Graduate Institute of
International Studies | Geneva
Economics

HEI Working Paper No: 10/2006

Explaining the Euro's Effect on Trade? Interest Rates in an Augmented Gravity Equation

Tommaso Mancini-Griffoli
Graduate Institute of International Studies

Abstract

If the Euro has boosted intra Euro-Area trade, what exactly in the new currency is responsible for such an effect? Most explanations focus on a decrease in exchange rate volatility or in transaction costs, receiving mixed empirical support. After briefly surveying the relevant literature, this paper points to a novel channel of transmission: the sharp decrease in real interest rates that accompanied the Euro. The argument is that lower interest rates spurred investment spending and manufacturing value added, as in Flam and Helpman (1987), and induced a greater number for firms to enter the export market, ultimately boosting trade. This phenomenon is captured in a simple model with fixed costs, where the number of firms or varieties supported in a market is endogenous. The model is used to augment the traditional trade gravity equation. In the end, empirical results are presented in support of the interest rate's role at explaining the ``Rose effect''.

Explaining the Euro's Effect on Trade? Interest Rates in an Augmented Gravity Equation*

Tommaso Mancini-Griffoli†

This draft: May 2006
Comments welcome.

Abstract

If the Euro has boosted intra Euro-Area trade, what exactly in the new currency is responsible for such an effect? Most explanations focus on a decrease in exchange rate volatility or in transaction costs, receiving mixed empirical support. After briefly surveying the relevant literature, this paper points to a novel channel of transmission: the sharp decrease in real interest rates that accompanied the Euro. The argument is that lower interest rates spurred investment spending and manufacturing value added, as in Flam and Helpman (1987), and induced a greater number for firms to enter the export market, ultimately boosting trade. This phenomenon is captured in a simple model with fixed costs, where the number of firms or varieties supported in a market is endogenous. The model is used to augment the traditional trade gravity equation. In the end, empirical results are presented in support of the interest rate's role at explaining the "Rose effect".

Keywords: Gravity equation, International Trade, Common Currency, Instability tests in Panel data, Euro Area.

JEL Codes: F1, F4, C23, C52

*I would like to thank first and foremost Richard Baldwin for invaluable feedback, insights and detailed comments. Sincere thanks also to Sergio Rebelo for inspiration. I am also indebted to Hans Genberg, Ivan Jaccard, Laurent Pauwels and Federico Trionfetti for their comments and encouragements. Thanks finally to conference participants at ModSim '05 (Melbourne), and CEPII '06 (Geneva). All remaining errors are of course mine.

†Graduate Institute of International Studies, Geneva. Avenue de la Paix 11A, 1202 Genève. Correspondence: mancini1@hei.unige.ch.

1 Introduction

Whether or not there has been a break in trade among Euro-Area countries after the adoption of the Euro, and, if so, what is responsible for it, remains a puzzle. Yet, it is a particularly interesting puzzle; one worth trying to solve. In the policy world, debates in accession countries often center around the expansionary effects of a common currency. In the academic realm, the recent adoption of the Euro is perceived by many as a natural experiment to test the famous hypothesis in Rose (2000) that a common currency increases trade by a formidable factor, all other things equal.

On the empirical side, papers that have tackled the issue have left the door open for more conclusive research. Most papers find a trade effect, but their conclusions are weakened by imprecise econometric techniques, rooted in test statistics whose asymptotic properties cannot be supported by the very few data-points available after the Euro's introduction. Mancini-Griffoli and Pauwels (2006) propose a more rigorous procedure, based on a formal end of sample test for panel data, building a distribution for the test statistic using parametric subsampling techniques. That paper generally corroborates the findings in the literature by rejecting the null of stability in trade between Euro-Area countries at the 10 - 1% level. Yet, the break seems to be short-lasting, spanning only 10 quarters (2.5 years) after its emergence in 1999 Q1.

But if a break does exist, what is really responsible for the increase in trade? What is the channel linking a common currency to export activity? The test in Mancini-Griffoli and Pauwels (2006) is a residual based test, leading to a rejection of the null hypothesis of coefficient stability if the post-break errors are especially large under the null. Thus, the conclusion that a break exists may be the result of running the gravity regression on a mis-specified model. This begs the question: what other variables, if any, should be part of the regression and do these help explain the break? Mancini-Griffoli and Pauwels (2006) take a first step in exploring an augmented gravity specification. The paper expands the regression model to include a term capturing political and institutional integration among Euro-Area countries. This follows the argument advanced by Nitsch (2002) and Nitsch and Berger (2005). Indeed, when controlling for this factor, there no longer exists evidence of a break in trade.

Although a promising explanation, the political and institutional integration story is limited in three main ways. First, the break in trade is found around 1999 Q1, while European integration received a significant boost in 1992 with the signing of the Maastricht treaty. Time to build lags and a ramping up of the ratification and integration process may account for the difference, but timing is still somewhat questionable. Second, the break appears short-lasting, while political and institutional integration is instead a long-lasting and relatively smooth process. At least, the process in Europe suffered no major setbacks in the 2001-2002 timeframe, when the break in trade seems to vanish. Third, the series for political and institutional integration, although borrowed from Berger Nitsch and developed with care, remains subjective and difficult to cross check. Given these hesitations, it is therefore still worth looking for other candidate explanations for the break in trade.

This paper points to a novel explanation based on real interest rates. From an empirical standpoint, the explanation seems promising. Real interest rates decreased substantially across Euro-Area countries, as a precondition and result of the Euro's introduction. Furthermore, their downward trend was short-lasting, while even exhibiting an upward correction in the 2001-2002 timeframe. Furthermore, as this paper will show, real interest rates seem to be correlated to trade with a significant and negative coefficient over the last twenty five years in Europe. Thus, real interest rates may be the missing variable in the gravity regression, or the link between the Euro and the perceived rise in trade.

This paper builds a simple model to explain this link and thereby provides microfoundations for an augmented gravity equation. The model is centered on endogenous firm entry, responding to a fixed cost of entry dependent on interest rates. The model fits with a story that firms must borrow funds at the ongoing real interest rate to set up or expand a costly export business, or with the explanation that exporting requires investment in capital whose rental cost depends on the real interest rate. Either way, the model shows that as interest rates decrease, more firms enter the market for exports, while increasing investment spending and ultimately boosting trade. A key factor in this model is the assumption that interest rates are set exogenously, as in Flam and Helpman (1987), or as is typical in a small open economy. The model remains simple, drawing its inspiration from Chatterjee and Cooper (1993), and, easily lends itself to provide an augmented gravity equation to test for a break in Euro-Area trade.

This paper is organized as follows. Section 2 offers a relatively detailed review of the literature on the microfoundations for gravity equations, as well as on explanations commonly given for the link between a common currency and trade. The section ends with a brief reference to papers emphasizing the role of fixed entry costs in trade fluctuations and hinting specifically at the effect of interest rates. Section 3 focusses on empirical evidence, discussing recent trends in Euro-Area interest rates and substantiating the link between interest rates and trade. Section 4 then introduces the model discussed above, ending with an augmented gravity equation. Section 5 tests this equation and concludes that, indeed, evidence for a break in trade disappears when controlling for interest rates. Finally, section 6 concludes.

2 Inspiration from the literature

2.1 Traditional microfoundations for the gravity equation

It is surprising that the gravity equation was so extensively used in empirical work without any allusion to rigorous microfoundations until the work of Anderson and van Wincoop in 2003. Maybe gravity regressions fit the data so well that researchers did not see the value of digging for foundations. Yet, Baldwin (2006) shows that the exercise of anchoring the gravity equation in a theoretical model is instructive: among other benefits, it helps emphasizes the limitations and errors evident in much of the early empirical literature.[1]

Anderson and van Wincoop (2003) were the first to explicitly build a microfounded model for the gravity equation in a simple and elegant paper[2]. They begin with a CES demand function for the sale of goods from country i to country j. But their equation involves the unobservable price p_i of the homogeneous good sold from country i. To overcome this hurdle, they consider an additional equation to substitute for p_i: the market clearing equation which captures the fact that country i's output is the sum of the sale of country i's goods to all trading partners, including itself. After substituting for p_i they find an updated demand function which they call their gravity equation:

$$x_{i,j} = \frac{y_i y_j}{y^w} \left(\frac{\tau_{i,j}}{P_i P_j} \right)^{1-\sigma} \tag{1}$$

where $x_{i,j}$ is the demand for country i's goods in country j (equivalently the export of country i to country j), y are domestic GDP, y^w is the sum of all countries' GDP, $\tau_{i,j}$ is the cost of trade between countries i and j, σ is the elasticity of substitution between goods consumed in country j (assumed symmetric across countries) and P is an index, defined as:

$$P_j^{1-\sigma} = \sum_i^K P_i^{\sigma-1} \frac{y_i}{y^w} \tau_{ij}^{1-\sigma}$$

where K is the number of trading partners.

Anderson and van Wincoop (2003) call this price index the "multilateral trade resistance term", as it captures a sort of average trade barrier between country j and all its trading partners. Importantly, the above equations show that for a given bilateral trade barrier between i and j, given by $\tau_{i,j}$, the higher is country j's multilateral trade resistance term, the lower will

[1] Baldwin (2006) gives an illuminating overview of the literature's main findings, hypotheses and notably mistakes - "gold, silver and bronze medals" - that are typically found.

