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Putting Currency Misalignment into Gravity: The Currency Union Effect Reconsidered

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Putting Currency Misalignment into Gravity: The Currency Union Effect Reconsidered *

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Abstract

Member countries of a currency union like the euro area have absorbed asymmetric shocks in ways that are inconsistent with a common nominal anchor. Based on a reformulation of the gravity model that allows for such bilateral misalignment, we disentangle the conventional microeconomic trade effect and macroeconomic trade effects deriving from bilateral misalignment within currency unions. Econometric estimation reveals that for the euro area the misalignment channel exerts a significant trade effect on bilateral exports. We retrieve country-specific estimates of the misalignment-induced effect on trade which demonstrate heterogeneous outlooks across countries for the costs and benefits from adopting the euro.

JEL Codes: F12, F13, F15
Keywords: Euro, gravity model, exchange rates, trade imbalances

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1 Introduction

Forming, or joining, a monetary union will always involve a trade-off between the benefit of less costly transactions for intra-union trade and the potential cost of macroeconomic imbalances caused by loss of monetary autonomy. Ex ante, for some countries the loss of monetary autonomy might seem a benefit in that the union might serve as a commitment device for a more stability-oriented price- and wage-setting behavior. Ex post, however, this disciplinary force will most likely be felt as a pain, and commitment will turn out to be imperfectly credible. Attempts to avoid this pain will then lead to macroeconomic imbalances, caused by the impossibility of nominal exchange rate adjustments leading to misalignments of real exchange rates between member countries. Macroeconomic imbalances, in turn, can take the form of internal balance (full employment) or external balance (current account in line with solvency), or combinations of both.[1] The theory of optimum currency areas tries to identify conditions under which the risk of such imbalances is low; see Silva and Tenreyro (2010). But in all likelihood, real world currency unions will entail non-trivial costs in terms of *endogenous* macroeconomic imbalances that could have been avoided with separate currencies.

There is a vast literature, sparked off by Rose (2000), which tries to quantify how much *additional* trade may be expected from a common currency on the grounds of less costly transactions. Various approaches have been proposed, but the dominant approach is based on the gravity model of bilateral trade.[2] The empirical estimates obtained vary a lot, but it is probably fair to say that the very large effect initially estimated by Rose (2000), indicating that a currency union triples trade between its member countries, has meanwhile given way to much lower expectations.[3] A pervasive feature of this literature is that it estimates the trade effects of a common currency independently of whether the union has also caused macroeconomic imbalances. The theory of optimum currency areas emphasizes that the loss from foregone monetary autonomy is lower with high bilateral volumes of trade between the countries considered. But there is also a reverse influence, meaning that macroeconomic imbalances caused by loss of nominal exchange rate flexibility will trigger trade effects. Somewhat surprisingly, the empirical literature ignores this feedback effect.

[1] This invokes the classic view of macroeconomic equilibrium first proposed by Meade (1951) and later refined by Corden (1994).

[2] For an alternative approach using treatment analysis, see Persson (2001). For a survey, see Silva and Tenreyro (2010).

[3] See again the survey by Silva and Tenreyro (2010).

Arguably, this is not for lack of knowledge, but for lack of a workable empirical approach to identify this macroeconomic channel of trade effects.

In this paper, we develop such an approach by a suitable extension of the gravity equation. We apply our approach to the euro area which seems like an ideal "show case" to demonstrate the importance of the issue and the virtues of our approach.

The run-up to the Economic and Monetary Union (EMU) of the European Union (EU) was characterized by a big aspiration and a big concern. The aspiration was that a common currency would reinvigorate the single market programme by establishing more cross-country transparency, wiping out all exchange rate uncertainty, and lowering administrative cost of intra-European trade. It was expected that this should enhance cross-border competition and deliver further gains from trade. The concern was that imposing a common nominal anchor on countries that face asymmetric shocks, or have different mechanisms of macroeconomic shock absorption, would lead to macroeconomic imbalances or else compromise long-run stability of that anchor. It was all too obvious that the countries in question would not satisfy optimum currency area (OCA) criteria. Therefore, in order to allay fears of a high-inflation euro zone, ex ante macroeconomic convergence was installed as a prerequisite for membership in the currency union. The famous Maastricht entry criteria were meant to guarantee the ability of all member countries to live with a *stable* common nominal anchor ex post. In addition, the Stability and Growth Pact (SGP) has installed a rule of conduct, in order to ensure that the stability of this anchor would not be jeopardized from member countries' waning fiscal discipline.

