^e m\tau)q-m^2\sigma^2q^2$. The key point is that the impact of the volatility is amplified by the marginal cost. Indeed, the impact rises with the square of marginal costs. Since small firms tend to have high marginal costs (that is why they are small), volatility systematically affects them most. Inspection of (8), for example, shows that a rise in $\sigma$ reduces the exports of a small firm more than it reduces the exports of a large firms.

Given this simple point, the argument is direct. Even holding constant the number of firms that are exporting, a given reduction in σ raises trade more when there are more small firms exporting. Of course, as the initial level of volatility falls, the range of exporting firms expands to include progressively smaller firms, so the impact of a marginal drop in σ rises as the initial level of σ falls.

The second point is even easier. As just mentioned, the minimum size-class of firms that export falls as volatility falls. Since the number of firms in each size class rises rapidly as size diminishes, each progressive marginal reduction of the minimum size-class brings an ever larger number of new exporters into action.

# 4. ESTIMATION

## 4.1. *The empirical model*

Our empirical work is based on a gravity model similar to the one used in Rose (2000) and most subsequent studies. The basic idea of the gravity is based on Helpman and Krugman (1985). Given CES preferences over domestic and imported varieties, the demand for a single imported variety is:

(10) $$x_{od}(j) = \frac{p_{od}(j)^{-\varepsilon}}{P_D} E_D$$

where $x_{od}(j)$ is the exports from the 'origin' nation to the 'destination' nation of variety j, $E_D$ is the destination nation's expenditure on imports, and $P_D$ is the destination nation's price index of goods that are substitutable with $x_{od}$; ε is the elasticity of substitution among all varieties, and, under Dixit-Stiglitz monopolistic competition, it is the demand elasticity facing exporters. The total volume of bilateral exports is just the number of varieties exported from origin nation 'o' to destination nation 'd' times the import level per variety, that is:

(11) $$X_{od} = n_{od} \frac{p_{od}^{-\varepsilon}}{P_D} E_D; \qquad n_{od} = \lambda L_O$$

where the second expression shows the assumption that the range of varieties available in nation 'o' is proportional to the size of 'o' endowment of factors, L. Here we have imposed symmetry on all nation-o made varieties.

Furthermore, we assume that the price of a typical variety varies with man-made trade barriers, with a distance related cost of trade, and with the unit factor cost in nation o. Thus, imposing:

(12) $$X_{od} = \frac{(w_o a_o (D_{od})^{\delta} \tau_{od})^{-\varepsilon}}{P_D} \lambda L_O E_D$$

where δ is the constant elasticity of trade costs with respect to bilateral distance, τ reflects all bilateral, man-made trade barriers, $w_o$ is the origin nation's factor cost and $a_o$ reflects its factor productivity level.

Assuming either factor price equalisation and a common technology, or different technology and a proportionality between factor rewards and factor productivity (i.e. wages are higher in highly productive nations in a way such that $w_i a_i$ is fairly constant across nations), we can write the aggregate bilateral exports as:

(13) $$X_{od} = \lambda(w_o a_o)^{-\varepsilon}(P_D)^{-1}(D_{od})^{-\varepsilon\delta}(\tau_{od})^{-\varepsilon} L_O E_D$$

where the constancy of '$w_0\, a_0$' across partnerships permits us to eliminate the subscripts.

Taking logs we have:

(14) $$\ln(X_{od}) = C + C_d + C_o + \beta_1 \ln(C_{od}) + \beta_2 \ln(D_{od}) + \ln(L_O E_D); \quad \beta_1 \equiv -\varepsilon,\ \beta_2 \equiv -\varepsilon\delta$$

where, the last two terms are the standard gravity factors, i.e. product of size variables, and bilateral distance. The other terms reflect an exporter specific term '$C_o$', an importer specific term '$C_d$' – these are sometimes called the remoteness factor or multilateral trade resistance – and bilateral trade barriers '$C_{od}$' that reflect expected risk and includes dummies for some well known bilateral trade barriers such as common membership in the EU, and membership in the euro area . Our theoretical section – equations (3) through (9) – provides an account of how expected risk is related to the volume of bilateral trade.

Most estimates of the gravity model use aggregate trade flows as the dependent variable so it is reasonable to take aggregate size measures as proxies for L and E. The usual practice is to take the two nations' real GDPs, under the assumption that the importer's expenditure will be proportional to its GDP and the range of products available in the exporting nation will be proportional to its GDP.

When using sectoral trade data, however, the mapping between L and E and GDPs is less clear. On the importer's side, one can think of using the corresponding sector's gross value added. However, the import-demand for, say, chemicals arises from many sectors other than the chemicals sector. On the export side, one can think of using sectoral production as a proxy for the number of varieties, but sector production data is difficult to get for long time periods and a broad sample of countries. Moreover, such sectoral value added measures are typically fraught with many measurement problems.

We experimented however with the value added per sector, deflated with overall manufacturing producer prices (for the reason explained above). For the importer, we took apparent consumption, which is equal to the value added of the sector, minus exports plus imports. Second, we used real GDP of the exporter and the importer. This has the inconvenient vis-à-vis the value added specification, that the income variable is the same across all the sectors, so that the regression does not contain any sector variant variable any more (except for the dependent variable). However, when we do not pool across sectors, the variable coefficient on the income variables should help circumvent this problem. The advantage of using the GDP is that we have a complete dataset, while for the value added and the apparent consumption we have many missing observations.

The distance, as usual, is measured as the great circle distance between national capitals. Furthermore, we define an EU-dummy which is equal to unit when both trading partners are member of the EU, and two EMU dummies: one, which is equal to unit if and when both partners are members of EMU (EMU2), and one which is equal to unit if and when only one of the two partners is in EMU.

### 4.2. *The data*

We focus on two sources of convexity. First, it is often asserted that volatility affects small firms more than it affects large ones. Consequently, the marginal impact of lower volatility will be large when the initial set of exporting firms includes more small firms (as predicted by the negative level relationship between minimum firm size and exporting). Second, the empirical distribution of firms in European nations is heavily skewed towards smaller firms. Thus each reduction in the minimum size-class necessary for exporting brings forth an ever larger number of new exporters. As the number of small firms, and hence the marginal costs are quite different across sectors, we decided to use sectoral data in our empirical analysis.

In our estimations, we use sectoral, bilateral import data on ISIC Rev.3 2-digit and 3-digit manufacturing sectors for the euro area of 12 nations, the 3 non-euro area EU members as well as Australia, Canada, Norway, Japan and the US (note that the Belgium-Luxembourg economic union does not report separate data for the two nations, and that Ireland is excluded due to some data shortages, so there are only 10 trade partners in the euro area of 12 countries). The exact sectors used for the regressions are reported in the appendix.

Trade (import) data are from the OECD Bilateral Trade Database, deflated using manufacturing producer prices. Although it would be more appropriate to use the import prices from each individual sector used in the regressions, the limited data availability for import or producer prices for our sample and sector breakdown obliged us to use overall manufacturing producer prices. [6]

Bilateral trade flows are significantly affected by income fluctuations and growth in EU nations has varied substantially in recent years. This, of course, is why we control for GDP in the regressions, but before turning to the formal statistical analysis, it is interesting to eyeball the raw trade flows.

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[6] Unit value indices are available only for a 2-digits breakdown and only for EU countries.

To reduce the data to a manageable dimension we group our raw data into broader SITC classifications: Chemicals and related products (sector 5), Manufactured goods classified chiefly by material (sector 6), Machinery and transport equipment (sector 7) and Miscellaneous manufactured articles (sector 8). Appendix B contains more information on the developments in these sectors.

Regarding exchange rate volatility, the argument to include this variable into the model is that the expected risk might reduce exports, as reflected in the variable $C_{od}$ in equation (14). In our model, we use two different definitions of exchange rate uncertainty: first, it is defined as the annual variance of the weekly nominal exchange rate return:

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

where $S_{ij}$ is the nominal exchange rate between currencies i and j, and the subscript w is the week. This measure is calculated for each country pairing for which the bilateral trade flows are analysed. We do not use a volatility measure based on real exchange rates, as the data would be less homogeneous across countries. The results should however not differ much, as inflation rates were rather similar across the countries of our sample over our estimation period.

As it is the expected risk that matters, we experiment with different moving averages of exchange rate volatility over the past, arguing that past exchange rate volatility should influence the expectation about future exchange rate volatility.

The second measure for exchange rate uncertainty is based on forward rates. It is defined as the annual average of the weekly growth rates of bilateral forward premium / discount rates in absolute values:

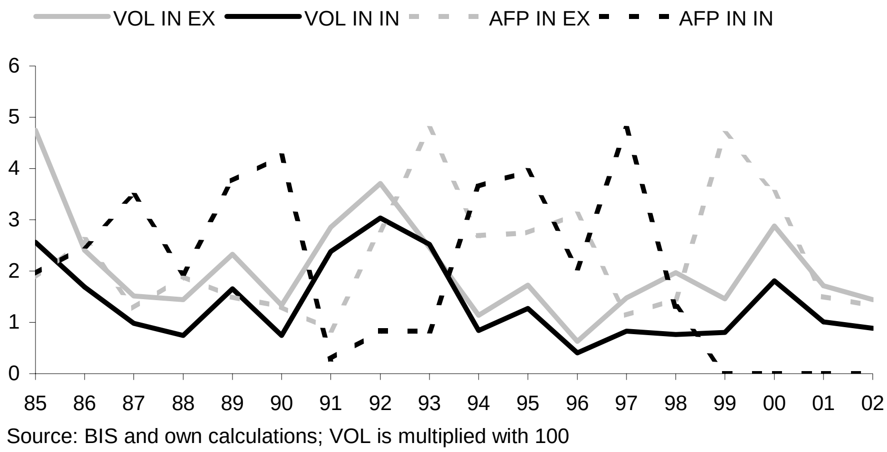
$$AFP_{ij,t} = \frac{1}{52}\sum_{w=1}^{52} abs\left(\frac{FP_{ijw}}{FP_{ij,w-1}} - 1\right)$$

where AFP is the absolute forward premium, and FP is the bilateral forward premium (converted into USD).

This measure has the advantage that it reflects the expectations on the exchange rate developments between the period when the contract for exports is concluded and the period when the exports have to be paid. Moreover, it takes into account that the exporter might cover the risk on the foreign exchange market.

Chart 1 shows the average intra- and extra-euro area exchange rate uncertainty for all euro area countries, using both definitions of uncertainty (VOL and AFP). As expected, intra-volatility is lower than extra-volatility, with a widening of this gap from around 1997 onwards due to the perspective of the creation of EMU in 1999. The chart also depicts the 1992-1994 crises in the ERM, with an effect on intra- and on extra-euro area exchange rate volatility. An interesting feature is that the absolute forecast premium seems to react with some lag to strong exchange rate movements, as for example in the 1992-1994 crisis in the ERM.

***Chart 1 Intra- and extra-euro area volatility***




*Source: BIS and own calculations*

*ININ (INEX): intra- (extra-)euro area exchange rate uncertainty; VOL is the annual variance of the weekly nominal exchange rate return as defined above, multiplied with 100 (to make it comparable with the AFP). AFP is the absolute forecast premium.*

## 5. EMPIRICAL RESULTS

We estimate the basic model on the pooled data set, and on each sector's data alone.

### 5.1. *The pooled results*

We perform least square estimations of (14) on a pool of non-overlapping sectoral and country data, allowing for exporter and importer fixed effects along with industry fixed effects.[7] While in the above discussion we presented the model in terms of exports from 'origin' to 'destination' nation, in the empirical tests we use import rather than export data due to data availability and reliability.[8] This should not affect the results, as exports from 'origin' to 'destination' are, from a theoretical point of view, equal to imports of 'destination' from 'origin'.