[2] Other, more recent, papers offer variations of the gravity specifications, such as Redding and Venables (2004).

be relative prices from country i and thus the higher will be imports from country i.

Indeed, the intuition inherent in the "multilateral trade resistance" term comes from considering trade costs in relative terms. As Baldwin (2006) points out, a naive gravity equation would predict very low trade between New Zealand and Australia, for instance, due to the considerable distance that separates these two countries. Yet, in relative terms, this distance is merely a fraction of that separating the two countries from their other trading partners. Thus, a gravity equation taking relative prices into account fits the data much more accurately.[3]

In constructing microfoundations, Anderson and van Wincoop (2003) therefore not only provided a more tractable model, but also brought new variables to the forefront of the debate. Indeed, *relative* GDP and prices had been overlooked in prior empirical work, a fact that Baldwin (2006) qualifies as the "gold medal error" of the early Rose (2000) legacy. Appropriately, the Anderson and van Wincoop (2003) paper immediately gave rise to the notable contributions of Rose and van Wincoop (2001) and Anderson and van Wincoop (2001)[4], each re-estimating the effects of a common currency on trade using relative measures of prices and GDP. The first paper essentially correcting Rose's (2000) seminal contribution, and the second focussing on the role of borders on trade. In both cases, though, a substantial trade effect persists.

2.2 What in a common currency could cause the break in trade?

Anderson and van Wincoop's (2003) model significantly modernized gravity estimations, yet, in its final form, the regression equation remains too bare to accurately pin-point the causality linking a common currency to trade. The most widely cited reasons for this link are twofold: (i) eliminated exchange rate volatility, and (ii) eradicated currency related transaction costs. Note that the argument advanced by Nitsch (2002) and Nitsch and Berger (2005), discussed in this paper's introduction, regarding the importance of institutional and political integration, is separate and can even be seen as independent of the adoption of a common currency. Of the two channels pointed out above, the second is likely to be the weakest, especially among the relatively well-functionning European capital markets, yet is arguably the only one captured by the gravity equation of Anderson and van Wincoop

[3]See Baldwin (2006) for a simplified derivation of the Anderson and van Wincoop gravity equation and an extensive discussion of the intuition behind their model.

[4]The dates on these papers may appear anachronistic, but the Anderson and van Wincoop (2003) paper appeared several years earlier as a working paper and immediately became influential.

(2003), specifically by the trade cost term $\tau_{i,j}$.[5]

A large literature has developed around the first channel, that of currency volatility or risk, and trade. The most notable theoretical contribution linking this channel to the gravity model is Bacchetta and van Wincoop (2000). This paper presents a general equilibrium model of trade rooted in a CES demand-gravity equation to evaluate the long debated question of the effects of currency volatility on trade.[6] Appropriately, their conclusions summarize the findings inherent in the older literature - both theoretical and empirical: the effect of lower exchange rate volatility on trade is ambiguous. An extensive review of the empirical literature can be found in Cote (1994), McKenzie (2000), H.M. Treasury (2003) and IMF (2004). The general verdict is that some papers find a positive effect, although weak, while most find no significant or consistent effect. To a certain extent, results seem to hinge on the particular definition of volatility.

From a theoretical perspective, the general equilibrium framework is especially useful to explain this ambiguity. Traditional wisdom has it that a currency appreciation will lead to lower exports, as domestic goods become more expensive abroad. But variations in exchange rates are often accompanied by changes in macro-economic factors that can have counter-balacing effects on trade. For instance, Bacchetta and van Wincoop (2000) suggest that a country's exchange rate appreciation with respect to one of its trading partners has a negative impact on exports through relative prices. Yet, if the appreciation is driven by a monetary expansion abroad, it could be coupled by an increase in import demand from the foreign country.

The opposing forces pointed out in Bacchetta and van Wincoop (2000) are especially true if the degree of pricing to market is high, since the usual expenditure switching channel will be under-utilized. In fact, the literature on limited passthrough, or pricing to market, offers further support for the murky relationship between currency movements and trade.[7] Indeed, when passthrough is low, a monetary expansion, although inducing a depreciation of the currency, can lead to improvements in terms of trade. Relative list prices do not change, but the home country will make more money in terms of domestic currency from the sale of its exports (once it repatriates revenues made in the appreciated foreign currency). This will naturally have "prosper-thy-self" effects, and possibly "prosper-the-neighbor" repercussions as well, since higher domestic revenues will translate in greater imports.

[5]And even then, the argument is weak, as transaction costs due to the conversion and accounting of multiple currencies is likely to be a fixed cost, not a variable cost as is $\tau_{i,j}$.

[6]Other papers mainly consider a partial equilibrium analysis, such as Obstfeld and Rogoff (1998).

[7]See, for instance, Betts and Devreux (2000) for a theoretical model of pricing to market and Campa and Goldberg (2002, 2005) or Gagnon and Ihrig (2004) for empirical estimates of the degree of pass-through for the US economy.

Partial equilibrium papers also offer a slew of explanations for why exchange rate volatility may not always hurt trade: firms can hedge using financial instruments, firms selling in multiple countries benefit from a natural hedge when currencies move in opposite direction, firms benefit from some offset of exchange rate movements by importing intermediate products from countries to which they export and finally time may offer a natural hedge, as exchange rate volatility can bring both painful appreciations and helpful depreciations over a medium term horizon.[8]

The only remaining argument for the link between exchange rate changes and trade would be that merely reducing volatility does not impact trade, but eradicating potential spikes in volatility makes a big difference. Such non-linearity (non-differentiability) would arise if it were the threat of a large and sudden currency crisis or major re-alignment that hampered trade, and not higher frequency movements. In this case, only the adoption of a common currency would credibly avoid this risk. We acknowledge this argument (which is relatively rare in the literature), although do not pursue it further given the extreme difficulty of testing it, as agents' expectations of future re-alignments are not revealed. None-the-less, the general equilibrium arguments advanced above still hold, even in the face of one-time and large currency movements, suggesting that risk of re-alignment should not impact trade significantly.

Thus, the first channel linking a common currency and trade, namely exchange rate volatility, remains relatively weak. We therefore leave aside the task of augmenting the basic Anderson and van Wincoop (2003) gravity equation with a model of exchange rate volatility.

2.3 The recent literature: fixed costs and interest rates

In our search for another channel linking a common currency to trade, and for an augmented gravity equation to test it against the break in Euro-Area trade, we find hints in the recent trade literature, emphasizing the effects of fixed entry costs.

On the empirical side, two papers are particularly worth noting: Bernard and Jensen (2004) and Eaton, Kortum and Kramarz (2004). Both papers look in details at firm level trade data and epitomize the growing body of micro-level empirical trade studies that have emerged recently. Their conclusions took the field by surprise: a large portion of trade fluctuations seems to come from the entry (or exit) of new firms in the export business.

[8] If anything, another strand of papers hints that the correlation between trade fluctuations and currency volatility ought to be low, without referring to effects on trade volume, though. Papers like Franke (1991) and Sercu and Vanhulle (1992), forecast greater inertia of firm entry into, and exit from, the export market due to the correlation of the option value of waiting to make a move with currency volatility. This idea finds its roots in Dixit and Pindyck (1982)

Within-sector firm reallocations, the so called “extensive margin” resulting from both entry and exit, had been overlooked until recently as a major driver of trade.

Baldwin and Taglioni (2004), in particular, use these facts as a spring board for their microfounded model of a common currency’s effect on trade, which stands as one of the very few, yet extremely useful, efforts to grasp exactly *what* in a common currency could affect trade. They postulate that as exchange rate volatility decreases, small and medium sized firms that did not have the means of protecting themselves on financial markets will start exporting, thus accounting for the sudden increase in trade following the adoption of a common currency. We will stray away from this model’s emphasis on exchange rate volatility, for the reasons mentioned earlier, but will retain the fundamental notion that the endogenously determined number of exporting firms, dependent on a fixed entry cost, is a key variable explaining trade patterns. Baldwin (2006) makes the same remark, suggesting that of the variables entering the gravity equation, a rise in n, the number of exporting firms in a given country, is likely to be the key to explain trade creation.

A recent strand of the trade literature (commonly referred to as the “new, new trade theory”) initiated by the seminal work of Marc Melitz (2003) and Bernard, Eaton, Jensen and Kortum (2003), places substantial emphasis on fixed trade costs. This feature, in addition to the assumption of firm heterogeneity, endogenously determines aggregate productivity, price, output and most importantly, the number of firms able to engage in trade. In these models, a firm considering entry evaluates its expected flow of profits over the uncertain realization of its productivity against its fixed entry costs. The decision to enter a market - based on a net present value calculation - is therefore explicitly akin to an investment decision. Consequently, interest rates play an important role in discounting future profits. But even if the model in Melitz (2003) has been used as a basis to specify gravity-type equations of trade (see Helpman, Melitz, Rubinstein (2004)), the particular effect of interest rates has so far not been emphasized.