After more than a decade, we now have a wealth of evidence to judge whether the aspirations have been met and the concerns have been justified. On the *macroeconomic side*, the verdict seems split. On the one hand, the European Central Bank (ECB) was undeniably successful in quickly establishing a stable nominal anchor for the entire euro zone; see Wyplosz (2006). On the other hand, member countries' longer-term abilities to live with this anchor in some cases *are* in serious doubt, judged from the build-up of macro-level imbalances within the euro area. A detailed report by the European Commission highlights sizable misalignments of real exchange rates within the euro zone, caused primarily by nominal wages in some member countries drifting away from their equilibrium levels, as implied by the common nominal anchor; see EU-Commission (2009).[4]

[4]More recently, the euro zone has come under severe stress from internal balance of payments crises that several of its member countries are experiencing, due to large current account deficits that can no longer be financed through private capital imports, or due to capital flight. These

On the *single market aspirations*, the verdict might draw on evidence of a trade-enhancing effect of the euro. While the famous tripling estimate which Rose (2000) has found for pre-euro currency unions has never been confirmed for the euro area, early literature has estimated positive effects on bilateral trade for the euro area as well. For instance, Micco et al. (2003) has reported trade effects in the vicinity of 15%. Yet, subsequent studies have revealed that a large part of this effect was due to somewhat flawed econometrics. More recent estimates, based on refined econometric techniques, reveal an effect barely above zero; see Baldwin et al. (2008), Baldwin (2010) and Silva and Tenreyro (2010). Arguably, this is disappointing, given the painful ex ante convergence that many countries have undergone in order to qualify for euro membership, and given the restraints on fiscal autonomy implied by the Stability and Growth Pact.

Estimates of trade effects close to zero are also disappointing against the backdrop of modern trade theory which emphasizes a number of different channels through which adopting a common currency should increase trade volumes between partner countries. These channels mostly work through lower transaction costs or lower "beachhead costs" of entering foreign markets via exports or FDI. According to recent trade models, such cost savings should exert trade effects that go beyond the traditional view that trade increases mainly through lower trade cost components in c.i.f.-prices of traded goods; see Baldwin (2010). Additional effects include lower market power and lower markups as well as the so-called extensive margin of trade, meaning the emergence of new first-time exporters, or exporting firms extending the range of products exported and/or the number of foreign markets served. In this paper we speak of these effects, in their entirety, as the *microeconomic trade effects* of a currency union.

Whatever the details of such microeconomic effects, if relevant they should show up in empirical estimates of the gravity model of trade, provided that the estimated equation is correctly specified. Strikingly, while much effort has gone into refining the econometric specification of the gravity model used, existing studies have completely ignored the potential trade impact of macroeconomic imbalances caused by the monetary union. The implicit assumption underlying all existing lit-

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crises have been caused, not so much by nominal cost divergencies, but by unsustainable paths of general government deficits, whether as a result of the financial crisis of 2007/08 (as in Ireland and Spain) or resulting from deeper-lying structural problems related to the respective government's budget (as in Greece, Portugal or Italy). However, in this paper we do not intend to contribute to the discussion of the present crisis. Instead, our focus squarely lies with macroeconomic imbalances caused by nominal cost divergencies within the euro zone.

erature apparently is that macroeconomic imbalances, potentially accumulating due to the absence of nominal exchange rate flexibility, have no bearing on gravity-based estimates of microeconomic effects. Yet, barring an explicit treatment of such imbalances in the gravity model, this assumption must remain dubious. And even if it is correct, microeconomic effects do not tell us the full story, if trade is additionally affected by macroeconomic imbalances caused by monetary union.