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[7] See the Data Appendix for a list of sectors; in the pooled regressions redundant sectors and 'not elsewhere classified' (nec) sectors were excluded; the former to avoid using the same data twice and the latter because the 'nec' sectors include relatively heterogeneous goods.

[8] Import data are found be more reliable than exports due the incentive for the exporter to underreport exports for tax purposes.

A first set of estimation results is reported in All coefficients of the pooled regression have the expected sign and are roughly of the right magnitude. Producer prices are included in the specifications with value added and with gross production per sector, following the model of Head and Mayer (2000). The income and size variables have the expected positive sign and are statistically significant. The "EU membership" dummy is also positive and significant. According to the estimations, members of the EU trade 16-17% more with each other than it would be the case if one, or both, trade partners were not members.

Table 4. To control for the effect of EMU, we estimate the equation with a dummy, which is equal to one when the importer and the exporter are both members of EMU, and zero otherwise. Moreover, we add a dummy, which is equal to one if only one of the partners is member of EMU. This dummy measures trade diversion or creation effect with respect to third countries. Following Micco et al. (2003) we call the first dummy EMU2 and the second dummy EMU1.

The specifications in All coefficients of the pooled regression have the expected sign and are roughly of the right magnitude. Producer prices are included in the specifications with value added and with gross production per sector, following the model of Head and Mayer (2000). The income and size variables have the expected positive sign and are statistically significant. The "EU membership" dummy is also positive and significant. According to the estimations, members of the EU trade 16-17% more with each other than it would be the case if one, or both, trade partners were not members.

Table 4 differ according to the dummy and uncertainty proxy used.[9]

All coefficients of the pooled regression have the expected sign and are roughly of the right magnitude. Producer prices are included in the specifications with value added and with gross production per sector, following the model of Head and Mayer (2000). The income and size variables have the expected positive sign and are statistically significant. The "EU membership" dummy is also positive and significant. According to the estimations, members of the EU trade 16-17% more with each other than it would be the case if one, or both, trade partners were not members.

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[9] As the time dimension consists of 10 years only, unit root and co-integration tests are relatively unreliable. Therefore, we do not consider an error correction framework for our estimation.

## Table 4: Pooled regression results

**EMU trade creation and trade diversion effects (1991-2002) - pooled data**

| | (1) | | | (2) | | | (3) | | | (4) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | coef | t-stat | | coef | t-stat | | coef | t-stat | | coef | t-stat | |
| **EMU2 (Both trade partners in EMU)** | 0.72 | *11.51* | *** | 0.53 | *8.37* | *** | 0.75 | *11.86* | *** | 0.57 | *8.84* | *** |
| **EMU1 (Only one trade partner in EMU)** | | | | | | | 0.14 | *3.24* | *** | 0.17 | *4.10* | *** |
| **(Value Added)i*(Apparent Consumption)j** | 0.49 | *26.16* | *** | 0.49 | *25.96* | *** | 0.49 | *25.66* | *** | 0.48 | *25.37* | *** |
| **(Producer Prices)i*(Producer Prices)j** | 0.31 | *13.94* | *** | 0.32 | *14.49* | *** | 0.31 | *14.20* | | 0.33 | *14.84* | *** |
| **EU Membership** | 2.86 | *53.97* | *** | 2.88 | *54.84* | *** | 2.86 | *53.78* | *** | 2.87 | *54.57* | *** |
| **Volatility (5 years moving average)** | -19.66 | *-13.06* | *** | | | | -19.36 | *-12.84* | *** | | | |
| **AFP** | | | | -0.38 | *-20.38* | *** | | | | -0.39 | *-20.39* | *** |
| **Constant** | -14.15 | *-19.83* | *** | -13.95 | *-19.64* | *** | -14.19 | *-19.88* | *** | -13.98 | *-19.68* | *** |
| **Rose Effect of EMU2** | **106%** | | | **70%** | | | **112%** | | | **76%** | | |
| **5%-confidence interval** | 82-132% | | | 50-93% | | | 87-140% | | | 55-100% | | |
| **Rose Effect of EMU1** | | | | | | | **15%** | | | **19%** | | |
| **5%-confidence interval** | | | | | | | 6-25% | | | 10-30% | | |
| **Number of observations** | 34892 | | | 34892 | | | 34892 | | | 34892 | | |
| **Adj R-squared** | 0.72 | | | 0.72 | | | 0.72 | | | 0.72 | | |
| **Root MSE** | 2.74 | | | 2.67 | | | 2.67 | | | 2.73 | | |

*Note: T-statistic in italics. The Rose effect is defined as [exp(EMU dummy coeff.) – 1]; it shows the trade increase, in percentage terms, due to monetary union. The 5% interval is calculated in the following way: the standard error of the coefficient is multiplied with the critical value at 2.5% (1.96) and subtracted for the lower bound and added for the upper bound of the confidence interval.*

### 5.1.1 Exchange rate uncertainty and volatility

Regarding exchange rate uncertainty, the five year moving average of the variance term (VOL) and the 6-month absolute forward premium (AFP) seemed to be most appropriate[10]. The trade reduction through exchange rate uncertainty can be calculated from the above results, by taking the average of the exchange rate uncertainty measure over time and over trading partners, and multiplying this measure with the estimated coefficient. The resulting trade reduction through exchange rate uncertainty amounts to 28% when using VOL as proxy, and to 38% when using AFP. An interesting feature is that the reduction in trade is significantly lower for the euro area countries, as they have historically relatively low exchange rate uncertainty. This can be calculated using the average of the respective uncertainty measures over euro area countries only. According to our estimation results, the intra-euro area trade reduction through exchange rate uncertainty amounts to 7% with VOL and 20% with AFP.

[10] We run the equations for windows from 1 to 8 years for VOL and for 1, 3 and 6 months for AFP and based our choice mainly on the adjusted R-squared.

### 5.1.2 Estimates of the “Rose effect”

Our estimate of the monetary union’s impact on intra-euro area trade –the so called ‘Rose effect’ - varies between 70% and 112% The effect is lower when using AFP as a proxy for exchange rate uncertainty, indicating that this variable is a better proxy for uncertainty than VOL. As explained above, the effect of AFP on bilateral trade flows is stronger than that of VOL. Taking these two findings together, the overall effect of EMU – which can be calculated by adding the above EMU effect from the dummy to the effect when setting the exchange rate uncertainty to zero – would vary between 91 and 119%.

All coefficients of the pooled regression have the expected sign and are roughly of the right magnitude. Producer prices are included in the specifications with value added and with gross production per sector, following the model of Head and Mayer (2000). The income and size variables have the expected positive sign and are statistically significant. The “EU membership” dummy is also positive and significant. According to the estimations, members of the EU trade 16-17% more with each other than it would be the case if one, or both, trade partners were not members.

All coefficients of the pooled regression have the expected sign and are roughly of the right magnitude. Producer prices are included in the specifications with value added and with gross production per sector, following the model of Head and Mayer (2000). The income and size variables have the expected positive sign and are statistically significant. The “EU membership” dummy is also positive and significant. According to the estimations, members of the EU trade 16-17% more with each other than it would be the case if one, or both, trade partners were not members.

Table 4 also shows the 5%-confidence interval of the EMU-effect, which is calculated in the following way: the standard error of the coefficient is multiplied with the critical value at 2.5% (1.96) and subtracted for the lower bound and added for the upper bound of the confidence interval. The intervals are very large, showing that the point estimates of the EMU effect should be treated with caution. In particular, the difference between the lower and the upper bound amounts to roughly 50% in all specifications. This finding is not surprising for a dummy variable, and is common to many other studies on the currency union effect on trade or ‘Rose’ effect. It shows how carefully the results need to be interpreted.

### 5.1.3 Trade with non-Eurozone nations

Interestingly, the third country dummy (EMU1) seems to indicate that there is no trade diversion, but rather some trade creation through EMU between participating and non-participating countries, which ranges between 15 and 19%.

This result is intriguing. 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 the Euro area. A possible explanation of this result is however that the increase in trade flows between euro area countries requires more imports as input for the production of the exports. The import intensity of euro area exports could indeed lead to a positive impact of lower intra-euro area exchange rate uncertainty on imports from non-euro area countries.

#### 5.1.4 About the volatility-trade link

Most notable is the fact that the exchange rate uncertainty and the monetary union dummies are jointly significant indicating that the effect of exchange rate uncertainty on trade flows might be non-linear.

Suppose the true relationship between volatility and trade is convex, as illustrated by the solid curve in Figure 1 . 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. There would still be room for a significant currency dummy.

Hence according to our empirical results, 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.

We can however imagine that data can also be characterized by alternative forms of non-linearity that are much smoother – forms that resemble the continuous line in figure 4-1, if the non-linearity is convex. The precise form of the non-linearity will depend upon functional forms, so we cannot make a robust prediction as to the exact form. 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 non-linearity in the trade-volatility link by introducing a squared volatility term in addition to the linear term.

## Table 5 : Detecting non-linearities in the trade-volatility link

**Non-linearity of the trade volatility link (1991-2002) - pooled data**

| | (1) | | (2) | | (3) | | (4) | |
|---|---|---|---|---|---|---|---|---|
| **EMU2 (Both trade partners in EMU)** | 0.57 | 8.87 *** | 0.17 | 2.31 ** | 0.60 | 9.38 *** | 0.20 | 2.67 *** |
| **EMU1 (Only one trade partner in EMU)** | | | | | 0.21 | 4.80 *** | 0.20 | 4.74 *** |
| **(Value Added)i*(Apparent Consumption)j** | 0.49 | 26.25 *** | 0.48 | 25.89 *** | 0.48 | 25.59 *** | 0.48 | 25.22 *** |
| **(Producer Prices)i*(Producer Prices)j** | 0.31 | 13.99 *** | 0.32 | 14.54 *** | 0.32 | 14.41 | 0.33 | 14.94 *** |
| **EU Membership** | 2.77 | 51.82 *** | 2.82 | 53.21 *** | 2.76 | 51.44 *** | 2.81 | 52.84 *** |
| **Volatility (5 years moving average)** | -61.54 | -16.45 *** | | | -63.16 | -16.82 *** | | |
| **Vol^2 (5 years moving average)** | 51083.18 | 12.22 *** | | | 53596.67 | 12.73 *** | | |
| **AFP** | | | -2.01 | -11.05 *** | | | -2.07 | -11.35 *** |
| **AFP^2** | | | 0.77 | 8.98 *** | | | 0.80 | 9.29 *** |
| **Constant** | -13.95 | -20.03 *** | -13.85 | -19.53 *** | -14.20 | -19.89 *** | -13.95 | -19.78 *** |
| **Rose Effect of EMU2** | **76%** | | **19%** | | **83%** | | **22%** | |
| **5%-confidence interval** | 55-100% | | 3-38% | | 61-107% | | 5-42% | |
| **Rose Effect of EMU1** | | | | | **23%** | | **22%** | |
| **5%-confidence interval** | | | | | 13-34% | | 13-33% | |
| **Number of observations** | 34892 | | 34892 | | 34892 | | 34892 | |
| **Adj R-squared** | 0.72 | | 0.72 | | 0.72 | | 0.72 | |
| **Root MSE** | 2.67 | | 2.66 | | 2.67 | | 2.66 | |

*Note: The superscript numbers are t-statistics.*

The results, shown in Table 5, provide direct support for the non-linearity hypothesis and some support for the smooth-form of the convexity since the linear term is negative and the quadratic term is positive.

The fact that EMU2 is significant even when the quadratic volatility term is included, suggests a couple of possibilities. First, the trade-volatility link may look like a combination of the smooth and discrete forms illustrated in Figure 1, i.e. 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 than can be captured by a second order approximation. To pursue this line of thinking, in table 6 we include a cubic volatility term and higher order terms and we re-estimate the equation without EMU dummies (in columns 1 and 3) and with EMU dummies (in columns 2 and 4). Results from columns (1) and (3) should provide more detail about the true nature of the detected non linearity. Results from columns (2) and (4) will, on the other hand, provide a hint as to our hypothesis that the trade-volatility link may look like a combination of the smooth and discrete forms illustrated in Figure 1. We report only the cubic and quadratic terms since STATA drops the 5th and above orders automatically. The results are mildly encouraging, as Table 6 shows.