But interest rates do not just enter the story on the side of expected profits. In fact, interest rates are also intimately tied to the fixed costs of entering the export market or expanding one’s foreign operations. These costs typically include having to adapt one’s products to foreign specifications, enlarge a plant, open an assembly line abroad, engage in R&D, undertake market research, or possibly hire a foreign workforce. To finance these costs, firms generally borrow the funds at the ongoing interest rate and compare these financing costs to the net present value of profits of their new project. Another way to see the link between entry costs and interest rates is to view the requirements to enter, or expand operations in, the export market as dependent on capital expenditures. Indeed, logistics, production, product adaptations or just maintaining an office abroad are all capital intensive activities, for which the relevant cost is the interest rate.

The model presented later in this paper will in fact choose the latter approach, namely of emphasizing the link between entry costs and interest rates through capital expenditures. First, this assumption engenders the most straightforward model and offers the most direct mapping to an augmented gravity equation. Indeed, considering a corporate bond market to capture the borrowing of firms would introduce issues of risk aversion and market completeness, while future profits rest on expectations of interest rate movements. But in fact, focussing on the net present value of profits or entry costs ends up being the same from the firm's point of view. The ratio of the two can be seen as representing Tobin's q. So independently of which moves with interest rates, as long as the ratio increases, firms decide to enter the export market, thereby making the two modeling approaches isomorphic. But, actually, it may be more sensible to focus on entry costs, since expected profits are hard to measure and are usually expressed with a large fork. Instead, costs of entry are much more tangible and immediate to firm managers and thus more likely to be sensitive to changes in interest rates.

The close link between the cost of entry and the number of firms in a market resonates with a related IO literature, surprisingly absent from the references in the "new, new trade" papers. In his book *Sunk Costs and Market Structure* (1991), John Sutton focusses, in part, on the role of exogenous sunk costs in determining industry concentration.[9] He very clearly lays out a theory by which concentration, or the number of firms in a given industry, is a positive function of market size and a negative function of set-up, or sunk, costs. This relationship fits industries where goods are homogeneous or horizontally differentiated (as in Shaked and Sutton, 1987) and is supported by a very comprehensive set of case studies.

3 Evidence in favor of interest rates

The above considerations suggest that it may indeed be reasonable to build a model linking interest rates to fixed entry costs, and, in turn, to trade movements through the number of exporting firms. But before proceeding to build a theoretical model, it is important to check if the relationship holds empirically. In particular, could interest rates be the missing variable in the baseline trade regression model of Mancini-Griffoli and Pauwels (2006)? For a variable to explain the break in trade, it must exhibit a noticeable movement across all Euro-Area countries during the time of the break and must be correlated to trade. We investigate both aspects in turn.

[9]The most relevant chapters are 2, 5, 6 and 7.

3.1 The path of interest rates

Because of the various convergence criteria to enter a monetary union, real interest rates in the Euro-Area have not been stationary over the last ten years, as would otherwise be expected. In particular, there has been a marked decrease and convergence in interest rates among the eventual Euro-Area countries starting around 1996.

Figure 1 shows how Euro-Area average real interest rates (over six quarters) were relatively stable (just below 10%) until about 1996, when a noticeable downward trend began.[10] In four years, real interest rates lost about 600 basis points, and four years later, after a further 200 basis point decrease, were at their lowest, around 2%. Note that *a posteriori*, it may seem like interest rates have been decreasing steadily since 1982, with a large correction between 1988 and 1996. But during the cycle, it must not have been clear that interest rates were going to move below their historical average of about 10% until about 1996. Figure 2 corroborates this finding by showing how year-on-year growth in average interest rates hovered slightly below zero until about 1996, after which it remained decisively negative, in the ballpark of -10% or more.

The decrease in real interest rates were a product of the convergence criteria for the Euro, but also probably of more solidly anchored inflation expectations following the transfer of power to the ECB, away from the national banks whose reputation for independence suffered throughout the 80s and early 90s, in many cases. The temptation for central banks to use monetary policy to favor short term growth for the convenience of succeeding governments was going to be eradicated.

Thus, the significant, ongoing and believable decrease in real interest rates that marked Euro-Area countries was the result of deep macro-economic transformations which we hypothesize had a structural impact on a wide range of activities, including trade.

3.2 The correlation between interest rates and trade

The link between interest rates and trade can be tested empirically. Because interest rates as well as the value of trade exhibit unit roots[11], we use the DOLS procedure for our regression to obtain non-biased coefficients and correct standard errors.[12] We refer to model A as the baseline model in Mancini-Griffoli and Pauwels (2006) for comparison, and to model C as a

[10]The average of six quarters is used in line with the structural break tests done later, although robustness of these results is checked by using different lag structures of interest rates.

[11]More details on this feature are presented later when discussing the structural break test.

[12]See Baltagi and Kao (2000) for more details, or appendix A for an overview of the DOLS procedure.

regression equation containing the standard output and real exchange rate variables, as in model A, as well as interest rates and wages. The latter is included for reasons that will become apparent only after the introduction of our model, but for now, it can be seen as controlling for another factor price, mirroring the introduction of interest rates in the regression. Note that interest rates enter as an average of six, four and two quarters, to reflect the fact that firms making decisions on the basis of interest rates will respond to trends, or averages, rather than spot rates.

Our results for the DOLS regressions are illustrated in table 7. The coefficients and signs on the long run cointegrated variables appear as expected and match those found in similar studies in the relevant literature. The coefficient on GDP (both domestic and foreign) is positive and significant. That on real exchange rates is negative (a depreciation causes a decrease in imports), but hardly significant (as in Micco, Ordoñez and Stein, 2003). Average interest rates appear as negative and significant, with a rather small magnitidue (indicating a realistic relationship between interest rates and trade: a decrease of 1% in interest rates increase trade by 0.07-0.1%). It is also encouraging to see that the inclusion of interest rates does not markedly change the coefficients on GDP, thereby underscoring that there do not seem to be problems of multicollinearity among our regressors, or alternatively that interest rates affect trade through a channel other than just consumption tilting. The only surprise at first glance is the magnitude and significance level of wages. But these can be attributed to the high degree of correlation between wages and trade, both smooth, upward sloping series.

Table 8 reports coefficients from the error correction model. The coefficients are as expected in terms of magnitude and sign, mainly corroborating the above results. This time, changes in wages now appear to have a more realistic magnitude, and are no longer significant. This is rather expected as there has been very little high frequency variation in real wages within the EU in the last twenty years. More importantly, average interest rates again exhibit a negative sign and realistic proportions. Note that the t-stats are reported for indicative purposes only, as they do not feature robust standard errors (unlike those in the DOLS procedure that explicitly corrects for cointegrated variables).

Thus, empirical evidence suggests that interest rates are a prime candidate to explain the link between a common currency and trade, given both the significant and wide-ranging movement in interest rates around the time of the Euro's introduction, and the correlation existing between interest rates and trade.

4 The model

4.1 Intuition, setup and summary

The purpose of building a model linking interest rates to trade is twofold. First, it is to crystalize an explanation for the empirical regularities noted above, and capture some of the key features noted earlier in the literature review, namely the importance of fixed production costs depending on interest rates. The second goal is to serve as microfoundations for an augmented gravity equation, similar to that in Anderson and van Wincoop (2003) or any of the prominent studies testing for a common currency effect (see Baldwin, 2006, for a literature review). We therefore aim for a class of models simple enough to translate easily into a gravity equation when linearized. To do so, we draw inspiration mainly from Chatterjee and Cooper (1993), instead of the more recent Ghironi and Melitz (2004), or Bilbiie, Ghironi and Melitz (2005).[13] The two sets of papers share many of the same features, but the latter introduces dynamics, by considering a time to build lag after investment takes place, as well as a one-time sunk cost. As our goal is to find guidance for empirical testing, and not numerical simulation, we draw inspiration essentially from the former model, assuming frictionless and immediate entry, as well as period-by-period fixed costs, as if the entry decision had to be renewed every period.[14]

The other key ingredients to the model are the following. We assume that all firms are homogenous and engage in trade. We will be concerned with the number of firms in the trade business, and simply assume that incoming firms are drawn from a pool of existing, potential entrants. Furthermore, the period-by-period fixed cost that firms have to pay to remain in the export market absorb both labor and capital from the economy; the latter is essential to link entry costs to interest rates, as discussed in the earlier literature review. Importantly, we consider interest rates to be exogenous, while capital is endogenous and supplied perfectly elastically, as in Flam and Helpman (1987) or as is typical in a small open economy.[15] Labor,

[13]Devreux, Head and Lapham (1996a,b) develop models similar to those in Chatterjee and Cooper (1993). These papers were written at a time when monopolistic competition was being introduced in macro-economics; the papers' primary goal was to study how market power in product markets affected the response of the economy to exogenous shocks (mainly productivity). I am thankful to Rebelo (2002) for a refreshingly clear introduction to these class of models. Some of the notation that follows is drawn from Rebelo (2002).

[14]It is interesting to note that in their conclusion, Chatterjee and Cooper suggest that "one extension... would be to add a lag in the entry process... [and] a specification in which there is a fixed cost of entry separate from the fixed cost of production", as if foreshadowing exactly what would come about ten years later in the dynamic models stemming from Melitz (2003).