In this paper we aim at two contributions. First, we develop an "augmented version" of the gravity model with explicit treatment of bilateral nominal cost divergencies and nominal exchange rates. A macroeconomic imbalance arises if cost divergencies are not fully offset by corresponding adjustments of nominal exchange rates. Trade flows as determined by our augmented gravity model in the absence of such imbalances are called "gravity norm" levels of trade. The conventional trade cost effect of a common currency is then defined as shifting these gravity norm levels of trade. In turn, macroeconomic imbalances are responsible for deviations form the gravity norm, and if such imbalances are caused by the currency union, then this constitutes a second important trade effect of the currency union.

Our augmented gravity model allows us to do two things. First, we identify conditions under which microeconomic effects may be estimated consistently by gravity methods, if trade is in fact subject to macroeconomic imbalances, as in the first decade of the euro zone. And secondly, it allows us to frame a very simple and intuitive question in terms of the gravity equation: Do bilateral cost divergencies affect trade flows more heavily if the two trading partners belong to the same monetary union than if they have separate currencies? If the answer is yes, this indicates that the lack of nominal exchange rate adjustment between countries of the union is a binding constraint leading to misalignments of real exchange rates with attendant trade effects.

The second contribution of the paper is to bring our augmented gravity model to the data, using the first decade of evidence with the euro zone. A principal problem with the augmented model is that gravity norm levels of trade are unobservable, if trade is in fact subject to misalignments. We develop a two-stage estimation strategy to solve this problem. In the first stage, we secure reliable estimates of the parameters that drive the microeconomic, or trade cost channel, in the gravity equation. A key insight from our theoretical model is that this can be done using standard gravity methods, irrespective of currency misalignment and without knowing unobservable gravity norm trade levels. Our empirical result here is in line with the consensus in the literature, which holds that the euro as such has had but a minor influence on trade by lowering real trade costs; see Baldwin et al. (2008), Baldwin (2010) and Silva and Tenreyro (2010). More importantly, however, stage one allows us to compute a complete matrix of estimated bilateral trade costs for each sample period. We then use these estimates, together with extraneous information, in order to calibrate gravity norm levels of trade from the equilibrium conditions of our gravity model.

With the gravity norm thus tied down numerically, stage two of our strategy turns to empirical estimation of the full augmented gravity model which focuses on the macroeconomic channel. Our augmented model relies on a relatively general view on nominal exchange rate formation in the face of bilateral nominal cost divergencies. Estimation of the model then tells us whether such cost divergencies systematically affect trade for euro member countries differently, compared to trading partners with separate currencies where a nominal exchange rate adjustment may absorb such divergencies. Our empirical results suggest an affirmative answer. Based on our estimation results, we are then able to portray a picture of country-heterogeneity in trade effects of the euro, reflecting the difficulties that different member countries have had in coming to terms with a stable nominal anchor enforced by a common monetary policy.

Although our paper is motivated by the unique experiment of the euro, the contributions of the paper command much more general relevance. Currency misalignments are a widespread phenomenon not restricted to currency unions. Actual currency regimes are characterized by varying degrees of tightness with which currencies of different countries are tied to each other. Egger (2008) uses the classification established by Reinhart and Rogoff (2004) to show that increasing exchange rate tightness (on a scale ranging from 1 to 14) tends to increase trade. This gets rid of the dichotomy underlying the original study by Rose and almost the entire subsequent literature. We would interpret this result as representing a trade cost effect, although it seems unclear why moving to a tighter currency arrangement while leaving national currencies in place should reduce transactions or beachhead cost of trade. However, it does seem plausible that increasing exchange rate tightness should increase the likelihood of currency misalignment of the type that we highlight in this paper. To the best of our knowledge, this paper is the first attempt to augment the gravity model in order to disentangle the trade cost channel of currency arrangements from the currency misalignments channel, and to investigate whether misalignment-induced trade effects are endogenous to the exchange rate arrangement.