## Table 6 : Higher order volatility terms

**Non-linearity of the trade volatility link (1991-2002) - pooled data**

| | (1) | | (2) | | (3) | | (4) | |
|---|---|---|---|---|---|---|---|---|
| **EMU2 (Both trade partners in EMU)** | | | 0.60 | 9.35 *** | | | 0.23 | 2.78 *** |
| **EMU1 (Only one trade partner in EMU)** | | | 0.21 | 4.81 *** | | | 0.22 | 5.05 *** |
| **(Value Added)i*(Apparent Consumption)j** | 0.51 | 27.11 *** | 0.48 | 25.58 *** | 0.49 | 26.04 *** | 0.48 | 25.25 *** |
| **(Producer Prices)i*(Producer Prices)j** | 0.29 | 13.10 *** | 0.32 | 14.41 *** | 0.31 | 14.30 *** | 0.33 | 14.84 *** |
| **EU Membership** | 2.84 | 53.48 *** | 2.76 | 51.42 *** | 2.83 | 53.15 *** | 2.81 | 52.76 *** |
| **Volatility (5 years moving average)** | -69.94 | -18.80 *** | -63.57 | -16.54 *** | | | | |
| **Vol^2 (5 years moving average)** | 59705.15 | 13.65 *** | 54399.25 | 12.09 *** | | | | |
| **Vol^3 (5 years moving average)** | -1621043 | -0.81 ns | -1013877 | -0.51 ns | | | | |
| **Vol^4 (5 years moving average)** | (dropped) | | (dropped) | | | | | |
| **AFP** | | | | | -1.31 | -1.72 * | -0.02 | -0.02 ns |
| **AFP^2** | | | | | 5.82 | 2.00 ** | 9.76 | 3.14 *** |
| **AFP^3** | | | | | -11.40 | 2.92 *** | -16.02 | -3.92 *** |
| **AFP^4** | | | | | -5.44 | -3.24 *** | -7.25 | -4.17 *** |
| **Constant** | -13 | -20.03 *** | -13.41 | -18.77 *** | 13.25 | -19.89 *** | -13.43 | -18.85 *** |
| **Rose Effect of EMU2** | | | **82%** | | | | **26%** | |
| **5%-confidence interval** | | | 61-107% | | | | 7-48% | |
| **Rose Effect of EMU1** | | | **23%** | | | | **24%** | |
| **5%-confidence interval** | | | 13-34% | | | | 14-35% | |
| **Number of observations** | 34892 | | 34892 | | 34892 | | 34892 | |
| **Adj R-squared** | 0.7201 | | 0.72 | | 0.72 | | 0.72 | |
| **Root MSE** | 2.6704 | | 2.67 | | 2.66 | | 2.66 | |

*Note: The superscript numbers are t-statistics.*

Columns (1) and (2) report results for the specification where exchange rate uncertainty is proxied by the 5-years moving average volatility term (VOL). As just mentioned, we estimate the same relationship without EMU dummy (column 1) and with a EMU dummy (column 2), respectively. Columns (3) and (4) report results for the same relationship – without and with EMU dummies – but where exchange rate uncertainty is proxied by the AFP term.

We first concentrate on the results from the AFP specification. When we exclude the EMU2 and EMU1 terms, as suggested by the smooth form of convexity, all volatility terms are individually significant and of the expected sign. The second order term is positive and the third order term negative – we do not have priors concerning higher order terms. In the VOL specification, the cubic term has the right sign but it is statistically not significant.

It is interesting and perhaps important that when we include linear, quadric and cubic volatility terms, the EMU2 and EMU1 dummies are still significant; see columns (2) and (4). This suggests that there may be a pure Monetary Union effect in the sense of a discrete jump in trade when volatility reaches zero. In conclusion, these tests signal the co-existence of a convex relationship between volatility and trade and of a discrete jump in presence of a Monetary Union.

## 5.2. *Sectoral results*

We estimated the model using a fixed-effect panel estimator (time series data on each bilateral trade flow) for each sector separately. Table 7 shows the results for the variable that are of greatest interest to us, namely the monetary union dummy and our uncertainty measure.[11] In particular, it shows - for the same four specifications as in the pooled regression – the percentage impact of EMU2 and EMU1 on trade, along with potential trade creation through the elimination of intra-euro area exchange rate uncertainty. Moreover, we show the sum of the EMU2 and the uncertainty effect. We only report those results which have a significance level of 10% or more.

We use all sectors, subsectors and their aggregations provided by the OECD STAN and BTD databases. Note that these report a somewhat overlapping classification of data with 2 and 3 digit sectors, depending on availability. For example, sector 27 is reported together with sector 28, and separately. Therefore, we mark the bigger categories, which encompass several sub-sectors, in bold in the table. Moreover, with the value added specification, the number of observations varies substantially between sectors (see Appendix), as sectoral value added data are not available for the complete sample.

The results indicate that while exchange rate uncertainty appears to be consistently negative and significant across sectors, the average effect of EMU2 is now somewhat lower than in the estimations where we pooled across sectors as well, with an average between 21 and 108% when taking the average only over those sectors, where the EMU2 dummy is significant.

Similar to the pooled regressions, results for the specifications with the volatility term (VOL) tend to report a higher EMU2 dummy coefficient than the ones with the absolute forecast premium (AFP). By construction, the EMU2 dummy reflects both the impact of the mere creation of EMU and residual effects linked to the elimination of exchange rate uncertainty and not otherwise depicted. Our finding might

[11] Tables with the full results for all variables can be found in the Appendix.

## Table 7: Sectoral results

| | | with VOL | | | | | | | | with AFP | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | with VA | | | | with GDP | | | | with VA | | | | with GDP | | | |
| | | EMU2 | EMU1 | VOL | SUM | EMU2 | EMU1 | VOL | SUM | EMU2 | EMU1 | AFP | SUM | EMU2 | EMU1 | AFP | SUM |
| **01-05** | **Agriculture, hunting, forestry and fishing** | | | 8 | 8 | 44 | | 6 | 50 | | | 21 | 10 | | | 10 | 21 |
| **10-14** | **Mining and quarrying** | | | 8 | 8 | | | 7 | 7 | | 10 | 12 | 16 | | | 6 | 12 |
| **15-16** | **Food products, beverages and tobacco** | 59 | | 5 | 64 | 67 | | 4 | 71 | 40 | 11 | 18 | 69 | 35 | | 18 | 53 |
| **17-19** | **Textiles, textile products, leather and footwear** | | -26 | 6 | -20 | 49 | | 6 | 55 | | -21 | 18 | -3 | | | 18 | 18 |
| **20** | **Wood and products of wood and cork** | 114 | 53 | 5 | 172 | 45 | | 5 | 50 | 67 | 71 | 22 | 169 | | | 30 | 22 |
| **21-22** | **Pulp, paper, paper products, printing and publishing** | 71 | | 7 | 78 | 62 | | 6 | 68 | 50 | | 19 | 72 | | | 22 | 19 |
| **23-25** | **Chemical, rubber, plastics and fuel products** | 79 | 23 | 5 | 107 | 47 | | 4 | 51 | 51 | 26 | 19 | 97 | | | 20 | 19 |
| 23 | Coke, refined petroleum products and nuclear fuel | | | 7 | 7 | | 50 | 7 | 57 | | 25 | 21 | 48 | | 44 | 23 | 64 |
| 24 | Chemicals and chemical products | 93 | 57 | 5 | 155 | 41 | | 4 | 45 | 62 | 60 | 19 | 143 | | | 21 | 19 |
| 2423 | Pharmaceuticals | 85 | 106 | 4 | 195 | | 30 | 3 | 33 | 54 | 107 | 16 | 178 | | 30 | 17 | 46 |
| 24ex2423 | Chemicals excluding pharmaceuticals | 74 | 36 | 5 | 114 | 47 | | 5 | 51 | | 44 | 19 | 64 | | | 21 | 19 |
| 25 | Rubber and plastics products | | -26 | 5 | -21 | 58 | | 6 | 64 | | -25 | 18 | -12 | | | 13 | 18 |
| **26** | **Other non-metallic mineral products** | | -19 | 6 | -14 | 34 | | 5 | 39 | | | 18 | 17 | | | 17 | 18 |
| **27-28** | **Basic metals and fabricated metal products** | | | 7 | 7 | 38 | | 6 | 44 | | | 19 | 20 | | | 20 | 19 |
| 27 | Basic metals | 103 | | 5 | 108 | | | 6 | 6 | 53 | | 19 | 76 | | | 23 | 19 |
| 271+2731 | Iron and steel | | | 6 | 6 | | | 6 | 6 | | | 18 | 25 | | | 25 | 18 |
| 272+2732 | Non-ferrous metals | 143 | | 7 | 150 | | | 9 | 9 | 61 | | 20 | 96 | | | 35 | 20 |
| 28 | Fabricated metal products | | | 4 | 4 | 42 | | 5 | 47 | | | 19 | 19 | | | 19 | 19 |
| **29-33** | **Machinery and equipment** | 65 | 32 | 5 | 101 | 45 | | 4 | 49 | 41 | 37 | 18 | 96 | | | 19 | 18 |
| 29 | Machinery and equipment, n.e.c. | 121 | 48 | 5 | 174 | 35 | | 4 | 39 | 83 | 53 | 18 | 157 | | | 21 | 18 |
| 30-33 | Electrical and optical equipment | 46 | | 6 | 52 | 47 | | 4 | 51 | | | 17 | 19 | | | 19 | 17 |
| 30 | Office, accounting and computing machinery | 175 | 42 | | 217 | 52 | | 3 | 56 | 112 | 50 | 20 | 184 | | | 22 | 20 |
| 31 | Electrical machinery and apparatus, nec | | -22 | | -22 | | | 6 | 6 | -29 | | 17 | -15 | | | 14 | 17 |
| 32 | Radio, television and communication | 101 | 54 | 6 | 160 | | | 5 | 5 | 60 | 54 | 18 | 135 | | | 22 | 18 |
| 33 | Medical, precision and optical instruments | 47 | 32 | 4 | 83 | 32 | | 3 | 35 | | 39 | 15 | 58 | | | 20 | 15 |
| **34-35** | **Transport equipment** | 207 | 60 | 7 | 274 | 47 | | 6 | 53 | 156 | 74 | 19 | 254 | | | 23 | 19 |
| 34 | Motor vehicles, trailers and semi-trailers | 149 | 62 | 7 | 219 | 53 | | 7 | 59 | 115 | 72 | 19 | 207 | | | 20 | 19 |
| 35 | Other transport equipment | 149 | 47 | 9 | 205 | 40 | | 7 | 46 | 120 | 72 | 21 | 218 | | | 26 | 21 |
| 351 | Building and repairing of ships and boats | 197 | | 8 | 205 | 160 | | 10 | 170 | 177 | | 23 | 197 | 98 | | 20 | 122 |
| 352+359 | Railroad equipment and transport equipment n.e.c. | | | 8 | 8 | | | 7 | 7 | | | 24 | 15 | | | 15 | 24 |
| 353 | Aircraft and spacecraft | | | | | | | 7 | 7 | | | 14 | 10 | | | 10 | 14 |
| **36-37** | **Manufacturing nec; recycling** | 74 | 34 | 5 | 112 | 50 | | 4 | 53 | 58 | 45 | 18 | 122 | | | 19 | 18 |
| **40-41** | **Electricity, gas and water supply** | | -85 | 34 | -51 | 665 | -57 | 18 | 626 | | -84 | 16 | -66 | 551 | -65 | 19 | 502 |
| | **Average** | **108** | **27** | **7** | **87** | **78** | **7** | **6** | **61** | **40** | **22** | **19** | **82** | **21** | **0** | **19** | **40** |

*Note: Rose effect is exp(EMU dummy)-1; it shows percent increase in trade due to monetary union.*

pledge in favour of the AFP as a more appropriate proxy for exchange rate uncertainty than the VOL specification.