[15]This assumption is all the more realistic in our case, as a decrease in real interest rates was dictated as one of the accession criteria to the Euro.

instead, is fixed and is assumed to be supplied with a vertical schedule; we thus assume full employment. Finally, the number of firms is endogenous and satisfies, each period, a free entry condition such that profits are zero. Note that this condition is similar to that in Ghironi and Melitz (2004), but since we consider period-by-period fixed costs, the free entry condition equates current profits to current fixed costs, instead of the net present value of future profits; this feature greatly simplifies our analysis.

In a nutshell, as interest rates diminish, fixed costs decline, more firms are able to enter the market, and all firms increase capital investment, two forces that boost total exports. Behind the scene, several features are at play: as interest rates decrease, lower market access costs increase the equilibrium number of firms in the market. Also, firms substitute capital for labor in production, thus freeing up workers to serve the newly entering firms. In the aggregate, labor will have remained fixed, but capital will have increased, thus assuring that total output, or trade, also increases.

Note that changes in interest rates would play a much more secondary role in traditional models of trade without fixed costs, where changes in factor prices would only have marginal effects on firms' production decisions. In such models, lower interest rates would favor capital intensive firms (presumably producing more differentiated goods), thus increasing intra-industry trade, but only marginally. On the contrary, the introduction of fixed costs has the hope of magnifying the effects of interest rates through market entry or exit.

4.2 The model

We begin, as in Anderson and van Wincoop (2003), with the usual CES demand equation, which, for simplicity, we present for the aggregate consumption in country i of varieties imported from country j:

$$C_{i,j,t} = \left(\int_0^{n_{j,t}} x_{i,j,t}^{1/\sigma} di \right)^{\sigma}$$

where σ is the elasticity of substitution between varieties[16] and $n_{j,t}$ is the number of active firms in country j (equivalently the number of differentiated varieties). For simplicity, we drop the time subscripts in the derivations below.

This gives rise to the usual demand for each variety of country j in country i, given by:

$$x_{i,j} = \left(\frac{p_{i,j}}{P_i} \right)^{\frac{\sigma}{1-\sigma}} C_i$$

We also report the equivalent equation in values, which will be more useful to us in the our empirical work. We simply remark that the value of

[16] $\sigma > 1$, and the more σ is away from 1, the more the goods are differentiated, or imperfect substitutes.

trade for a given variety from country j to i, called $v_{i,j}$, is $x_{i,j} \cdot p_{i,j}$. Thus, we write:

$$v_{i,j} = \left(\frac{p_{i,j}}{P_i}\right)^{\frac{1}{1-\sigma}} Y_i$$

where $Y_i = P_i C_i$, where P_i is the aggregate price index defined later.

Furthermore, we assume the standard full pass-through pricing condition as well as PPP, such that:

$$p_{i,j} = p_j \tau_{i,j} \frac{1}{\epsilon_{i,j}} \tag{2}$$

where $\epsilon_{i,j}$ is the nominal exchange rate between countries i and j specified as the price in j's currency of one unit of i's currency.

Finally, assuming that firms are homogenous in production technology, aggregate demand (in value terms) for country j's varieties in country i, $V_{i,j}$, is $n_j \cdot v_{i,j}$, where n_j is the number of varieties or firms in country j. This relation gives rise to the following basic demand equation (or equation determining exports of country j's varieties to country i):

$$V_{i,j} = n_j \left(\frac{p_j \tau_{i,j} \frac{1}{\epsilon_{i,j}}}{P_i}\right)^{\frac{1}{1-\sigma}} Y_i \tag{3}$$

The remainder of the model will mostly aim to determine n_j and in particular link n_j to R_j, the real interest rate in country j. This procedure resembles the approach in Baldwin (2006) when outlining the microfoundations of Flam and Nordström's (2003) gravity specification. Indeed, Baldwin (2006) solves for the number of exporting firms as a function of real GDP then plugs this result back into the CES demand equation.

Firms' production function can be summarized by a Cobb-Douglas equation:

$$x_j = A(K_j - \bar{K})^{1-\gamma}(L_j - \bar{L})^{\gamma} \tag{4}$$

where $\bar{K}$ and $\bar{L}$ are the fixed costs needed to operate; as specified earlier, these act like an overhead by deviating resources away from production, similarly to Ghironi and Melitz (2004) or Bilbiie, Ghironi and Melitz (2005) who define entry costs as a function of labor.

Straightforward cost minimization subject to the production of amount x_j, the wage rate w_j and the interest rate R_j, yields the optimal utilization of capital and labor:

$$K_j = \bar{K} + \frac{(R_j/w_j)^{-\gamma}(\gamma/(1-\gamma))^{-\gamma}}{A} x_j \tag{5}$$

and

$$L_j = \bar{L} + \frac{(R_j/w_j)^{1-\gamma}(\gamma/(1-\gamma))^{1-\gamma}}{A} x_j \tag{6}$$

In turn, this yields the following non-homogeneous cost function:

$$TC(x_j, w_j, R_j) = R_j \bar{K} + w_j \bar{L} + \frac{1}{A} \frac{R_j^{1-\gamma} w_j^{\gamma}}{(1-\gamma)^{1-\gamma} \gamma^{\gamma}} x_j \tag{7}$$

where TC stands for total costs.

We therefore see very clearly that costs can be separated into a fixed part $R_j \bar{K} + w_j \bar{L}$ and a remaining variable part. For simplicity, we call the first a_0 and the second a_1, both of which, as expected, vary positively with factor prices. We can therefore write the firm's optimal price as:

$$p_j = \sigma a_1 \tag{8}$$

as is usual in the CES case, where σ is the elasticity of substitution between goods and also represents the fixed markup over the marginal cost a_1.

Firms are assumed to enter the market freely, until profits are zero for all firms. Entry is frictionless and instantaneous, in the way that there is no lag separating entry from production, contrarily to Ghironi and Melitz (2004) or Bilbiie, Ghironi and Melitz (2005). The zero profit or free entry condition, which holds at every period, helps determine the number of firms that can remain active in the market. In particular, this condition specifies that $\pi = 0$ at equilibrium, where π are profits per firm. We therefore write that at equilibrium:

$$\pi = p_j x_j - a_0 - a_1 x_j = 0$$

or

$$(p_j - a_1) x_j = a_0 \tag{9}$$

namely, operating profits equal fixed costs. As mentioned earlier, this is the instantaneous version of the zero profit condition in Ghironi and Melitz (2004) or Bilbiie, Ghironi and Melitz (2005).

Importantly, this condition allows us to solve x_j:

$$x_j = \frac{a_0(R_j)}{(\sigma - 1) a_1(R_j)} \equiv x \tag{10}$$

where we added (R_j) to emphasize the dependence on interest rates.

Thus, x_j, each firm's output, is fixed in equilibrium by the free entry condition. Note that interest rates do not cancel out, although they appear both in the numerator and the denominator, as substitution towards or away from capital is not allowed in fixed costs, but only in variable costs. Thus, changes in R_j affect the amount of firm output. This is as in Flam and Helpman (1987). We will analyze this result more closely later when in a position to study the contemporaneous effect on the number of firms.

For now, to build intuition for this result, it is worth looking into greater detail at the mechanism linking the number of firms and profits: the aggregate price index. Indeed, the aggregate price depends negatively on the number of firms. As is usual in the CES setting, the price index is the power mean of prices of each variety taken over all trading partners $s \in \{0, S\}$:

$$P_j = \left(\int_0^S \int_0^{n_s} p_{j,s}(i)^{\frac{1}{1-\sigma}} di \quad ds \right)^{1-\sigma}$$

where the inner integral is taken over all firms, n_s, in country s and where $p_{j,s}(i)$ captures the price of variety i from country s in country j. This expression simplifies, since the price $p_{j,s}(i)$ is the same for all firms in s. This yields:

$$P_j = \left(\int_0^S n_s p_{j,s}^{\frac{1}{1-\sigma}} ds \right)^{1-\sigma}$$

where we clearly see that the aggregate price decreases with n_s (recall, $1 - \sigma < 0$). Appropriately, this link is commonly referred to as the variety effect and is central to explaining the zero profit condition. As more firms enter the market, aggregate prices decrease. Since a firm's demand function is a negative function of aggregate prices (relative prices matter), each firm sells less. Operating profits for a given firm, $(\sigma - 1)a_1 x$, thus decrease until they are equal to a_0, the fixed cost of operation, and firms stop entering. Thus, the zero profit condition determines the output of each firm.

At this point, the labor market clearing condition allows us to find the number of active firms in the market. Intuitively, if firm output is fixed and total labor is given, the number of firms able to survive in the market is determined by total labor divided by the number of workers employed by each firm. The approach of using the labor market clearing condition as an additional constraint to solve for the number of firms is shared with Bilbiie, Ghironi and Melitz (2005).