Our paper fundamentally differs from other papers in the literature that have included exchange rate effects in the gravity equation. These papers usually demonstrate a very straightforward negative trade effect of real exchange rate appreciations on trade; see Micco et al. (2003) and Flam and Nordström (2007). Our concern, however, is fundamentally different. First, our concern is *misalignment* of real exchange rates, not real exchange rates as such. And we develop a theoretical gravity model which incorporates a precise definition of misalignment. Secondly, and more importantly, our main concern is whether such misalignments are *endogenous* to the formation of a currency union. And our augmented gravity model allows us to answer this question by means of empirical estimation. Our results suggest that conventional estimates of the microeconomic trade effects as such, while correct for an "average member country", are of limited interest for any individual country. They combine with misalignment-induced effects which by definition are asymmetric across countries. Our contribution therefore also goes beyond the work by Berger and Nitsch (2010), which documents real exchange rate effects on trade balances in periods of less flexible or fixed exchange rates, but offers no theoretical underpinning, nor explicit empirical conclusions regarding country heterogeneity.

The paper is structured as follows. The next section motivates our analysis by showing descriptive evidence on misalignments in the euro area. Section 3 then develops the augmented gravity model. In section 4 we first describe the data and estimation methods, followed by an implementation of our two-stage estimation strategy. Section 4 also presents a detailed picture of country-heterogeneity and some checks for robustness. Section 5 concludes the paper.

2 Descriptive evidence on misalignment

Before we proceed with a refinement of gravity-modeling and estimation, we take a quick look at the data, in order to demonstrate that we are talking about a phenomenon of empirical importance. We calculate bilateral measures of nominal cost-divergence which may be thought of as approximations to $c(\mathbf{w}_{it})/c(\mathbf{w}_{jt})$, where $\mathbf{w}_{.t}$ denotes a vector of nominal factor prices (e.g., wages) prevailing in euro area countries i and j, respectively, at time t, and $c(\cdot)$ denotes a minimum unit-cost function for a common (aggregate) output. For ease of exposition we assume $c(\cdot)$ to be the same for each country, but this is in no way crucial for what we are doing.[5] Considering that within the euro area nominal exchange rate adjustments are no longer possible, any upward or downward trend in these measures of relative unit-cost must be seen as an intra-euro "currency misalignment".

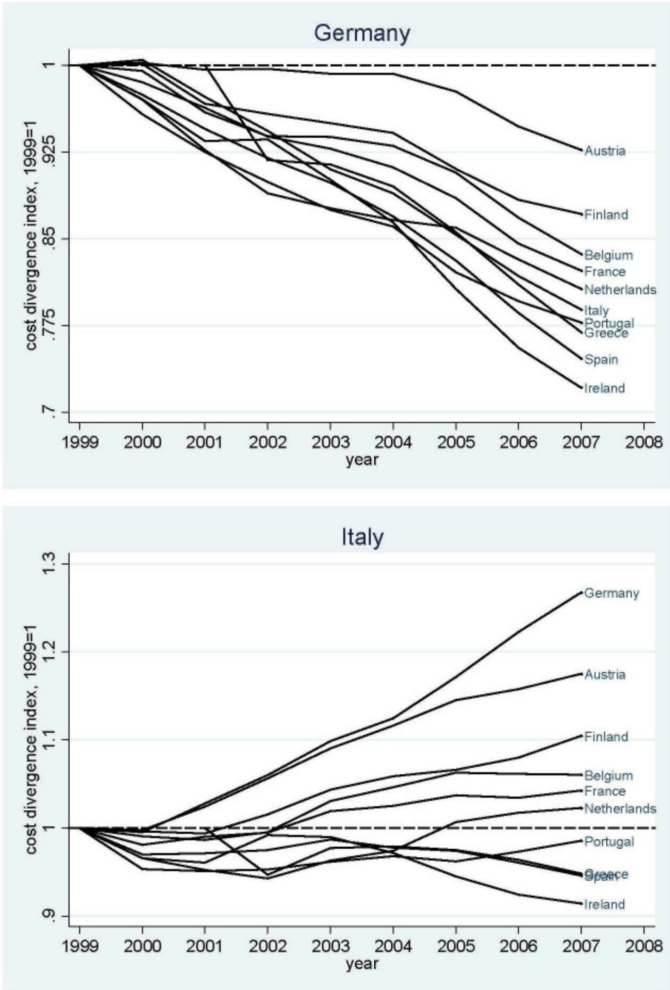
We focus on total-economy unit labor costs, relying on data from the Organization for Economic Cooperation and Development (OECD). These measures, representing the average cost of labor per unit of output, can be seen as a reflection of a country's cost competitiveness.[6] Germany and Italy are good cases in point. Figure 1 shows the values of $c(\mathbf{w}_{it})/c(\mathbf{w}_{jt})$, where the left-hand panel sets i = Germany and the right-hand panel sets i = Italy, with j indicating other euro members in either case. We set the index base-year to 1999, thus assuming that the euro entry exchange rates at the start were roughly in line with bilateral purchasing power, defined as equality of unit-cost in common currency. The figure clearly shows that the currency misalignment was not a "dead channel" for trade between the two countries and the other euro area members. Germany has experienced significant real depreciation vis à vis all other countries, indicating substantial gains in relative competitiveness. For Italy, the picture is a little less clear cut, but in the majority of cases it has experienced a sizable real appreciation and a loss in relative competitiveness. In a bilateral trade context, we would then expect exports from Germany to Italy to rise above, while those from Italy to Germany would fall, relative to what we will subsequently call the gravity norm level of bilateral trade.