It is insightful to look at the joint effect of the elimination of exchange rate uncertainty (measured using the AFP or VOL data) and the 'Rose' effect (i.e. the effect of the mere creation of a currency union). The sum of the coefficients for the two effects indicates figures for trade creation ranging from 40% to 87%.[12] Furthermore, the combined effect doesn't show swings as large as the ones reported earlier for the individual EMU dummy effect. It shows, on the contrary, little sensitiveness to the chosen specification of exchange rate uncertainty and volatility – trade creation amounts to 61-87% when using the VOL specifications, and to 40-82% for the AFP specifications. Ordering the sectors according to the size of the coefficients for VOL and AFP shows that – although similar when using the same uncertainty measure – the ranking differs between VOL and AFP specifications.

The impact of EMU seems to differ substantially across sectors, with relatively strong effects for the following sectors "Electricity, gas and water supply", "Building and repairing ships and boats", "Office, accounting and computing machinery", "Motor vehicles, trailers and semi-trailers", "Non-pharmaceutical chemicals", and "Chemical, rubber, plastics and fuel products". It should be noted that the first sector was subject to a huge number of privatisations over the last years in the EU, so that the EMU dummy could catch up some of this effect as well. At the same time, we find no significant EMU effect for protected manufactures and commodities, as "Aircraft and spacecraft", "Coke, refined petroleum products and nuclear fuel", "Iron and steel", "Mining and quarrying", "Railroad equipment transport equipment" and "Agriculture, hunting, forestry and fishing".

Our findings suggest that the theoretical model proposed in section 3 explains better those sectors characterised by imperfect competition features and increasing returns to scale. It should be noted that, similarly to the pooled regression, the size variable seems to have an impact on the size and significance of the EMU dummies. In particular, the effect appears stronger when using the value added rather than the GDP specification, and it is mostly not significant for the specification with GDP and volatility. As expected, the ordering of the sectors according to the size of the EMU effect is similar between the two GDP specification on the one hand, and between the two value added specifications on the other hand, while differences emerge between the GDP and the value added specification.

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[12] It should be noted that this average includes all sectors, rather than only those where the EMU2 dummy is significant, as above. Therefore, it is not fully comparable with the average over the EMU2 dummy effect.

Finally, the third country dummy points to trade creation of 10-17% between non-euro area and euro area countries, but is mostly not significant when using the GDP specification. The ordering of the sectors according to the size of the third country effect is similar in both value-added specifications.

As for the pooled regression, we also calculated a 5%-confidence interval in order to check the results obtained above (see Table 8).

The results show that the 5%-confidence interval is very large for most sectors, varying for example for the sector 'Machinery and equipment' between 11 and 143%. The size of the interval differs across sectors, but the results confirm those of the pooled regression, in that point estimates for the EMU effect need to be taken with caution.

**Table 8: Sectoral results with 5%-confidence intervals**

| | | **Specification with VOL** | | | | **Specification with AFP** | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Specif. with VA | | Specif. with GDP | | Specif. with VA | | Specif. with GDP | |
| | | EMU2 | EMU1 | EMU2 | EMU1 | EMU2 | EMU1 | EMU2 | EMU1 |
| **01-05** | **Agric., hunting, forestry and fishing** | | | -2-111 | | | | | |
| **10-14** | **Mining and quarrying** | | | | | | 10-10 | | |
| **15-16** | **Food products, beverages and tobacco** | 9-131 | | 20-134 | | -4-104 | 11-11 | -4-89 | |
| **17-19** | **Textiles, textile products, leather and footwear** | | -43--4 | 5-112 | | | -39-3 | | |
| **20** | **Wood and products of wood and cork** | 39-230 | 15-103 | 1-109 | | 9-157 | 30-126 | | |
| **21-22** | **Pulp, paper&products, printing& publ.** | 17-148 | | 15-128 | | 3-117 | | | |
| **23-25** | **Chemical, rubber, plastics&fuel prod.** | 25-156 | -3-55 | 3-110 | | 6-115 | 0-59 | | |
| 23 | Coke, refined petroleum prod.&nucl.fuel | | | | 0-124 | | 24-26 | | -4-114 |
| 24 | Chemicals and chemical products | 32-183 | 22-101 | -1-100 | | 11-138 | 25-105 | | |
| 2423 | Pharmaceuticals | 17-193 | 45-193 | | -2-72 | -3-145 | 46-193 | | -2-71 |
| 24ex2423 | Chemicals excluding pharmaceuticals | 11-173 | 0-84 | 4-107 | | | 6-94 | | |
| 25 | Rubber and plastics products | | -42--7 | 13-122 | | | -41--6 | | |
| **26** | **Other non-metallic mineral products** | | -36-2 | -5-88 | | | | | |
| **27-28** | **Basic metals & fabricated metal prod.** | | | -3-96 | | | | | |
| 27 | Basic metals | 32-211 | | | | -1-135 | | | |
| 271+2731 | Iron and steel | | | | | | | | |
| 272+2732 | Non-ferrous metals | 46-303 | | | | -3-168 | | | |
| 28 | Fabricated metal products | | | 2-98 | | | | | |
| **29-33** | **Machinery and equipment** | 11-143 | 2-70 | 1-108 | | -5-108 | 6-76 | | |
| 29 | Machinery and equipment, n.e.c. | 50-226 | 15-90 | -4-91 | | 24-170 | 19-97 | | |
| 30-33 | Electrical and optical equipment | 1-109 | | 3-108 | | | | | |
| 30 | Office, accounting&computing machinery | 86-306 | 6-89 | 6-119 | | 43-214 | 13-99 | | |
| 31 | Electrical machinery and apparatus, nec | | -40-1 | | | -51-3 | | | |
| 32 | Radio, television and communication | 36-196 | 13-109 | | | 8-136 | 14-109 | | |
| 33 | Medical, precision and optical instruments | -5-128 | -5-83 | -5-83 | | | 0-92 | | |
| **34-35** | **Transport equipment** | 107-357 | 21-111 | 2-113 | | 72-281 | 33-129 | | |
| 34 | Motor vehicles, trailers and semi-trailers | 57-296 | 21-117 | 5-121 | | 35-242 | 29-130 | | |
| 35 | Other transport equipment | 50-312 | 6-105 | -6-106 | | 33-265 | 24-140 | | |
| 351 | Building and repairing of ships and boats | 21-631 | | 40-384 | | 12-585 | | 6-272 | |
| 352+359 | Railroad equip.&transport equip. n.e.c. | | | | | | | | |
| 353 | Aircraft and spacecraft | | | | | | | | |
| 36-37 | Manufacturing nec; recycling | 18-156 | 5-70 | 7-110 | | 8-133 | 14-85 | | |
| **40-41** | **Electricity, gas and water supply** | | -93--66 | 217-1744 | -77--19 | | -93--64 | 165-1498 | -81--33 |

*Note: The 5% interval is calculated in the following way: the standard error of the coefficient is multiplied with the critical value at 2.5% (1.96) and subtracted from (for the lower bound of the confidence interval), and added to (for the upper bound of the confidence interval) the coefficient estimate.*

## 6. CONCLUDING REMARKS

This paper contributes to the rapidly growing literature on the impact of Europe's monetary union on trade, with two elements.

It proposes a theoretical model explaining why the mere creation of a monetary union can have a positive effect on trade even when a linear exchange rate volatility term is taken into account. It also contributes to the empirical literature on the impact of Europe's monetary union on trade, by proposing, for the first time, an analysis of sectoral data. Our theoretical model shows that in a monopolistic competition set-up, the effect of exchange rate uncertainty on trade has non linear features, indicating that EMU should have an effect on top to the one observed when setting exchange rate volatility equal to zero. The marginal increase in trade as volatility falls gets progressively larger as volatility approaches zero. In other words, we find evidence supporting the hypothesis of a convex trade-volatility link. To provide intuition for the non-linearity of the link, we illustrate two sources of convexity. First, exchange rate systematically affects small firms more that large firms. Second, the empirical distribution of firms is skewed heavily towards small firms. Hence our model leads to the conclusion that a reduction in exchange rate volatility raises the sales per exporting firm and the number of exporting firms. This finding is crucial and at the same time new in the literature, as it suggests that the trade-exchange rate uncertainty relationship can be proxied by a linear volatility term along with a currency union dummy. In our empirical part we test the theoretical findings on a sectorally disaggregated dataset. As customary in the relevant literature, we empirically test a gravity-like model of trade. We use a range of different specifications allowing us to test the results for their sensitivity to the chosen specification for exchange rate uncertainty, for the size variable of the gravity equation and for different sectors. A first set of estimations pools data across countries and sectors, while in a second instance data are pooled only across countries, allowing thereby for sectoral differences.

We introduce both an exchange rate uncertainty term (proxied by two alternative measures: the variance of the nominal exchange rate return, VOL, and the absolute forecast premium, AFP) and an EMU dummy into our model. The results for both specifications lead us to conclude that the effect of exchange rate uncertainty is negative, significant and robust to changes in the specification. Furthermore, our overall finding of joint significance of exchange rate uncertainty and the EMU dummy is in line with the intuition from the theory that points to non-linearities in the relationship between trade and exchange rate uncertainty.

The results indicate that the mere creation of EMU would increase trade by 70-112% according to the regression pooled both by country and industry, and by 21-108% when allowing for sector specific coefficients (taking into account only significant estimates). The EMU effect is smaller when using AFP as proxy for exchange rate uncertainty. We believe that this might indicate that the AFP is a better proxy for exchange rate uncertainty. In this context, the bigger figures for the EMU dummy can be read as reflecting some of the uncertainty impact that the VOL proxy is unable to depict. Adding the effect of the elimination of exchange rate uncertainty to the so-called 'Rose' effect of the mere creation of a currency union, the results indicate a trade creation between 91 and 119% according to the pooled regression, and 40 to 87% according to the sectoral regression (taking this time account of all sectors, i.e. not excluding those for which the EMU dummy was not significant). We also found further evidence for the convex form of the trade-exchange rate uncertainty relationship when introducing higher order uncertainty terms into the pooled regression.

It should be noted that the size of the EMU effect is also sensitive to the choice of the size variable (GDP or value added by sector). Measurement problems and the limited availability of sectoral value added data are possible sources of the observed discrepancies. Differences in results might derive from the fact that when dealing with sectoral data, the mapping between empirical and theoretical measures for the size variables of the gravity equation (endowment of factors and expenditures) is problematic. Both aggregate GDP and sectoral value added are imperfect approximations of real import demand and export supply, which take into account cross sector elasticities. Hence, given the difficulties of precisely assessing the trade creation brought about by the EMU, we suggest considering the figures provided by our estimations as possible ranges of the Rose effect.

We also test whether EMU has a significant impact on trade flows with non-EMU countries. In line with other authors, we find a significant and positive impact in most specifications, indicating that third countries tend to trade up to 27% more with EMU countries since the creation of EMU. This effect is also stronger for those sectors characterised by increasing returns to scale and imperfect competition features.