More formally, the labor market clears when $\int_{n_j} L(i)di = E_j$ where E_j is the amount of workers available in country j and $L(i)$ is the amount of workers employed by each firm, labeled L_j earlier. This yields the important condition:

$$n_j = \frac{E_j}{L_j} \tag{11}$$

To close the model, we use the equation for firm output (10) and the equation determining optimal labor demand per firm (6), to solve for L_j. We find:

$$L_j = \bar{L} + \frac{\gamma(R_j \bar{K} + w_j \bar{L})}{w_j(\sigma - 1)} = \bar{L} + \frac{\gamma a_0}{w_j(\sigma - 1)} \tag{12}$$

So that the number of firms in country j is given by:

$$n_j = \frac{E_j(\sigma - 1)w_j}{w_j \bar{L}(\sigma - 1 + \gamma) + \gamma R_j \bar{K}} \tag{13}$$

The particularities of this somewhat complicated expression are not central. The important aspect of n_j is its dependence on interest rates R_j. From the labor market clearing condition (11), we know that $\partial n_j/\partial R_j = (\partial n_j/\partial L_j)(\partial L_j/\partial R_j)$. From inspection, we know that the first term in parenthesis is negative and the second positive. Thus, $\partial n_j/\partial R_j < 0$; as interest rates decline, the number of firms rises. Note that the positive sign of the second partial comes from having introduced fixed costs, as is evident by the dependence of equation (12) above on a_0.

The negative relation between n_j and R_j is a key result, central to our model and its prediction that lower interest rates increase the number of firms engaged in trade. Two essential elements are at work behind this result. First, as capital costs decrease, firms substitute capital for labor, thus freeing up labor for more firms to enter. Second, as entry or fixed costs decrease, more firms can afford to enter. In turn, this decreases output per firm.[17] The relationships corroborate the IO results mentioned earlier, whereby as setup costs diminish, concentration declines in favor of more, smaller firms. Notice, in fact, that making use of (12) and (10), we can show that $\partial n_j/\partial a_0 < 0$ but $\partial x_j/\partial a_0 > 0$, thereby supporting the notion that as interest rates decrease (a decline in a_0), a greater number of smaller firms co-exist. As for the aggregate effect, per the production function (4), we conclude unambiguously that trade volume increases, since labor is fixed and capital increases with a lower interest rate. In addition, more exporting firms contribute to total trade increasing.

To finish the development of the model, we come back to the demand equation (3) in which we plug our result for n_j (13) above. Furthermore, we make use of the PPP price equation (2) and firms' optimal price equation (8). This yields:

$$V_{i,j} = \frac{E_j(\sigma-1)w_j}{w_j\bar{L}(\sigma-1+\gamma)+\gamma R_j\bar{K}} \left(\frac{\sigma a_{1,j}\tau_{i,j}\frac{1}{\epsilon_{i,j}}}{P_i}\right)^{\frac{1}{1-\sigma}} Y_i \tag{14}$$

This equation draws the line where the rigorous model stops and we begin to introduce a series of simplifications in order to arrive at an equation that is easily testable.

4.3 Towards an augmented gravity equation

First, we write the complicated expression for n_j more stylistically, as $n_j = (E_j^{\eta} \cdot w_j^{\rho})/R_j^{\kappa}$ to emphasize the negative relationship with interest rates and the positive one with wages (for the same reasons but opposite to those discussed above linking interest rates to the number of firms). The superscripts

[17] The appendix breaks up the two effects mentioned above in some detail, and shows that in fact output per firm could increase with a decrease in interest rates, but under rare conditions.

capture elasticities of each variable with respect to the number of exporting firms.

To simplify the estimation procedure, circumvent unreliable employment data and minimize the divergence from more traditional gravity equations, we make an additional simplification.[18] We assume a constant difference in labor productivities between Euro-Area countries and exploit the positive correlation between output and employment. This allows us to replace E_j with Y_j in the above equation.

To simplify further, we follow Baldwin (2006) which shows, in an interpretation of Flam and Nordström (2003)'s methodology, how we can divide top and bottom of our demand system by P_i and define $\xi_{i,j}$ as the real exchange rate between country i and j, given by $(1/\epsilon_{i,j})\sigma a_{1,j}/P_i$. This is a somewhat unconventional definition of the real exchange rate, which usually includes P_j in the numerator instead of $\sigma a_{1,j}$. Yet, to the extent that the aggregate price is a function of each domestic firm's price, which is itself a function of marginal costs and the markup, our simplification does not introduce notable distortions to the model. This is especially true as we consider σ to be constant across time and countries.

Finally, we follow Mancini-Griffoli and Pauwels (2006) in defining the trade cost $\tau_{i,j}$ as a time independent, country-pair-specific effect, capturing distance, common language, type and efficiency of the legal system and other such factors commonly found in traditional gravity equations. We call this parameter $\alpha_{i,j}$.

This leaves us with the following equation:

$$V_{i,j} = \frac{Y_i^{\eta} \cdot w_j^{\rho}}{R_j^{\kappa}} \left(\alpha_{i,j}\xi_{i,j}\right)^{\frac{1}{1-\sigma}} Y_j \tag{15}$$

which can be linearized for estimation purposes by taking logs of both sides. This leads to the regression equation:

$$V_{i,j,t} = \alpha_{i,j} + \gamma_1 Y_{i,t} + \gamma_2 Y_{j,t} + \gamma_3 \xi_{i,j,t} + \gamma_5 \bar{R}_{j,t} + \gamma_6 W_{j,t-4} + \epsilon_{i,t} \tag{16}$$

where the γ's are reduced form coefficients and where we use the definition $\bar{R}_{j,t} = (1/6)\sum_{s=t-6}^{t-1} R_{j,s}$ to capture trend interest rates, deemed to be the relevant measure for entrepreneurs' decisions (we alter this definition in robustness tests) and where $W_{j,t-4}$ captures wages one year ago, in line with findings that wages tend to stick for about four quarters. The lags on interest rates and wages also allow us to minimize problems of endogeneity with GDP.

The specification above represents our augmented gravity equation. It has the advantage of being derived from a microfounded model linking interest rates to trade, and to be similar the traditional gravity equations used

[18] Indeed, there is a great amount of heterogeneity between European countries in classifying labor, especially as far as it is linked to export-oriented industries.

widely in the "Rose effect" literature. Indeed, we can go back and forth between the two by simply dropping or adding interest rates and wages.

5 Do interest rates explain the break in trade?

5.1 Brief overview of the test

Mancini-Griffoli and Pauwels (2006) introduces a rigorous statistical test for end of sample instability in panel data, adapted from a similar test for time series in Andrews (2003). The particular advantage of the test is its reliance on an empirically determined distribution of critical values, making it robust to very few regularity conditions and maintaining power in the face of a small number of data points after a presumed break. This feature not only allows for asymptotically valid critical values, but to test a potentially short-lasting effect of the Euro.

Below, we use this test to ask if the break in Euro-Area trade remains despite the additional terms in the augmented gravity regression. But to interpret results, it is useful to review a few cornerstones of the end of sample test.[19] We call the test statistic S, as in Andrews (2003). The statistic is a type of mean squared error calculated over the sample following the break point, while imposing constant coefficients throughout the entire sample. The test consists of comparing the S statistic to analogous statistics, called S_{τ_r}, taken over the sample prior to the potential break point, in a rolling window fashion. We reject the Null if S is greater than $\alpha\%$ of the S_{τ_r} statistics, where α is our desired level of significance and the distribution of the S_{τ_r} is determined by empirical subsampling techniques (any assumed parametrization of the distribution would be erroneous, yielding asymptotically invalid standard errors, given the very small number of observations after the breakpoint). In essence, the test pivots around the fact that if instability exists in a series, the errors estimated with coefficients assumed to be constant over the entire sample will be much "larger" after the break point than before.

We work with a panel of fourteen EU countries (excluding Greece) and unilateral trade data. Our dataset includes quarterly observations from 1980 Q1 to 2004 Q4, thus satisfying the necessary condition to carry out the end of sample test, namely of stationary, ergodic, and large sample series prior to the potential point of instability. Trade data are from IMF DOTS, while remaining data are from Eurostat or OECD, as in most studies in the related literature. We focus on trade within the Euro-Area (Mancini-Griffoli and Pauwels (2006) consider other control groups made up of EU, but non-Euro-Area countries). Our null hypothesis is that the coefficients in our regression remain stable throughout the sample. We label our augmented regression

[19]Please refer to Mancini-Griffoli and Pauwels (2006) for details on the test.

equation above model C and compare it to model A, the baseline gravity regression in Mancini-Griffoli and Pauwels (2006).

5.2 Test results

We first control for unit roots in our series, using the Breitung (1997,1999) as well as Im, Pesaran and Shin (IPS, 2003) procedures. As the results in table 1 show, we cannot reject the Null of a unit root with reasonable significance for any series, although the evidence is somewhat mixed for interest rates.

Table 2 reports test results for two different cointegrating vectors corresponding to the two model specifications mentioned above: models A and C. On the basis of the Pedroni (1999, 2004) tests, we detect the presence of cointegration between all series. We view this as an encouraging finding of a significant long term relationship among our variables, but also as reason to opt for a unit root in interest rates.

We therefore run our test for a break in trade on an error correction model (ECM), based on the augmented regression equation above. Mancini-Griffoli and Pauwels (2006) discuss the specification of the ECM model for panel data as well as some of its properties.

The traditional gravity regression, captured by model A (including just GDP of country i and j, the real exchange rate and the country-pair-specific fixed effect), indicate the existence of a break in trade between Euro-Area countries, starting in 1999 Q1 and lasting for 10 quarters (2.5 years). The Null of stability is rejected with at least 90% significance over this entire period, with peaks of 99% significance for a break length of 7 quarters. Thus, the panel end-of-sample instability test that we employ replicates quite faithfully the results found in the literature, except for a slightly later break date and especially for the short break length (although some of the most recent papers are beginning to find a short-lasting effect, see Baldwin (2006) for a summary). These results are shown in table 3 and are a repetition of those shown in Mancini-Griffoli and Pauwels (2006).