Table 3 presents evidence for the rest of the euro area. The values in the first column refer to export-weighted averages over all euro area partner countries in the year 2007; the second column explicitly shows the change in the respective values since 1999. The table documents a considerable degree of divergence in bilateral unit labor costs across countries in the euro zone. We conclude that there is a multiple and varied pattern of bilateral misalignment. Living with a common nominal anchor has proven less trouble-free ex post than was hoped for ex ante. In view of the above considerations, this strongly suggests a euro-induced effect of implicit currency misalignment on bilateral trade that should be taken into account

[5]The crucial assumption is that we compare country-specific nominal unit cost for a *common* (aggregate) good. It is immaterial whether an upward or downward trend in the above measure is caused by asymmetric technological improvements that are not fully passed on to factor prices, or by diverging factor prices which are not mandated by underlying technological improvements.

[6]This measure of competitiveness is not fully comprehensive. Changes in the cost of capital should be considered as well when assessing the overall competitiveness of a country. However, in the euro area interest rates are set by the ECB for all members while labor market policies remain within the realm of national governments. Hence, focusing on labor costs seems warranted.

Figure 1: **Unit labor cost relative to other euro-area countries**



Note: Figure shows the development of relative unit labor costs since the introduction of the euro for Germany and Italy, respectively.

when estimating the trade effect in a gravity context.

A remaining concern is whether the new currency arrangement indeed stands for a strong break with the monetary past of the respective countries. In particular, from a legal perspective, exchange rates where far from a free float under the European Monetary System (EMS) even before the currency union was formed. However, the bands within which national currencies were allowed to fluctuate still provided ample opportunity for exchange rate adjustments, in order to compensate for diverging nominal cost conditions.[7]

[7]The European Monetary System (EMS) has allowed nominal exchange rates to fluctuate within a band of 4.5% in the time from 1979 through 1993. Italy was an exception and was allowed to

Table 1: **Currency misalignment by country**

Country	2007	1999 to 2007
Germany	0.8190	-0.1810
Austria	0.9886	-0.0114
Finland	1.0031	0.0031
France	1.0363	0.0363
Belgium	1.0386	0.0386
Portugal	1.0590	0.0590
Italy	1.0935	0.0935
Netherlands	1.1035	0.1035
Spain	1.1293	0.1293
Greece	1.1375	0.1375
Ireland	1.1765	0.1765

Notes: Table shows (export-weighted) averages of relative unit labor costs across all other euro member countries. Values are normalized to 1 in 1999.