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## Appendix A Data

Imports: OECD Bilateral Sectoral Trade Database. The sectors (ISIC Rev. 3) are ISIC rev 3 sectors

| | Industry |
|---|---|
| 01-05 | AGRICULTURE, HUNTING, FORESTRY AND FISHING |
| 10-14 | MINING AND QUARRYING |
| 15-16 | FOOD PRODUCTS, BEVERAGES AND TOBACCO |
| 15-37 | TOTAL MANUFACTURING |
| 17-19 | TEXTILES, TEXTILE PRODUCTS, LEATHER AND FOOTWEAR |
| 20 | WOOD AND PRODUCTS OF WOOD AND CORK |
| 21-22 | PULP, PAPER, PAPER PRODUCTS, PRINTING AND PUBLISHING |
| 23 | ....COKE, REFINED PETROLEUM PRODUCTS AND NUCLEAR FUEL |
| 23-25 | CHEMICAL, RUBBER, PLASTICS AND FUEL PRODUCTS |
| 24 | ....CHEMICALS AND CHEMICAL PRODUCTS |
| 2423 | ......PHARMACEUTICALS |
| 24ex2423 | ......CHEMICALS EXCLUDING PHARMACEUTICALS |
| 25 | ....RUBBER AND PLASTICS PRODUCTS |
| 26 | OTHER NON-METALLIC MINERAL PRODUCTS |
| 27 | ....BASIC METALS |
| 27-28 | BASIC METALS AND FABRICATED METAL PRODUCTS |
| 271+2731 | ......IRON AND STEEL |
| 272+2732 | ......NON-FERROUS METALS |
| 28 | ....FABRICATED METAL PRODUCTS |
| 29 | ....MACHINERY AND EQUIPMENT, N.E.C. |
| 29-33 | MACHINERY AND EQUIPMENT |
| 30 | ......OFFICE, ACCOUNTING AND COMPUTING MACHINERY |
| 30-33 | ....ELECTRICAL AND OPTICAL EQUIPMENT |
| 31 | ......ELECTRICAL MACHINERY AND APPARATUS, NEC |
| 32 | ......RADIO, TELEVISION AND COMMUNICATION EQUIPMENT |
| 33 | ......MEDICAL, PRECISION AND OPTICAL INSTRUMENTS |
| 34 | ....MOTOR VEHICLES, TRAILERS AND SEMI-TRAILERS |
| 34-35 | TRANSPORT EQUIPMENT |
| 35 | ....OTHER TRANSPORT EQUIPMENT |
| 351 | ......BUILDING AND REPAIRING OF SHIPS AND BOATS |
| 352+359 | ......RAILROAD EQUIPMENT AND TRANSPORT EQUIPMENT N.E.C. |
| 353 | ......AIRCRAFT AND SPACECRAFT |
| 36-37 | MANUFACTURING NEC; RECYCLING |
| 40-41 | ELECTRICITY, GAS AND WATER SUPPLY |
| | GRAND TOTAL |

Imports are deflated using overall manufacturing producer prices.

Exchange rates: Bank of Internationl Settlements (BIS).

GDP: Real GDP, OECD Main Economic Indicators.

Value added per sector and gross production: OECD Structural Statistics for Industry and Services (see www.oecd.org/std/industry-services for more information), deflated with manufacturing producer prices.

PPI: from OECD Main Economic Indicators, originally in national currency, converted into USD using OECD exchange rates. Note that for the euro area countries, the original data were back-converted into an artificial euro, so that we converted them into USD using the euro for the whole period (also pre-EMU) (see newsletter OECD, Nb 4 page 6).

## Appendix B   Composition of bilateral trade flows

In , we calculate the percentage of each of these sectors in total manufacturing trade for intra-euro area exports (intra-intra), exports from intra- to extra-euro area countries (intra-extra), exports from extra- to intra-euro area countries (extra-intra) and trade between extra-euro area countries (extra-extra). For all four groupings according to the direction of the trade flows, sector 7 (machinery and transport equipment) represents the largest share with about 50 or more percent. Intra-euro area countries export more of sector 6 goods (manufactured goods classified chiefly by material) to both destinations than extra-euro area countries.

**Table 9: Relative importance of trade sectors**

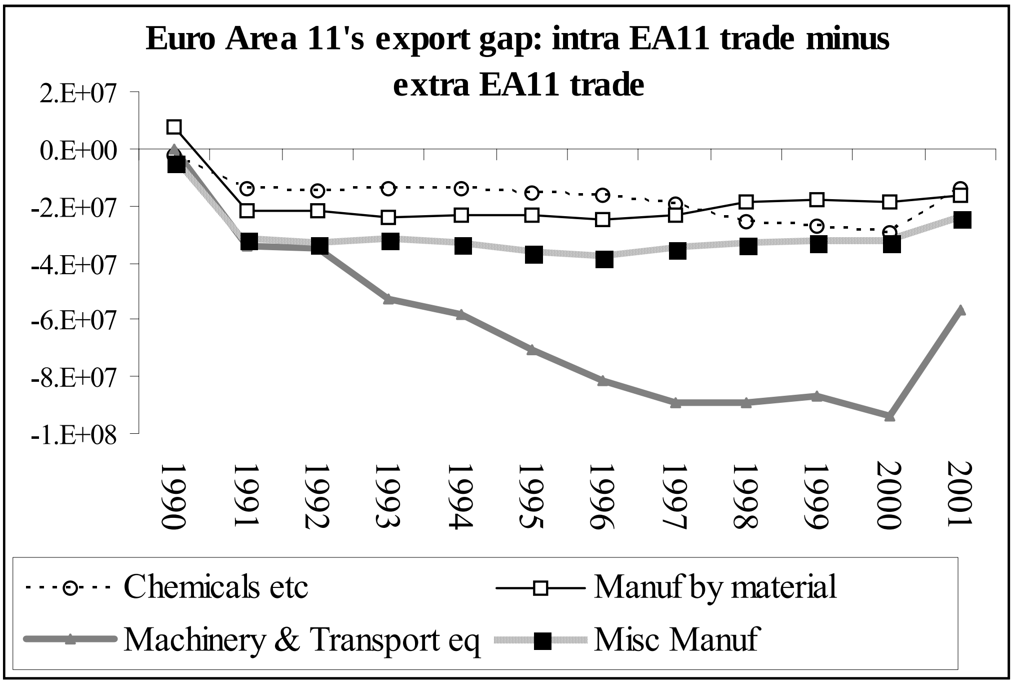
*Percentage of the main sectors in total exports*

| | Intra-intra | Intra-extra | Extra-intra | Extra-extra |
|---|---|---|---|---|
| 5 - Chemicals and related products | 15.7 | 15.2 | 10.6 | 16.4 |
| 6 - Manufactured goods classified chiefly by material | 22.9 | 20.9 | 15.4 | 14.6 |
| 7 - Machinery and transport equipment | 47.6 | 47.7 | 61.6 | 52.6 |
| 8 - Miscellaneous manufactured articles | 13.7 | 16.3 | 12.4 | 16.4 |

The shares differ however quite a lot between the individual countries. In particular, Greece is an exception to the relatively big size of sector 7 (machinery and transport equipment) (only 7% of the total), while the sector represents almost 80% of Japan's total manufacturing exports, a share which is significantly higher than in the euro area. The share of sector 8 (Miscellaneous manufactured articles) is particularly high for Italy, Portugal, Denmark and Greece while it is very small for Finland, Norway, Japan and Canada. This is mainly related to the sectors 'clothing' and 'footwear', and partly also to the sector 'furniture'. Exports in sectors 5 (Chemicals and related products) and 6 (Manufactured goods classified chiefly by material) differ substantially between the different countries, with the biggest share in Ireland (35%) and the smallest share in Portugal and Japan (5%) for sector 5, and with the biggest share in Finland and Norway (48 and 47% respectively) and the smallest share in Ireland (5%) for sector 6.

Table 9 shows the development over time of intra- and extra-euro area exports in the four above-mentioned sectors. From this graph we can see that the euro area's exports to non euro area nations have grown faster than intra-group trade over the past decade (the gap is negative). Moreover, there does seem to have been a large change between 2000 and 2001, with this movement especially remarkable in the largest sector – machinery and transport equipment. This means that since 2001, intra-euro area trade has been growing more in this sector than extra-euro area trade. The other sectors show a similar up tick, but it is noticeably more muted, especially for the miscellaneous category.

***Chart 2 Euro area's intra- and extra-euro area nominal trade by sector***




Regarding individual countries, Finland, France, Italy, the Netherlands and Spain have faster intra- than extra-euro area trade growth, while for the other countries there is no convincing evidence for stronger intra- than extra-euro area trade growth. In particular for Austria and Belgium, extra-euro area trade increased substantially more than intra-trade in most sectors. While for Austria, this might be explained by the relatively high share of trade to Eastern European countries, it is more surprising for Belgium. For Austria, the stronger increase in extra-trade comes mainly from organic and inorganic chemicals as well as from pharmaceutical products, together with power generating machinery and equipment, office machines, telecommunications and road vehicles. For the two latter sectors, intra-euro area trade also grew less rapidly than extra trade in Belgium. For Belgium, extra-trade increased stronger than intra-trade mainly from around 1995 onwards for sectors 7 and 8 (mainly for telecommunications and road vehicles, and for sanitary, plumbing and lighting fixtures, furniture, clothing and footwear). Summarising the analysis above, it appears that there are substantial differences in trade exposure across the countries examined here, which can be relevant for their reaction to exchange rate risk and to the effect of currency union on their trade. In particular, sectors in which domestic production of the euro area and international trade are substitutable are obviously reacting stronger to exchange rate changes than those where the country is largely depending on imports from outside the euro area.