In model C, instead, the break disappears, thereby justifying this paper's hypothesis of the importance of interest rates. Results are presented in table 4. For any given break period, the S statistic decreases far below its equivalent measure under model A with respect to the S_{τ_r} distribution. The probability of rejecting the null of stability decreases below the 10% level for all post-break sample periods. Most notably, for the period where the break is strongest in model A, 1999 Q1 - 2000 Q4, controlling for interest rates makes the difference between rejecting (at the 1% level) and not rejecting the null hypothesis at all. If decreasing interest rates are indeed part of the story behind the boom in Euro-Area trade, as these results suggest and according to the theoretical model presented earlier, the rather late break date with respect to expectations of adopting the Euro may be explained. Since interest rates started decreasing persistently between 1996 and 1997, it is normal that effects of capital accumulation would only be felt about two years later, due to the lag between installing and benefitting from new capital. Indeed, model C includes average interest rates over six quarters to account for this time to build characteristic. Also, the explanation attached to interest rates conveniently fits the short time span of the break in trade, as real interest rates can only realistically decrease (or be expected to decrease) for a limited time. In fact, figures 1 and 2 show that there was an important correction in the downward trend in interest rates around 2001 and lasting approximately 6 quarters. This may have contributed to shortening or abating the perceived trade effect of the Euro.

We conduct several robustness checks to verify whether the marked decrease in interest rates can really explain the structural break found in model A for Euro-Area data. For these, we use an alternate definition of average interest rates. For the tests mentioned above, we had defined $\bar{R}_{i,t}$ to include 6 lags. In tables 5 and 6 below, we show that even if it were to include 4 or 2 lags, we would still fail to reject the null of no structural break. Thus, altering the lag structure of the average interest rate does not change our main findings.

6 Conclusion

The recent trade literature finds a break in trade among Euro-Area countries after the adoption of the Euro. Mancini-Griffoli and Pauwels (2006) corroborate this finding - although pointing to a short-lasting break - with more powerful econometric tests. But the question remains, *what* in the new currency is responsible for boosting trade?

This paper aims to address this question. This paper first reviewed the relevant literature, concluding that the usual suspect - the channel of exchange rate volatility - does not seem to be very prominent in fostering trade. This paper then drew hints from a more recent strand of the trade literature emphasizing the importance of firm entry as a driver of trade fluctuations, and particularly the central role played by fixed entry costs. Could interest rates be seen as tied to these costs?

Empirically, this paper demonstrated that there is reason to believe that interest rates may be an important link between the Euro and a rise in trade. Interest rates moved downwards to a significant extent across the Euro-Area as a precondition and consequence of the Euro. Also, this paper provided evidence of the correlation between interest rates and trade, in a DOLS panel regression of Euro-Area trade in the last twenty years.

Given such evidence, this paper proposed a simple theoretical model linking trade to the number of exporting firms, and these to fixed entry costs themselves tied to interest rates. Conveniently, this model simplified to a regression equation, of a form very similar to standard gravity equations, but in particular including interest rates as an additional variable.

This paper ended by showing that the same test for end-of-sample break as presented in Mancini-Griffoli and Pauwels (2006) no longer found evidence of a break in Euro-Area trade. Thus, interest rates could well be one of the variables missing from the standard gravity equation whose errors jump after the introduction of the Euro. From the perspective of accession countries, this is not very good news, as it gives a microfounded explanation for why the trade effect of adopting the Euro might indeed be short-lasting.

References

[1] Anderson, James E., and Eric van Wincoop (2003). "Gravity with Gravitas: A Solution to the Border Puzzle" *American Economic Review*, 93 (1), March, 170-192.

[2] ———————— (2001) "Borders, Trade and Welfare", *NBER working paper* no. 8515.

[3] Andrews, D. W. K. (2002). "End-of-sample Instability Tests," *Econometrica* 71 (6): 1661-1694.

[4] Andrews, D. W. K. (1993). "Tests for Parameter Instability and Structural Change with Unknown Change Point," *Econometrica* 61: 821-856.

[5] Andrews, D. W. K. and R. C. Fair (1988). "Inference in Nonlinear Econometric Models with Structural Change," *Review of Economic Studies* 55: 615-640.

[6] Bacchetta, Philippe and Eric Van Wincoop (2000). "Does Exchange-Rate Stability Increase Trade and Welfare?," *American Economic Review* 90 (5), December.

[7] Basu, S. and J. Fernald (1997). "Returns to scale in U.S. production: estimates and implications," *Journal of Political Economy*, 105: 249 - 283.

[8] Betts, C., and M. B. Devereux (1999). "The International Effects of Monetary and Fiscal Policy in a Two Country Model", forthcoming in Maurice Obstfeld, Guillermo Calvo, and Rudiger Dornbusch, ed. *Essays in Honor of Robert A. Mundell*, Cambridge: The MIT Press.

[9] Baldwin, R. E. (2006). "The Euro's Trade Effects," *Mimeo*, The Graduate Institute of International Studies, Geneva.

[10] Baldwin, R. E. and D. Taglioni (2004). "Positive OCA criteria: microfoundations for the Rose effect," *HEI working paper*.

[11] Baltagi, B.H. and C. Kao (2000). "Nonstationary panels, cointegration in panels and dynamic panels: a survey," in *Advances in Econometrics: Nonstationary panels, panel cointegration and dynamic panels*, B. H. Baltagi, T. B. Fomsby and R. C. Hill, eds., Vol. 15, Oxford, Elsevier, 2000: 7-51.

[12] Barr, D., F. Breedon, D. Miles (2003). "Life on the outside: economic conditions and prospects outside euroland," *Economic Policy*, 37.

[13] Barro, R. and S. Tenreyro (2000). "Closed and open economy models of business cycles with marked-up and sticky prices," *NBER Working Paper* No. 8043.

[14] Bayoumi, Tamim and Eichengreen, Barry (1997). "Is Regionalism Simply a Diversion? Evidence from the Evolution of the EC and EFTA," in Takatoshi Ito and Anne O. Krueger, eds., *Regionalism versus Multilateral Trade Arrangements*. Chicago: University of Chicago Press.

[15] Bernard, A., J. Eaton, J. Bradford Jensen, and S. Kortum (2003). "Plants and Productivity in International Trade," *American Economic Review*, 93, 4: 1268-1290.

[16] Bernard, A. and J. Jensen (2004), "Entry, Expansion, and Intensity in the US Export Boom," *Review of International Economics*, Volume 12 Issue 4 Page 662 - September 2004.

[17] Betts, C. and M. Devereux (2000). "Exchange Rate Dynamics in a Model of Pricing-to-Market," *Journal of International Economics* 50 (1), 215-244.

[18] Bilbiie, F., F. Ghironi and M. Melitz (2005). "Business cycles and firm dynamics," *Mimeo*.

[19] Brown, R., J. Durbin and J. Evans (1975). "Techniques for Testing the Constancy of Regression Relationships over Time," *Journal of the Royal Statistical Society*, Series B, 37, pp.149-172.

[20] Burnside, C., M. Eichenbaum and S. Rebelo (1995). "Capital utilization and returns to scale," *NBER Macroeconomics Annual*, 67-119.

[21] Campa, J. M., L. Goldberg and J. M. Gonzales Minguez (2005). "Exchange-Rate Pass-Through to Import Prices in the Euro Area," *NBER Working Paper*, no. 11632.

[22] J. M. Campa and L. Goldberg (2002). "Exchange Rate Pass Through into Import Prices," *Review of Economics and Statistics*, November.

[23] Chatterjee, S. and R. Cooper (1993). "Entry and exit. Product variety and the business cycle," NBER working paper no. 4562.

[24] Cheng, I-Hui and Howard J. Wall (2004). "Controlling for Heterogeneity in Gravity Models of Trade and Integration," *Federal Reserve Bank of St. Louis Working Paper Series*, WP 1999-010E.

[25] Chow, G. C. (1960). "Tests of Equality Between Sets of Coefficient in Two Linear Regressions," *Econometrica* 28: 591-605.

[26] Cote, A. (1994). "Exchange Rate Volatility and Trade," *Working Paper* No. 94-5, Bank of Canada.

[27] Davidson, R. and J. G. McKinnon (1993). *Estimation and Inference in Econometrics.* New York: Oxford University Press.

[28] Devreux, M. B., A. C. Head, B. J. Lapham (1996a). "Aggregate fluctuations with increasing returns to specialization and scale," *Journal of economic dynamics and control* 20: 627-656.

[29] Devreux, M. B., A. C. Head, B. J. Lapham (1996b). "Monopolistic competition, increasing returns, and the effects of government spending," *Journal of Money, Credit and Banking* 28: 233-254.

[30] Dixit, Avinash and R. S. Pindyck (1982). *Investment under uncertainty.* Princeton: Princeton University Press, 1994.