3 An augmented gravity model

In the introduction, we have argued that the formation of a currency union potentially affects trade in two distinct ways. The first is the so-called *microeconomic channel* where a common currency lowers the costs of opening up and operating trading relationships across member countries. The second is what we call the *misalignment-channel.* It comes into play whenever member countries of a currency union experience trends in their nominal unit-costs that would normally tend to cause nominal exchange rate adjustments, but now give rise to misalignment of real exchange rates because the common currency rules out such adjustments. Both channels are well understood in principle, but the literature on the trade effects of the euro has exclusively focused on the microeconomic channel, although misalignment was a widespread phenomenon in the first decade of the euro zone, as demonstrated in the preceding section. In this section, we develop a reformulation

widen this band to 6%. Following a massive disruption in 1993, the band was further widened to 15%. Note also that not all countries in the sample were at all times members of the EMS. In particular, Austria joined in 1995, Finland in 1996 and Greece in 1998.

of the gravity model of trade, typically used in this literature, so that both channels are present on an equal footing. The principal concern motivating our effort is that a complete neglect of the misalignment channel may undermine the validity and correct interpretation of existing estimates relating to the microeconomic effect. In any case, they do not tell us the full story. In the subsequent section, we will therefore empirically implement and estimate our augmented version of the gravity model, which allows us to disentangle and quantify both channels and thus to tell a more complete story of the trade effects of the euro.

3.1 Microeconomic effects and the gravity norm

We view the *microeconomic channel* of a common currency as affecting what we call the gravity norm volumes of trade. The gravity norm, in turn, is defined as bilateral trade flows that emerge from a generalized gravity model with explicit introduction of national currencies, if *all* exchange rates satisfy a specific condition of bilateral purchasing power parity. The *misalignment channel* then gives rise to deviations from these gravity norm trade levels, whenever currency valuations violate bilateral purchasing power parity. In this subsection we introduce the gravity norm, and the next subsection will model the misalignment-channel.

Derivation of the gravity norm equation for bilateral trade volumes follows the standard approach, but it explicitly takes into account the existence of multiple currencies. Suppose we have the usual Dixit-Stiglitz-type underpinning of the gravity approach. As is well known, this features product differentiation on the firm level, with a zero profit equilibrium driven by monopolistic markups and free entry of firms. Denoting the c.i.f.-price in country j for a variety arriving from country i by p_{ij}, the quantity of demand D_{ij} for this variety in country j is

$$D_{ij} = Y_j \left(P_j\right)^{\sigma-1} \left(p_{ij}\right)^{-\sigma}, \tag{1}$$

where $\sigma > 1$ denotes a uniform elasticity of substitution between different varieties of goods. In this expression, Y_j is equal to country j's GDP, and P_j is the exact price index (unit-expenditure function), depending on prices of all varieties shipped to market j:

$$P_j = \left[\sum_i N_i \left(p_{ij}\right)^{1-\sigma}\right]^{1/(1-\sigma)}, \tag{2}$$

where N_i is the number of varieties produced by country i. Importantly, all variables on the right-hand side of (1) are in country j's currency. Notice that in replacing expenditure levels through GDP, we assume total trade to be balanced. This assumption will have to be relaxed when allowing for currency misalignment below.

Suppose that in each country there are K primary factors, and assume that all input use is in terms of the same bundle of primary inputs. We model this by means of a concave, constant-returns-to-scale function $g(\mathbf{v})$, where $\mathbf{v}$ denotes a vector of factor inputs employed in order to generate the input bundle. More specifically, we assume that production of a variety requires a fixed amount f and a constant amount a of this bundle per unit of output. For ease of exposition, we assume technology to be uniform across all countries, although our results in no way hinge on this assumption. We assume that all firms have the same productivity in terms of both marginal and fixed cost. Variable and fixed cost in country i then depend on country i's factor prices. Writing $c(\mathbf{w})$ for the minimum unit-cost function dual to $g(\mathbf{v})$, *nominal* cost conditions in domestic currency are governed by $c_i = c(\mathbf{w}_i)$, where $\mathbf{w}_i$ denotes a $K \times 1$ vector of *nominal* factor prices in country i.