# Appendix C Detailed results

## Table 10: Sectoral results with value added and volatility

| ISIC SECTOR | INDUSTRY | $VA_i*AC_j$ | | $PP_i*PP_j$ | | EMU2 | | EMU1 | | EU | | VOL | | C | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | coeff. | t-stat | coeff. | t-stat | coeff. | t-stat | coeff. | t-stat | coeff. | t-stat | coeff. | t-stat | coeff. | t-stat | NOBS | ARSQ |
| **01-05** | **Agriculture, hunting, forestry and fishing** | 0.91 | 4.19 | -0.42 | -2.35 | -0.08 | -0.55 | -0.11 | -1.21 | 1.56 | 14.37 | -21.60 | -7.20 | -6.44 | -1.05 | 2704 | 0.68 |
| **10-14** | **Mining and quarrying** | -0.05 | -0.71 | -0.22 | -0.96 | -0.27 | -1.24 | 0.08 | 0.58 | 1.13 | 7.91 | -22.60 | -5.98 | 10.50 | 1.82 | 2070 | 0.65 |
| **15-16** | **Food products, beverages and tobacco** | 0.78 | 2.83 | -0.59 | -1.99 | 0.46 | 2.43 | 0.04 | 0.30 | 3.52 | 24.66 | -14.55 | -3.54 | 4.16 | 0.30 | 2596 | 0.62 |
| **17-19** | **Textiles, textile products, leather and footwear** | 0.16 | 1.37 | -1.08 | -5.42 | -0.05 | -0.25 | -0.31 | -2.27 | 2.62 | 19.11 | -17.89 | -4.49 | 38.15 | 6.14 | 2928 | 0.57 |
| **20** | **Wood and products of wood and cork** | 0.21 | 1.13 | 0.77 | 2.59 | 0.76 | 3.44 | 0.42 | 2.93 | 3.34 | 19.04 | -15.39 | -3.24 | -23.23 | -2.80 | 2315 | 0.62 |
| **21-22** | **Pulp, paper, paper products, printing and publishing** | 0.72 | 4.10 | -0.46 | -1.64 | 0.53 | 2.80 | 0.11 | 0.87 | 3.08 | 20.90 | -21.39 | -5.17 | 2.96 | 0.26 | 2687 | 0.66 |
| **23-25** | **Chemical, rubber, plastics and fuel products** | 1.22 | 8.06 | -0.56 | -1.94 | 0.58 | 3.20 | 0.21 | 1.72 | 2.80 | 18.82 | -14.35 | -3.42 | -10.26 | -0.94 | 2789 | 0.66 |
| 23 | Coke, refined petroleum products and nuclear fuel | 0.24 | 2.27 | -1.51 | -3.36 | 0.05 | 0.14 | 0.16 | 0.69 | 3.57 | 14.12 | -20.11 | -2.89 | 50.78 | 3.24 | 2074 | 0.60 |
| 24 | Chemicals and chemical products | 0.69 | 4.12 | -0.16 | -0.52 | 0.66 | 3.37 | 0.45 | 3.52 | 2.83 | 18.89 | -14.87 | -3.58 | -5.98 | -0.65 | 2697 | 0.67 |
| 2423 | Pharmaceuticals | 0.71 | 4.86 | 0.16 | 0.53 | 0.62 | 2.62 | 0.72 | 4.04 | 2.90 | 15.53 | -10.22 | -1.91 | -16.62 | -1.66 | 2266 | 0.65 |
| 24ex2423 | Chemicals excluding pharmaceuticals | 0.25 | 1.59 | -0.36 | -1.06 | 0.55 | 2.40 | 0.30 | 1.95 | 2.94 | 18.00 | -13.32 | -2.79 | 9.68 | 0.92 | 2305 | 0.66 |
| 25 | Rubber and plastics products | 3.09 | 14.20 | -1.83 | -7.27 | -0.06 | -0.35 | -0.31 | -2.58 | 2.56 | 17.94 | -14.08 | -3.49 | -29.75 | -4.12 | 2710 | 0.68 |
| **26** | **Other non-metallic mineral products** | 1.23 | 5.86 | -0.91 | -3.75 | 0.06 | 0.32 | -0.21 | -1.76 | 2.60 | 19.36 | -16.46 | -4.16 | 4.17 | 0.60 | 2868 | 0.63 |
| **27-28** | **Basic metals and fabricated metal products** | 0.96 | 4.64 | -1.05 | -3.85 | 0.17 | 0.94 | 0.00 | 0.00 | 3.23 | 21.72 | -19.77 | -4.76 | 17.34 | 1.85 | 2812 | 0.63 |
| 27 | Basic metals | 0.06 | 0.39 | -0.21 | -0.69 | 0.71 | 3.23 | 0.10 | 0.71 | 3.40 | 20.06 | -15.70 | -3.26 | 4.88 | 0.59 | 2255 | 0.63 |
| 271+2731 | Iron and steel | 0.72 | 5.42 | 0.15 | 0.46 | 0.37 | 1.31 | -0.22 | -1.13 | 2.75 | 14.38 | -15.97 | -2.98 | -11.33 | -1.36 | 1679 | 0.67 |
| 272+2732 | Non-ferrous metals | -0.36 | -1.64 | -0.01 | -0.03 | 0.89 | 3.43 | 0.19 | 0.99 | 3.65 | 15.38 | -21.24 | -3.43 | 18.97 | 2.20 | 1427 | 0.60 |
| 28 | Fabricated metal products | 1.64 | 6.96 | -1.29 | -4.93 | 0.05 | 0.28 | -0.18 | -1.42 | 2.78 | 17.64 | -11.92 | -2.64 | 7.39 | 1.14 | 2472 | 0.64 |
| **29-33** | **Machinery and equipment** | 0.75 | 3.66 | -0.25 | -1.01 | 0.50 | 2.50 | 0.28 | 2.12 | 2.99 | 19.91 | -13.56 | -3.17 | -5.62 | -0.68 | 2812 | 0.68 |
| 29 | Machinery and equipment, n.e.c. | 0.00 | 0.01 | 0.79 | 2.93 | 0.79 | 4.00 | 0.39 | 3.01 | 2.67 | 17.40 | -13.90 | -3.17 | -18.76 | -3.20 | 2542 | 0.68 |
| 30-33 | Electrical and optical equipment | 0.82 | 4.97 | -0.72 | -3.21 | 0.38 | 2.04 | 0.18 | 1.43 | 3.09 | 20.30 | -17.18 | -3.97 | 7.69 | 1.15 | 2712 | 0.69 |
| 30 | Office, accounting and computing machinery | -0.03 | -0.26 | 0.56 | 4.54 | 1.01 | 5.06 | 0.35 | 2.39 | 3.08 | 17.08 | -6.04 | -1.15 | -7.97 | -2.27 | 2075 | 0.72 |
| 31 | Electrical machinery and apparatus, nec | 2.54 | 11.46 | -0.63 | -2.40 | -0.25 | -1.31 | -0.25 | -1.86 | 2.75 | 16.12 | -7.09 | -1.45 | -51.07 | -5.27 | 2208 | 0.66 |
| 32 | Radio, television and communication | 0.28 | 2.05 | -0.26 | -1.26 | 0.70 | 3.49 | 0.43 | 2.76 | 3.78 | 19.09 | -16.56 | -3.09 | 7.33 | 1.14 | 2102 | 0.69 |
| 33 | Medical, precision and optical instruments | 0.60 | 2.30 | -1.46 | -5.95 | 0.39 | 1.73 | 0.28 | 1.67 | 3.24 | 16.08 | -10.93 | -1.92 | 44.89 | 4.56 | 1728 | 0.70 |
| **34-35** | **Transport equipment** | -0.07 | -0.57 | 1.23 | 4.52 | 1.12 | 5.54 | 0.47 | 3.34 | 3.10 | 19.49 | -18.96 | -4.17 | -23.51 | -2.76 | 2671 | 0.70 |
| 34 | Motor vehicles, trailers and semi-trailers | -0.29 | -2.69 | 1.12 | 4.79 | 0.91 | 3.87 | 0.48 | 3.26 | 3.35 | 19.80 | -20.12 | -4.23 | -13.95 | -1.82 | 2278 | 0.71 |
| 35 | Other transport equipment | 0.31 | 2.50 | -0.02 | -0.05 | 0.91 | 3.54 | 0.39 | 2.30 | 2.29 | 12.45 | -25.75 | -5.03 | -0.31 | -0.03 | 2088 | 0.66 |
| 351 | Building and repairing of ships and boats | 0.12 | 1.03 | -0.91 | -3.04 | 1.09 | 2.37 | 0.19 | 0.71 | 0.16 | 0.47 | -22.60 | -2.91 | 32.35 | 3.56 | 1275 | 0.62 |
| 352+359 | Railroad equipment and transport equipment n.e.c. | 0.31 | 2.10 | -0.05 | -0.21 | 0.32 | 1.25 | 0.16 | 0.93 | 1.29 | 6.44 | -22.75 | -4.37 | -0.14 | -0.02 | 1614 | 0.75 |
| 353 | Aircraft and spacecraft | 0.06 | 0.57 | -0.14 | -0.53 | 0.40 | 1.04 | 0.09 | 0.37 | 1.50 | 5.55 | -9.10 | -1.29 | -0.29 | -0.05 | 1213 | 0.69 |
| **36-37** | **Manufacturing nec; recycling** | 0.25 | 1.71 | -0.26 | -1.11 | 0.55 | 2.78 | 0.29 | 2.33 | 2.61 | 18.83 | -14.10 | -3.35 | 2.03 | 0.35 | 2755 | 0.66 |
| **40-41** | **Electricity, gas and water supply** | -0.32 | -0.32 | -2.33 | -2.63 | 0.97 | 1.54 | -1.91 | -4.52 | 2.63 | 5.09 | -96.70 | -6.50 | 65.53 | 2.03 | 2001 | 0.25 |

*VA: value added, AC: apparent consumption, PP: producer prices, EMU2: dummy =1 if both are member of EMU, EMU1: dummy = 1 if one is member of EMU, C: constant, NOBS: number of observations, ARSQ: Adjusted R-squared.*