[31] Dufour, J.-M., E. Ghysels, and A. Hall (1994). "Generalised Predictive Tests and Structural Change Analysis in Econometrics," *International Economic Review* 35: 199-229.

[32] Eaton, J., S. Kortum and F. Kramarz (2004). "An anatomy of international trade: evidence from French firms," *Mimeo.*

[33] Fair, R. C. (2002). "Testing for a New Economy in the 1990s," *Yale ICF Working* Paper No. 02-48.

[34] Flam, Harry and Hakan Nordström (2003). "Trade volume effects of the euro: Aggregate and sector estimates," *Mimeo.*

[35] Flam, H. and E. Helpman (1987). "Vertical Product Differentiation and North-South Trade," *American Economic Review*, 810-822.

[36] Franke, G. (1991). "Exchange Rate Volatility and International Trading Strategy," *Journal of International Money and Finance* 10, pp. 292-307.

[37] Gagnon, J. E. and J. Ihrig (2004). "Monetary Policy and Exchange Rate Pass-through," *International Journal of Finance and Economics*, vol. 9, pp. 315-38.

[38] Glick, Reuven and Andrew Rose (2002). "Does a Currency Union Affect Trade? The Time Series Evidence", *European Economic Review* 46-6, 1125-1151.

[39] Helpman, E., M. Melitz, and Y. Rubinstein (2004) "Trading partners and trading volumes," *Mimeo*.

[40] H. M. Treasury, *EMU and Trade*, HMSO: London, 2003.

[41] IMF, prepared by P. Clark, N. Tamirisa, and S.-J. Wei, with A. Sadikov, and L. Zeng, *Exchange Rate Volatility and Trade Flows - Some New Evidence*, IMF: Washington D.C., 2004.

[42] Mancini-Griffoli, T. and L. Pauwels (2006). "Is there a Euro effect on trade? An application of end-of-sample instability tests for panel data," *HEI Working Paper*, The Graduate Institute of International Studies, Geneva.

[43] Mark, N. and D. Sul (2003). "Cointegration vector estimation by panel DOLS and long run money demand," *Oxford Bulletin of Economics and Statistics*, 65: 665-680.

[44] Melitz, M. (2003). "The impact of trade on intra-industry reallocations and aggregate industry productivity," Econometrica 71: 1695-1725.

[45] McKenzie, M. D. (2000). "The Impact of Exchange Rate Volatility on International Trade Flows," *Journal of Economic Surveys*, Vol. 13, No. 1, pp. 71-106.

[46] Micco, A., E. Stein, G. Ordonez (2003) "The Currency Union Effect on Trade: Early Evidence From EMU", Economic Policy, 316-356.

[47] Nitsch, V. and H. Berger (2005). "Zooming out: the trade effect of the Euro in historical perspective," *CESIFO Working Paper* No. 1435.

[48] Nitsch, V. (2005). "Currency Union Entries and Trade", forthcoming in *Globalization of Capital Markets and Monetary Policy*, edited by J. Hölscher and H. Tomann, P. Macmillan.

[49] Nitsch V. (2004). "Have a break, have a ...national currency: when do monetary unions fall apart?" *CESifo working paper* no. 1113.

[50] Obstfeld, M. and K. Rogoff (1998). "Risk and Exchange Rates," *NBER Working Papers Series*, no. 6694.

[51] Rebelo, S. (2002). "Monopolistic competition with fixed costs and real investment," *Mimeo*, Studentzentrum Gerzensee.

[52] Redding, S. and A. Venables (2004). "Economic Geography and International Inequality," *Journal of International Economics*, 62, pp. 53-82.

[53] Rose, A. K. and E. van Wincoop (2001). "National Money as a Barrier to International Trade: The Real Case for Currency Union," *American Economic Review, Papers and Proceedings* 91(2), 386-390.

[54] Rose, A. (2000). "One market one money: estimating the effect of common currencies on trade," *Economic Policy*, 30.

[55] Sercu, P. and C. Vanhulle (1992). "Exchange Rate Volatility, International Trade, and the Value of Exporting Firms", *Journal of Banking and Finance* 16, pp. 155-82.

[56] Shaked, A. and J. Sutton (1987). "Product Differentiation and Industrial Structure" *Journal of Industrial Economics*, 1987, 36(2).

[57] Sutton, J. (1991). *Sunk Costs and Market Structure*. Cambridge, Massachusetts: The MIT Press.

A Deriving DOLS

To understand the derivation of the DOLS estimator and the source of the bias it aims to adjust, it is helpful to refer to the standard representation of the panel cointegrated regression, presented possibly most clearly in Mark and Sul (2002):

$$y_{i,t} = \alpha_i + \gamma' x_{i,t} + u_{i,t}$$

where $(1, -\gamma')$ is the cointegrating vector between $y_{i,t}$ and $x_{i,t}$. Furthermore, the error $u_{i,t}$ is independent across i but possibly dependent across t, α_i are individual specific fixed effects, that can be augmented to include time effects as well, and $x_{i,t}$ is a vector of non-stationary regressors given by:

$$x_{i,t} = x_{i,t-1} + \nu_{i,t}$$

This implies, of course, that $y_{i,t} = y_{i,t-1} + \gamma' \nu_{i,t} + \Delta u_{i,t}$, namely that the dependent variable is also cointegrated. The setup yields two forms of bias. First, the serial correlation in the errors, and second the endogeneity of the regressors, due to the non-zero correlation between $u_{i,t}$ and at most p leads and lags of $\nu_{i,t}$. To correct for endogeneity, project $u_{i,t}$ onto the leads and lags of the $\nu_{i,t}$ to yield:

$$u_{i,t} = \sum_{j=-p}^{p} \delta' \nu_{i,t+j} + \epsilon_{i,t} = \sum_{j=-p}^{p} \delta' \Delta x_{i,t+j} + \epsilon_{i,t}$$

where $\epsilon_{i,t}$ is by construction orthogonal to the leads and lags of $\nu_{i,t}$.

Replacing this result into the regression equation yields:

$$y_{i,t} = \alpha_i + \gamma' x_{i,t} + \sum_{j=-p}^{p} \delta' \Delta x_{i,t+j} + \epsilon_{i,t}$$

which can be estimated by fixed effects to yield the DOLS estimator. Note that the equation above is a close analog of the more familiar error correction form of time series models.[20]

B Breaking down the interest rate effect on the number of firms

We come back on one of the main result of the paper, namely that $\partial n_j / \partial R_j < 0$ to give greater details on the breakdown of this effect. We first note that we can solve for the number of exporting firms in country j as a negative

[20]See Baltagi and Kao (2000) and references mentioned there for refinements and asymptotic properties of this estimator.

function of L_j, the optimal number of workers employed in each firm, as in equation (13) in the text. Second, the solution for L_j is expressed as a function of R_j and x_j, as in equation (6). Finally, x_j, or output per firm, is also a function of R_j, as noticeable in equation (10). Thus, the first and second observations allows us to write:

$$\frac{\partial n_j}{\partial R_j} = \frac{\partial n_j}{\partial L_j}\frac{\partial L_j}{\partial R_j} \tag{17}$$

Inspection of equation (13) tells us that the first partial is negative. By making use of the second and third observations above, the second partial can be written as:

$$\begin{aligned}\frac{\partial L_j}{\partial R_j} &= \frac{(1-\gamma)(1/w_j)(R_j/w_j)^{-\gamma}(\gamma/(1-\gamma))^{1-\gamma}}{A}x_j + \\ &\quad \frac{(R_j/w_j)^{1-\gamma}(\gamma/(1-\gamma))^{1-\gamma}}{A}\frac{\partial x_j}{\partial R_j}\end{aligned}$$

where we can refer to the first term on the right hand side as the factor substitution effect and the second as the firm size effect. Indeed, as interest rates decrease, firms substitute capital for labor in production, as captured by the first term, which, by inspection, is positive. This is important to free up workers for the entry of more firms. But also, as interest rates decrease, firm size is affected. But whether size increases or decreases is technically ambiguous, although regular conditions imply that the size should decrease with a drop in interest rates. But whatever the effect on firm size, we know from equation (12) in the text that L_j decreases with lower interest rates, thus unambiguously increasing the number of firms.

Intuitively, as interest rates decrease, firm size will decrease with the number of firms (as discussed in the text). But variable costs also decrease, thus lower price and boosting output. A glance at the equation determining (10) will make it clear that a_0 and a_1, which both depend on R_j, have opposite effects on x_j.

Digging a little into the mathematics of this effect allows so see these opposing forces more clearly. We can write:

$$\frac{\partial x_j}{\partial R_j} = \frac{1}{(\sigma-1)a_1}\frac{\partial a_0}{\partial R_j} - \frac{a_0(\sigma-1)}{((\sigma-1)a_1)^2}\frac{\partial a_1}{\partial R_j} \tag{18}$$

where the effects of a_0 and a_1 clearly work in opposite directions.