Arguably, monetary stability over time requires that the purchasing power of a unit of money over the inputs required to generate a unit of aggregate output should remain constant. We therefore define a stable nominal anchor as a constant level of $c(\mathbf{w})$.[8] By analogy, we define *bilateral purchasing power parity* (PPP) between countries i and j as a situation where both countries have the same nominal cost of generating a unit level of the bundle $g(\mathbf{v})$, if expressed in the same currency unit. Using E_{ij} to denote the price of currency i in units of currency j, the PPP level of the nominal exchange rate, henceforth denoted by $\tilde{E}_{ij}$, is then implicitly defined through

$$c\left(\mathbf{w}_i \tilde{E}_{ij}\right) = c(\mathbf{w}_j) \quad \Longrightarrow \quad \tilde{E}_{ij} = \frac{c(\mathbf{w}_j)}{c(\mathbf{w}_i)}. \tag{3}$$

The second equation uses linear homogeneity of the minimum unit-cost function. Notice that with M different currencies there are $M-1$ independent exchange rates. If PPP holds between countries i and j, as well as between i and k, then it also holds for countries j and k.

In what follows, we use

$$m_{ij} := E_{ij} \Big/ \tilde{E}_{ij} \,. \tag{4}$$

as the factor of *bilateral currency misalignment*. If $m_{ij} = 1$ for all i and j, then there is no currency misalignment, and for any i and j we have $E_{ij} c(\mathbf{w}_i) = c(\mathbf{w}_j)$.

[8] This avoids dependence of the nominal anchor on the degree of variety offered in goods markets, which would arise if we were to use the unit-expenditure function P as a purchasing power benchmark.

For the remainder of this paper, we adopt currency 1 as our numéraire currency. If $E_{ij} = \tilde{E}_{ij}$ for all currency pairs, then the minimum-unit-cost of the factor bundle $g(\mathbf{v})$ is the same world-wide: $(E_{ij}E_{j1})\,c(\mathbf{w}_i) = c(\mathbf{w}_1)$.[9] All possible countries of origin for any country j's imports then have the same underlying cost conditions, governed by real forces like productivity. Obviously, this holds irrespective of which currency we choose as the numéraire. The gravity norm satisfies full neutrality of money.

The markup pricing condition of firms acting under monopolistic competition implies that the c.i.f.-price of a typical variety exported from i to j, measured in country j's currency, is equal to

$$p_{ij} = E_{ij}\frac{T_{ij}c\left(\mathbf{w}_i\right)a}{\rho}, \quad \text{with } \rho := (\sigma-1)/\,\sigma < 1. \tag{5}$$

For simplicity, we scale units such that $a = 1$. In this equation, T_{ij} denotes the familiar "iceberg-cost-term" that represents trade barriers and transaction costs familiar from a typical gravity equation, as well as the currency arrangement for trade between countries i and j. The presumption is that T_{ij} is lower if they use a common currency.

Using a tilde to denote gravity norm values of variables that satisfy bilateral PPP as defined in (3), and expressing all nominal variables in the numéraire currency 1, we may write the mill price of a typical variety produced in country i as $\tilde{p}_i \equiv p_i E_{i1} = c(\mathbf{w}_1)/\rho$. The c.i.f. price of this variety in country j is $\tilde{p}_{ij} \equiv T_{ij}\tilde{p}_i = T_{ij}c(\mathbf{w}_1)/\rho$, and the gravity norm price index emerges as

$$\tilde{P}_j = \left[\sum\nolimits_i \tilde{N}_i\left(T_{ij}c(\mathbf{w}_1)/\,\rho\right)^{1-\sigma}\right]^{1/(1-\sigma)} = \frac{c(\mathbf{w}_1)}{\rho}\left[\sum\nolimits_i \tilde{N}_i\left(T_{ij}\right)^{1-\sigma}\right]^{1/(1-\sigma)}. \tag{6}$$

Moreover, country i's gravity norm GDP may be written as

$$\tilde{Y}_i = \tilde{N}_i q_i \tilde{p}_i = \tilde{N}_i q_i c(\mathbf{w}_1)/\rho, \tag{7}$$

where $\tilde{N}_i$ and q_i are the number of varieties and the output level per variety, respectively, that country i observes in a zero-profit equilibrium of monopolistic competition. Notice that we allow the gravity norm number of firms, $\tilde{N}_i$, to be different from the actual number of firms in a misalignment-ridden equilibrium, which we shall de-