## Table 11: Sectoral results with GDP and volatility

| ISIC SECTOR | INDUSTRY | $GDP_i$-$GDP_j$ | | EMU2 | | EMU1 | | EU | | VOL | | C | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | coeff. | t-stat | coeff. | t-stat | coeff. | t-stat | coeff. | t-stat | coeff. | t-stat | coeff. | t-stat | NOBS | ARSQ |
| **01-05** | **Agriculture, hunting, forestry and fishing** | -0.10 | -0.30 | 0.36 | 1.87 | 0.20 | 1.43 | 3.06 | 20.71 | -16.16 | -3.85 | 9.13 | 2.86 | 3060 | 0.59 |
| **10-14** | **Mining and quarrying** | 0.41 | 1.16 | 0.10 | 0.51 | 0.18 | 1.20 | 2.31 | 14.92 | -20.14 | -4.58 | 4.96 | 1.48 | 3060 | 0.61 |
| **15-16** | **Food products, beverages and tobacco** | 0.55 | 1.84 | 0.51 | 3.01 | 0.03 | 0.27 | 3.21 | 24.84 | -12.34 | -3.36 | 4.18 | 1.49 | 3060 | 0.62 |
| **17-19** | **Textiles, textile products, leather and footwear** | 0.27 | 0.85 | 0.40 | 2.22 | 0.08 | 0.65 | 2.66 | 19.57 | -16.87 | -4.37 | 2.71 | 0.92 | 3060 | 0.57 |
| **20** | **Wood and products of wood and cork** | 1.26 | 3.87 | 0.37 | 1.99 | 0.00 | 0.02 | 2.45 | 17.35 | -15.72 | -3.91 | -5.27 | -1.72 | 3060 | 0.62 |
| **21-22** | **Pulp, paper, paper products, printing and publishing** | 0.90 | 2.97 | 0.48 | 2.75 | 0.05 | 0.38 | 2.61 | 19.65 | -17.36 | -4.60 | 1.33 | 0.46 | 3060 | 0.66 |
| **23-25** | **Chemical, rubber, plastics and fuel products** | 1.40 | 4.44 | 0.39 | 2.14 | 0.09 | 0.68 | 2.68 | 19.54 | -11.04 | -2.84 | -1.86 | -0.63 | 3060 | 0.66 |
| 23 | Coke, refined petroleum products and nuclear fuel | -0.65 | -1.31 | 0.41 | 1.42 | 0.40 | 1.95 | 3.31 | 15.28 | -20.62 | -3.35 | 11.90 | 2.52 | 3060 | 0.58 |
| 24 | Chemicals and chemical products | 1.52 | 4.90 | 0.34 | 1.92 | 0.09 | 0.69 | 2.62 | 19.47 | -11.21 | -2.93 | -4.39 | -1.50 | 3060 | 0.67 |
| 2423 | Pharmaceuticals | 2.44 | 7.08 | 0.26 | 1.30 | 0.26 | 1.81 | 2.48 | 16.50 | -8.45 | -1.98 | -16.59 | -5.10 | 3060 | 0.66 |
| 24ex2423 | Chemicals excluding pharmaceuticals | 0.97 | 3.15 | 0.38 | 2.18 | 0.10 | 0.76 | 2.64 | 19.82 | -13.16 | -3.48 | 0.31 | 0.11 | 3060 | 0.68 |
| 25 | Rubber and plastics products | 0.92 | 3.04 | 0.46 | 2.65 | 0.02 | 0.13 | 2.67 | 20.35 | -15.84 | -4.24 | -1.65 | -0.58 | 3060 | 0.66 |
| **26** | **Other non-metallic mineral products** | 0.81 | 2.66 | 0.29 | 1.68 | 0.02 | 0.13 | 2.46 | 18.67 | -15.48 | -4.13 | -3.36 | -1.17 | 3060 | 0.63 |
| **27-28** | **Basic metals and fabricated metal products** | 0.79 | 2.54 | 0.32 | 1.80 | 0.01 | 0.04 | 3.08 | 22.73 | -15.96 | -4.14 | 1.16 | 0.39 | 3060 | 0.63 |
| 27 | Basic metals | 0.66 | 2.03 | 0.26 | 1.39 | -0.01 | -0.04 | 3.20 | 22.62 | -18.56 | -4.62 | 2.88 | 0.94 | 3060 | 0.64 |
| 271+2731 | Iron and steel | 1.11 | 3.07 | 0.14 | 0.66 | -0.11 | -0.75 | 3.21 | 20.36 | -18.00 | -4.01 | 1.50 | 0.44 | 3060 | 0.65 |
| 272+2732 | Non-ferrous metals | 0.44 | 1.22 | 0.26 | 1.24 | 0.11 | 0.75 | 3.18 | 20.16 | -25.79 | -5.75 | 2.81 | 0.82 | 3060 | 0.61 |
| 28 | Fabricated metal products | 1.05 | 3.57 | 0.35 | 2.08 | 0.00 | -0.01 | 2.64 | 20.55 | -14.71 | -4.04 | -2.05 | -0.74 | 3060 | 0.66 |
| **29-33** | **Machinery and equipment** | 1.76 | 5.54 | 0.37 | 2.04 | 0.04 | 0.32 | 2.75 | 19.88 | -11.22 | -2.86 | -6.24 | -2.09 | 3060 | 0.68 |
| 29 | Machinery and equipment, n.e.c. | 1.54 | 5.03 | 0.30 | 1.72 | 0.04 | 0.28 | 2.53 | 19.04 | -11.33 | -3.00 | -6.80 | -2.35 | 3060 | 0.69 |
| 30-33 | Electrical and optical equipment | 1.84 | 5.90 | 0.38 | 2.14 | 0.02 | 0.18 | 2.78 | 20.50 | -12.28 | -3.19 | -10.88 | -3.70 | 3060 | 0.69 |
| 30 | Office, accounting and computing machinery | 1.31 | 4.07 | 0.42 | 2.28 | -0.06 | -0.46 | 2.78 | 19.93 | -9.96 | -2.51 | -5.58 | -1.85 | 3060 | 0.74 |
| 31 | Electrical machinery and apparatus, nec | 1.60 | 5.29 | 0.29 | 1.65 | 0.02 | 0.12 | 2.51 | 19.15 | -16.10 | -4.32 | -8.40 | -2.96 | 3060 | 0.68 |
| 32 | Radio, television and communication | 2.74 | 8.79 | 0.25 | 1.37 | -0.09 | -0.66 | 2.83 | 20.83 | -14.89 | -3.86 | -21.27 | -7.20 | 3060 | 0.72 |
| 33 | Medical, precision and optical instruments | 1.75 | 6.04 | 0.28 | 1.66 | 0.00 | -0.01 | 2.28 | 18.07 | -8.34 | -2.32 | -8.95 | -3.27 | 3060 | 0.72 |
| **34-35** | **Transport equipment** | 1.88 | 5.70 | 0.39 | 2.04 | -0.01 | -0.08 | 2.94 | 20.55 | -16.44 | -4.04 | -2.64 | -0.85 | 3060 | 0.70 |
| 34 | Motor vehicles, trailers and semi-trailers | 1.38 | 4.19 | 0.42 | 2.24 | 0.06 | 0.45 | 3.38 | 23.53 | -18.68 | -4.58 | -5.68 | -1.83 | 3060 | 0.72 |
| 35 | Other transport equipment | 2.15 | 6.19 | 0.33 | 1.67 | -0.06 | -0.45 | 2.01 | 13.30 | -19.82 | -4.62 | -12.29 | -3.77 | 3060 | 0.69 |
| 351 | Building and repairing of ships and boats | 1.27 | 2.29 | 0.95 | 3.01 | 0.36 | 1.58 | 0.94 | 3.89 | -29.45 | -4.31 | -5.97 | -1.15 | 3060 | 0.56 |
| 352+359 | Railroad equipment and transport equipment n.e.c. | 2.60 | 6.51 | 0.00 | -0.01 | -0.17 | -1.03 | 2.39 | 13.74 | -21.30 | -4.31 | -19.69 | -5.23 | 3060 | 0.68 |
| 353 | Aircraft and spacecraft | 2.05 | 4.44 | 0.25 | 0.95 | -0.05 | -0.25 | 2.37 | 11.80 | -19.02 | -3.33 | -11.29 | -2.59 | 3060 | 0.67 |
| **36-37** | **Manufacturing nec; recycling** | 1.15 | 3.83 | 0.40 | 2.33 | 0.05 | 0.36 | 2.44 | 18.63 | -10.63 | -2.86 | 1.57 | 0.55 | 3060 | 0.67 |
| **40-41** | **Electricity, gas and water supply** | 1.10 | 1.41 | 2.03 | 4.53 | -0.85 | -2.61 | 2.24 | 6.58 | -52.43 | -5.42 | -12.84 | -1.75 | 3060 | 0.24 |

*EMU2: dummy =1 if both are member of EMU, EMU1: dummy = 1 if one is member of EMU, C: constant, NOBS: number of observations, ARSQ: Adjustred R-squared.*

## Table 12: Sectoral results with value added and AFP

| ISIC SECTOR | INDUSTRY | $VA_i*AC_j$ | | $PP_i*PP_j$ | | EMU2 | | EMU1 | | EU | | AFP | | C | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | coeff. | t-stat | coeff. | t-stat | coeff. | t-stat | coeff. | t-stat | coeff. | t-stat | coeff. | t-stat | coeff. | t-stat | NOBS | ARSQ |
| **01-05** | **Agriculture, hunting, forestry and fishing** | 0.71 | 3.24 | -0.24 | -1.34 | -0.06 | -0.42 | -0.06 | -0.73 | 1.66 | 15.28 | -0.19 | -4.72 | -6.70 | -1.09 | 2704 | 0.68 |
| **10-14** | **Mining and quarrying** | -0.06 | -0.82 | -0.25 | -1.05 | -0.20 | -0.88 | 0.10 | 72.00 | 1.24 | 8.66 | -0.10 | -1.96 | 10.96 | 1.88 | 2070 | 0.64 |
| **15-16** | **Food products, beverages and tobacco** | 0.51 | 1.81 | -0.44 | -1.51 | 0.34 | 1.77 | 0.10 | 83.00 | 3.51 | 24.79 | -0.34 | -6.51 | 4.59 | 37.00 | 2596 | 0.63 |
| **17-19** | **Textiles, textile products, leather and footwear** | 0.13 | 1.11 | -0.98 | -4.90 | -0.16 | -0.84 | -0.23 | -1.74 | 2.64 | 19.43 | -0.33 | -6.82 | 36.36 | 5.89 | 2928 | 0.58 |
| **20** | **Wood and products of wood and cork** | 0.02 | 13.00 | 1.12 | 3.91 | 0.52 | 2.37 | 0.54 | 3.79 | 3.27 | 18.94 | -0.57 | -9.66 | -27.00 | -3.41 | 2315 | 0.63 |
| **21-22** | **Pulp, paper, paper products, printing and publishing** | 0.66 | 3.79 | -0.21 | -0.78 | 0.40 | 2.12 | 0.17 | 1.35 | 3.09 | 21.19 | -0.42 | -8.08 | -3.72 | -0.34 | 2687 | 0.66 |
| **23-25** | **Chemical, rubber, plastics and fuel products** | 1.20 | 8.02 | -0.31 | -1.12 | 0.41 | 2.27 | 0.23 | 1.97 | 2.76 | 18.72 | -0.38 | -7.43 | -18.27 | -1.73 | 2789 | 0.67 |
| 23 | Coke, refined petroleum products and nuclear fuel | 0.24 | 2.30 | -1.20 | -2.71 | -0.07 | -0.20 | 0.22 | 98.00 | 3.57 | 14.23 | -0.44 | -4.90 | 41.23 | 2.67 | 2074 | 0.60 |
| 24ex2423 | Chemicals and chemical products | 0.28 | 1.80 | -0.25 | -0.77 | 0.35 | 1.51 | 0.36 | 2.37 | 2.90 | 17.87 | -0.39 | -7.13 | 6.28 | 0.60 | 2305 | 0.67 |
| 24 | Pharmaceuticals | 0.71 | 4.25 | 0.04 | 0.13 | 0.48 | 2.48 | 0.47 | 3.73 | 2.79 | 18.78 | -0.39 | -7.64 | -13.75 | -1.80 | 2697 | 0.68 |
| 2423 | Chemicals excluding pharmaceuticals | 0.74 | 5.08 | 0.34 | 1.13 | 0.43 | 1.84 | 0.73 | 4.09 | 2.82 | 15.14 | -0.33 | -5.30 | -23.22 | -2.35 | 2266 | 0.65 |
| 25 | Rubber and plastics products | 3.01 | 13.79 | -1.55 | -6.30 | -0.13 | -0.78 | -0.29 | -2.46 | 2.54 | 17.81 | -0.25 | -5.20 | -37.26 | -4.68 | 2710 | 0.68 |
| **26** | **Other non-metallic mineral products** | 1.02 | 4.80 | -0.64 | -2.67 | -0.01 | -0.09 | -0.13 | -1.04 | 2.61 | 19.60 | -0.33 | -6.74 | 2.28 | 0.33 | 2868 | 0.63 |
| **27-28** | **Basic metals and fabricated metal products** | 0.96 | 4.70 | -0.78 | -2.93 | 0.02 | 0.10 | 0.02 | 0.13 | 3.18 | 21.52 | -0.38 | -7.54 | 7.32 | 0.81 | 2812 | 0.64 |
| 27 | Basic metals | 0.20 | 1.42 | -0.20 | -0.65 | 0.42 | 1.92 | 0.12 | 0.83 | 3.36 | 20.01 | -0.44 | -7.65 | 4.28 | 0.51 | 2255 | 0.64 |
| 271+2731 | Iron and steel | 0.82 | 6.14 | 0.19 | 0.61 | 0.09 | 0.31 | -0.05 | -0.26 | 2.73 | 14.47 | -0.47 | -6.87 | -13.95 | -1.69 | 1679 | 0.68 |
| 272+2732 | Non-ferrous metals | -0.44 | -2.00 | 0.13 | 0.47 | 0.48 | 1.83 | 0.30 | 1.59 | 3.72 | 16.03 | -0.66 | -7.96 | 18.23 | 2.16 | 1427 | 0.62 |
| 28 | Fabricated metal products | 1.45 | 6.17 | -0.99 | -3.88 | -0.08 | -0.45 | -0.12 | -0.93 | 2.73 | 17.48 | -0.36 | -7.01 | 2.92 | 0.48 | 2472 | 0.64 |
| **29-33** | **Machinery and equipment** | 0.69 | 3.40 | -0.08 | -0.31 | 0.34 | 1.71 | 0.31 | 2.41 | 2.95 | 19.80 | -0.36 | -7.02 | -6.89 | -0.76 | 2812 | 0.68 |
| 29 | Machinery and equipment, n.e.c. | -0.05 | -0.22 | 0.93 | 3.51 | 0.61 | 3.05 | 0.43 | 3.32 | 2.63 | 17.33 | -0.39 | -7.43 | -21.05 | -3.70 | 2542 | 0.68 |
| 30-33 | Electrical and optical equipment | 0.85 | 5.21 | -0.55 | -2.49 | 0.20 | 1.08 | 0.20 | 1.57 | 3.06 | 20.19 | -0.37 | -7.16 | 2.14 | 33.00 | 2712 | 0.69 |
| 30 | Office, accounting and computing machinery | -0.04 | -0.45 | 0.60 | 4.89 | 0.75 | 3.74 | 0.40 | 2.80 | 2.99 | 16.74 | -0.42 | -6.81 | -12.37 | -4.02 | 2075 | 0.73 |
| 31 | Electrical machinery and apparatus, nec | 2.37 | 10.65 | -0.52 | -2.00 | -0.34 | -1.79 | -0.19 | -1.39 | 2.71 | 15.93 | -0.26 | -4.75 | -48.98 | -5.20 | 2208 | 0.67 |
| 32 | Radio, television and communication | 0.34 | 2.53 | -0.10 | -0.52 | 0.47 | 2.33 | 0.43 | 2.80 | 3.61 | 18.36 | -0.41 | -7.02 | -3.58 | -0.65 | 2102 | 0.70 |
| 33 | Medical, precision and optical instruments | 0.57 | 2.20 | -1.31 | -5.41 | 0.17 | 0.77 | 0.33 | 1.97 | 3.14 | 15.61 | -0.38 | -5.63 | 28.48 | 3.62 | 1728 | 0.71 |
| **34-35** | **Transport equipment** | -0.10 | -0.88 | 1.51 | 5.63 | 0.94 | 4.62 | 0.56 | 3.99 | 3.05 | 19.36 | -0.45 | -7.63 | -30.81 | -3.73 | 2671 | 0.70 |
| 34 | Motor vehicles, trailers and semi-trailers | -0.31 | -2.87 | 1.32 | 5.74 | 0.77 | 3.24 | 0.54 | 3.68 | 3.33 | 19.76 | -0.38 | -6.37 | -20.31 | -2.72 | 2278 | 0.71 |
| 35 | Other transport equipment | 0.28 | 2.29 | 0.21 | 0.64 | 0.79 | 3.07 | 0.54 | 3.23 | 2.30 | 12.60 | -0.49 | -6.81 | -6.19 | -0.65 | 2088 | 0.66 |
| 351 | Building and repairing of ships and boats | 0.10 | 0.85 | -0.76 | -2.54 | 1.02 | 2.20 | 0.33 | 1.28 | 0.20 | 0.60 | -0.38 | -3.28 | 28.73 | 3.16 | 1275 | 0.62 |
| 352+359 | Railroad equipment and transport equipment n.e.c. | 0.31 | 2.13 | -0.03 | -0.13 | 0.26 | 1.00 | 0.27 | 1.61 | 1.35 | 6.77 | -0.29 | -4.26 | -0.75 | -0.13 | 1614 | 0.75 |
| 353 | Aircraft and spacecraft | 0.05 | 0.51 | -0.15 | -0.56 | 0.33 | 0.85 | 0.12 | 0.51 | 1.52 | 5.61 | -0.19 | -2.00 | -1.45 | -0.23 | 1213 | 0.70 |
| **36-37** | **Manufacturing nec; recycling** | 0.15 | 1.02 | 0.03 | 0.13 | 0.46 | 2.34 | 0.37 | 3.02 | 2.58 | 18.72 | -0.36 | -7.09 | -3.42 | -0.62 | 2755 | 0.67 |
| **40-41** | **Electricity, gas and water supply** | -0.70 | -0.68 | -2.63 | -2.93 | 1.05 | 1.64 | -1.86 | -4.36 | 3.00 | 5.80 | -0.36 | -2.09 | 71.47 | 2.37 | 2001 | 0.24 |