So that the firm entry effect dominate, and thus firm size decrease with lower interest rates, the above equation boils down to a condition on the relative size of fixed costs:

$$\frac{\partial x_j}{\partial R_j} > 0 \quad \text{iff} \quad R_j\bar{K} > \frac{1-\gamma}{\gamma}w_j\bar{L}$$

Weights on production functions are notoriously difficult to estimate, given the endogeneity of capital and labor to changes in productivity and the difficulty of measuring capital utilization. Simple regressions often find a coefficient close to zero on capital, since the capital stock, commonly used to evaluate capital used in production, does not change much over time. Other estimations, using electricity consumption as a proxy for capital utilization find a coefficient on capital of around 0.6 and one of 0.4 on labor.[21] Given this latter estimate, the above condition suggests that the fixed costs due to capital must be at least 1.5 those stemming from labor, a requirement that should be easily satisfied as fixed costs are typically dominated by the setup of capital. The fact that firm size varies negatively with the number of firms, which rises as fixed costs decrease, rejoins the basic dynamics emphasized in the IO literature, linking concentration to set-up costs and average prices to competitive intensity.

Thus, coming back to equation (18) above, we conclude that as interest rates decrease, labor per firm decreases due to the substitution effect and the firm size effect, which is likely to be dominated by the firm entry effect. Together, these contribute to unambiguously making $\partial L_j/\partial R_j$ positive and thus $\partial n_j/\partial R_j$ negative, as explained in the text.

[21] See Burnside, Eichenbaum and Rebelo (1995), or Basu and Fernald (1997).

C Real interest rates in the EU

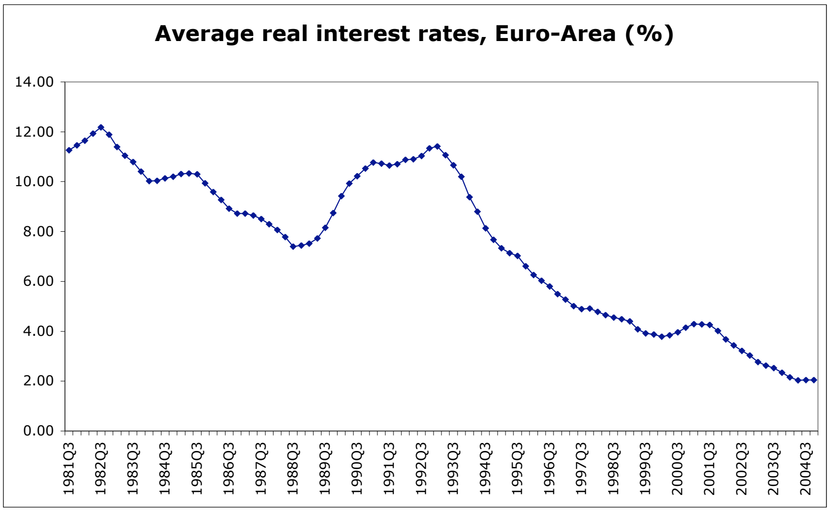

Figure 1: Average real interest rates (over six quarters) were relatively stable (just below 10% on average) until about 1996, when a noticeable downward trend began. In four years, real interest rates lost about 600 basis points, and four years later, after a further 200 basis point decrease, were at their lowest, at around 2%.

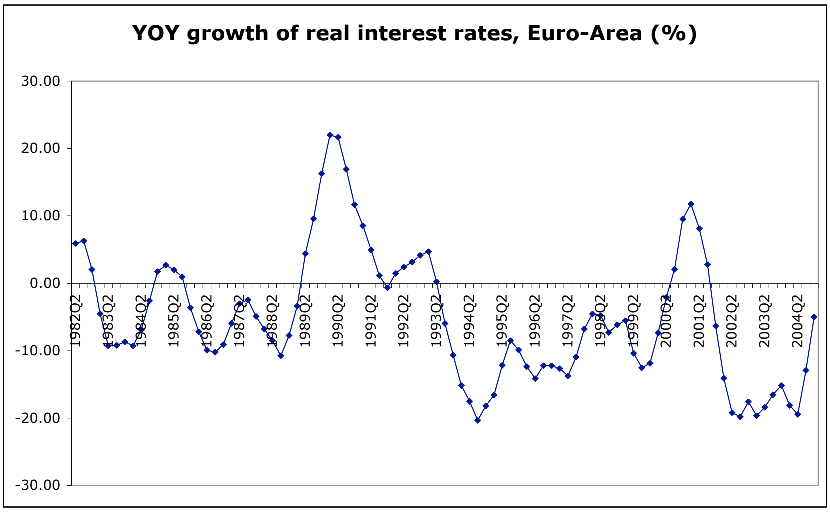

Figure 2: Year-on-year growth of average real interest rates hovered slightly below zero until about 1996, after which it remained decisively negative, in the order of -10% or more.

D Empirical evidence

Table 1: Unit Root tests for the Euro Area series

	Breitung test				IPS test			
	intercept		int. & slope		intercept		int. & slope	
	Stat	Prob.	Stat	Prob.	Stat	Prob.	Stat	Prob.
V_t	-1.05	0.15	1.42	0.92	3.09	1.00	-7.62	0.00
Y_t	-0.32	0.37	1.89	0.97	0.76	1.00	0.17	0.57
w_t	0.23	0.59	-0.45	0.33	3.22	1.00	-1.63	0.05
R_t	-1.08	0.13	-2.47	0.006	12.6	1.00	2.87	0.99

Table 2: Pedroni's (1999) Cointegration Results

Specification	$\nu - statistic$	$\rho - statistic$
(A)	12.6	-26.5
(C)	8.8	-22.3

Table 3: Baseline Model (A)

Span	S	S_r: 1%	S_r: 5%	S_r: 10%
$1999Q1 - 2000Q3$	61.8	82	67.4	53.5
$1999Q1 - 2000Q4$	73.1	72.8	64.4	55
$1999Q1 - 2001Q1$	50	69.5	61.4	51.6
$1999Q1 - 2001Q3$	50.2	65.4	56.9	48.9
$1999Q1 - 2002Q1$	36.9	62.5	50.7	44.7
$1999Q1 - 2004Q4$	22	87.9	66.4	54.6

Table 4: Augmented Gravity Model (C)

Break Period	S	S_r: 1%	S_r: 5%	S_r: 10%
$1999Q1 - 2000Q3$	51.9	119	99.2	74.1
$1999Q1 - 2000Q4$	66.4	105	92.3	81.3
$1999Q1 - 2001Q1$	45.8	106	92.6	72.3
$1999Q1 - 2001Q3$	46.6	98.8	89.2	82
$1999Q1 - 2002Q1$	39.6	96.7	81.7	65.9
$1999Q1 - 2004Q4$	37.8	114	95.5	79.7

Table 5: Average Interest Rate with 4 lags

Span	S	S_r: 1%	S_r: 5%	S_r: 10%
$1999Q1 - 2000Q4$	62.4	101	89.5	75
$1999Q1 - 2001Q3$	42.8	93	89.5	72.5
$1999Q1 - 2002Q3$	37.4	86.1	77.2	72.2

Table 6: Average Interest Rate with 2 lags

Span	S	S_r: 1%	S_r: 5%	S_r: 10%
$1999Q1 - 2000Q4$	67.9	108	87.1	68.2
$1999Q1 - 2001Q3$	47.3	95.7	88.3	72.1
$1999Q1 - 2002Q3$	41.1	90.8	78.6	71.4

Table 7: DOLS Results for $1980Q1 - 1999Q1$

Specification	$\mathrm{Y_{i,t}}$	$\mathrm{Y_{j,t}}$	$\xi_{\mathrm{i,j,t}}$	$\mathrm{w_{j,t-4}}$	$\bar{\mathrm{R}}^6_{\mathrm{j,t}}$	$\bar{\mathrm{R}}^4_{\mathrm{j,t}}$	$\bar{\mathrm{R}}^2_{\mathrm{j,t}}$
(A)	1.09	0.37	-0.05				
	(44.4)	(15.2)	(-2.4)				
(C)	0.92	0.35	-0.02	0.49	-0.11		
	(36.9)	(14.8)	(-1.1)	(12.7)	(-11.0)		
(C)	0.91	0.35	-0.02	0.49		-0.12	
	(36.6)	(14.8)	(-0.8)	(12.8)		(-11.31)	
(C)	0.94	0.36	-0.06	0.52			-0.11
	(37.4)	(14.8)	(-2.7)	(13.8)			(-10.8)

t-statistics appear in parentheses. The superscript on $\bar{R}_{j,t}$ indicates the number of lags in the definition of average interest rates. The p leads and lags used in the DOLS correction terms (see appendix A for details) is 4 in all cases, except for $\bar{R}^6_{j,t}$ and $w_{j,t-4}$ where we use $p = 2$ since there are already sufficient lags in the definition of the variables.

Table 8: ECM Results for $1980Q1 - 1999Q1$

Specification	$\Delta\mathrm{Y_{i,t}}$	$\Delta\mathrm{Y_{j,t}}$	$\Delta\xi_{\mathrm{i,j,t}}$	$\widehat{\varepsilon}_{i,t-1}$	$\Delta\mathrm{w_{j,t-4}}$	$\Delta\bar{\mathrm{R}}_{\mathrm{j,t}}$
(A)	0.79	0.36	-0.03	-0.14		
	(14.8)	(6.7)	(-0.35)	(-24.3)		
(C)	0.74	0.4	-0.01	-0.17	0.005	-0.06
	(12.9)	(7)	(-0.16)	(-24.8)	(0.04)	(-2.2)

t-statistics appear in parentheses.