*VA: value added, AC: apparent consumption, PP: producer prices, EMU2: dummy =1 if both are member of EMU, EMU1: dummy = 1 if one is member of EMU, C: constant, NOBS: number of observations, ARSQ: Adjustred R-squared.*

# Table 13: Sectoral results with value added and AFP

| ISIC SECTOR | INDUSTRY | $GDP_i \cdot GDP_j$ | | EMU2 | | EMU1 | | EU | | AFP | | C | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | coeff. | t-stat | coeff. | t-stat | coeff. | t-stat | coeff. | t-stat | coeff. | t-stat | coeff. | t-stat | NOBS | ARSQ |
| **01-05** | **Agriculture, hunting, forestry and fishing** | 0.00 | -0.01 | 0.12 | 0.59 | 0.18 | 1.29 | 3.05 | 20.84 | -0.39 | -7.59 | 8.82 | 2.85 | 3060 | 0.60 |
| **10-14** | **Mining and quarrying** | 0.67 | 1.92 | -0.03 | -0.16 | 0.12 | 0.80 | 2.33 | 15.07 | -0.23 | -4.22 | 2.03 | 0.62 | 3060 | 0.61 |
| **15-16** | **Food products, beverages and tobacco** | 0.60 | 2.09 | 0.30 | 1.73 | 0.02 | 0.18 | 3.20 | 24.99 | -0.34 | -7.54 | 3.96 | 1.46 | 3060 | 0.63 |
| **17-19** | **Textiles, textile products, leather and footwear** | 0.41 | 1.33 | 0.19 | 1.03 | 0.05 | 0.41 | 2.66 | 19.71 | -0.34 | -7.10 | 4.40 | 1.54 | 3060 | 0.58 |
| **20** | **Wood and products of wood and cork** | 1.33 | 4.24 | 0.10 | 0.55 | -0.01 | -0.10 | 2.44 | 17.47 | -0.43 | -8.56 | -5.28 | -1.78 | 3060 | 0.63 |
| **21-22** | **Pulp, paper, paper products, printing and publishing** | 1.05 | 3.53 | 0.26 | 1.49 | 0.02 | 0.12 | 2.61 | 19.80 | -0.35 | -7.52 | -1.06 | -0.38 | 3060 | 0.67 |
| **23-25** | **Chemical, rubber, plastics and fuel products** | 1.42 | 4.66 | 0.16 | 0.89 | 0.08 | 0.65 | 2.66 | 19.61 | -0.35 | -7.35 | -2.77 | -0.96 | 3060 | 0.66 |
| 23 | Coke, refined petroleum products and nuclear fuel | -0.47 | -0.97 | 0.16 | 0.55 | 0.36 | 1.77 | 3.32 | 15.36 | -0.39 | -5.15 | 12.99 | 2.84 | 3060 | 0.59 |
| 24ex2423 | Chemicals and chemical products | 1.03 | 3.47 | 0.16 | 0.91 | 0.08 | 0.66 | 2.63 | 19.93 | -0.35 | -7.50 | -0.03 | -0.01 | 3060 | 0.69 |
| 24 | Pharmaceuticals | 1.54 | 5.13 | 0.11 | 0.62 | 0.08 | 0.67 | 2.61 | 19.55 | -0.36 | -7.67 | -4.28 | -1.51 | 3060 | 0.68 |
| 2423 | Chemicals excluding pharmaceuticals | 2.45 | 7.28 | 0.06 | 0.32 | 0.26 | 1.84 | 2.46 | 16.51 | -0.31 | -5.77 | -14.09 | -4.46 | 3060 | 0.66 |
| 25 | Rubber and plastics products | 1.04 | 3.53 | 0.24 | 1.39 | -0.01 | -0.08 | 2.67 | 20.49 | -0.35 | -7.46 | -1.50 | -0.54 | 3060 | 0.67 |
| **26** | **Other non-metallic mineral products** | 0.92 | 3.11 | 0.08 | 0.44 | -0.01 | -0.07 | 2.46 | 18.79 | -0.35 | -7.44 | -1.19 | -0.43 | 3060 | 0.63 |
| **27-28** | **Basic metals and fabricated metal products** | 0.91 | 2.99 | 0.10 | 0.55 | -0.02 | -0.16 | 3.08 | 22.89 | -0.35 | -7.43 | 1.03 | 0.36 | 3060 | 0.64 |
| 27 | Basic metals | 0.82 | 2.60 | 0.04 | 0.20 | -0.04 | -0.32 | 3.20 | 22.78 | -0.36 | -7.15 | 1.13 | 0.38 | 3060 | 0.64 |
| 271+2731 | Iron and steel | 1.28 | 3.61 | -0.07 | -0.34 | -0.15 | -1.01 | 3.22 | 20.48 | -0.34 | -6.06 | -4.39 | -1.32 | 3060 | 0.65 |
| 272+2732 | Non-ferrous metals | 0.73 | 2.06 | 0.03 | 0.16 | 0.05 | 0.31 | 3.20 | 20.34 | -0.37 | -6.62 | 1.09 | 0.33 | 3060 | 0.61 |
| 28 | Fabricated metal products | 1.14 | 3.99 | 0.12 | 0.73 | -0.02 | -0.17 | 2.63 | 20.70 | -0.36 | -8.06 | -2.20 | -0.82 | 3060 | 0.66 |
| **29-33** | **Machinery and equipment** | 1.80 | 5.82 | 0.16 | 0.85 | 0.04 | 0.27 | 2.74 | 19.95 | -0.34 | -7.01 | -5.06 | -1.74 | 3060 | 0.69 |
| 29 | Machinery and equipment, n.e.c. | 1.58 | 5.31 | 0.08 | 0.47 | 0.03 | 0.23 | 2.52 | 19.12 | -0.35 | -7.40 | -4.04 | -1.45 | 3060 | 0.69 |
| 30-33 | Electrical and optical equipment | 1.90 | 6.27 | 0.17 | 0.97 | 0.01 | 0.08 | 2.77 | 20.59 | -0.33 | -6.92 | -6.74 | -2.37 | 3060 | 0.70 |
| 30 | Office, accounting and computing machinery | 1.30 | 4.18 | 0.18 | 0.95 | -0.06 | -0.44 | 2.76 | 20.00 | -0.38 | -7.79 | -2.31 | -0.79 | 3060 | 0.74 |
| 31 | Electrical machinery and apparatus, nec | 1.73 | 5.89 | 0.08 | 0.46 | -0.01 | -0.12 | 2.51 | 19.28 | -0.33 | -7.14 | -7.35 | -2.67 | 3060 | 0.68 |
| 32 | Radio, television and communication | 2.84 | 9.37 | 0.03 | 0.15 | -0.11 | -0.84 | 2.82 | 20.96 | -0.35 | -7.33 | -17.13 | -6.01 | 3060 | 0.73 |
| 33 | Medical, precision and optical instruments | 1.76 | 6.24 | 0.09 | 0.55 | 0.00 | -0.01 | 2.27 | 18.11 | -0.29 | -6.51 | -6.71 | -2.53 | 3060 | 0.73 |
| **34-35** | **Transport equipment** | 2.00 | 6.24 | 0.16 | 0.82 | -0.04 | -0.28 | 2.94 | 20.69 | -0.37 | -7.24 | -7.95 | -2.64 | 3060 | 0.71 |
| 34 | Motor vehicles, trailers and semi-trailers | 1.55 | 4.83 | 0.21 | 1.08 | 0.02 | 0.17 | 3.38 | 23.70 | -0.35 | -6.93 | -5.23 | -1.73 | 3060 | 0.72 |
| 35 | Other transport equipment | 2.32 | 6.87 | 0.09 | 0.45 | -0.10 | -0.73 | 2.01 | 13.41 | -0.39 | -7.35 | -11.53 | -3.64 | 3060 | 0.69 |
| 351 | Building and repairing of ships and boats | 1.58 | 2.94 | 0.68 | 2.13 | 0.29 | 1.26 | 0.96 | 3.99 | -0.44 | 5.20 | -11.36 | 2.24 | 3060 | 0.56 |
| 352+359 | Railroad equipment and transport equipment n.e.c. | 2.76 | 7.11 | -0.29 | -1.26 | -0.21 | -1.26 | 2.39 | 13.83 | -0.46 | -7.54 | -19.96 | -5.47 | 3060 | 0.68 |
| 353 | Aircraft and spacecraft | 2.27 | 5.02 | 0.09 | 0.34 | -0.10 | -0.52 | 2.38 | 11.89 | -0.26 | -3.72 | -9.64 | -2.27 | 3060 | 0.67 |
| **36-37** | **Manufacturing nec; recycling** | 1.18 | 4.03 | 0.18 | 1.06 | 0.04 | 0.34 | 2.43 | 18.70 | -0.35 | -7.49 | -2.47 | -0.90 | 3060 | 0.67 |
| **40-41** | **Electricity, gas and water supply** | 1.91 | 2.49 | 1.87 | 4.09 | -1.04 | -3.21 | 2.33 | 6.82 | -0.30 | -2.46 | -25.62 | -3.55 | 3060 | 0.23 |

*EMU2: dummy =1 if both are member of EMU, EMU1: dummy = 1 if one is member of EMU, C: constant, NOBS: number of observations, ARSQ: Adjustred R-squared.*

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