[9]Bilateral PPP implies that nominal cost in country i, expressed in j-currency is $E_{ij}c(\mathbf{w}_i) = c(\mathbf{w}_j)$. It also implies that the nominal cost in country j, expressed in country 1's currency is $E_{j1}c(\mathbf{w}_j) = c(\mathbf{w}_1)$. Taken together, this implies $E_{ij}E_{j1}c(\mathbf{w}_i) = c(\mathbf{w}_1)$ for all i and j.

note by N_i. In contrast, the level of output per firm is assumed to be the same in the gravity norm and the misalignment-ridden equilibrium, denoted by q_i. The reason is as follows. Assuming that the fixed cost f and variable cost a are given in terms of the same input bundle $g(\mathbf{v})$, q_i is determined independently of currency valuations as $q_i = f(\sigma - 1)/a$. The gravity norm number of firms then is $\tilde{N}_i = g(\mathbf{v}_i)/(f\sigma)$. This follows from free entry and the full employment condition, respectively. Since currency misalignment potentially leads to actual employment levels below $\mathbf{v}_i$, the number of firms in a misalignment-ridden equilibrium will typically deviate from $\tilde{N}_i$; see below.

World commodity market clearing implies $q_i = \sum_j \tilde{D}_{ij} T_{ij}$. Following Anderson and Van Wincoop (2003), we may now solve for the gravity norm mill price for country i, $\tilde{p}_i$, by inserting the market equilibrium condition into the definition of gravity norm income $\tilde{Y}_i$ in (7), which gives $\tilde{Y}_i = \tilde{N}_i \sum_j \tilde{Y}_j \left(\tilde{P}_j\right)^{\sigma-1} (\tilde{p}_{ij})^{1-\sigma}$. Rewriting this as $\tilde{N}_i (\tilde{p}_i)^{1-\sigma} \sum_j \tilde{Y}_j \left(T_{ij}/\tilde{P}_j\right)^{1-\sigma}$ and using $\tilde{s}_i := \tilde{Y}_i/\tilde{Y}_W$ (and analogously for $\tilde{s}_j$), we solve for

$$\tilde{N}_i (\tilde{p}_i)^{1-\sigma} = \tilde{s}_i \left(\tilde{\Pi}_i\right)^{\sigma-1}, \tag{8}$$

$$\text{where} \quad \tilde{\Pi}_i = \left[\sum_j \tilde{s}_j \left(T_{ij}/\tilde{P}_j\right)^{1-\sigma}\right]^{1/(1-\sigma)}. \tag{9}$$

Going back to the demand function (1), and writing $\tilde{X}_{ij}$ for the gravity norm value of bilateral exports, we have $\tilde{X}_{ij} = \tilde{p}_{ij} \tilde{D}_{ij} \tilde{N}_i = \tilde{Y}_j \left(\tilde{P}_j\right)^{\sigma-1} (T_{ij})^{1-\sigma} \tilde{N}_i (\tilde{p}_i)^{1-\sigma}$. Substituting for $\tilde{N}_i (\tilde{p}_i)^{1-\sigma}$, we have

$$\tilde{X}_{ij} = \frac{\tilde{Y}_j \tilde{Y}_i}{\tilde{Y}_W} \left(\frac{T_{ij}}{\tilde{\Pi}_i \tilde{P}_j}\right)^{1-\sigma}. \tag{10}$$

Substituting for $(\tilde{p}_i)^{1-\sigma}$ also in $\tilde{P}_j$ as given in (6) implies

$$\tilde{P}_j = \left[\sum_i \tilde{N}_i (\tilde{p}_i)^{1-\sigma} (T_{ij})^{1-\sigma}\right]^{1/(1-\sigma)} = \left[\sum_i \tilde{s}_i \left(T_{ij}/\tilde{\Pi}_i\right)^{1-\sigma}\right]^{1/(1-\sigma)}. \tag{11}$$

Equations (9) and (11) capture what Anderson and Van Wincoop (2003) call "multilateral trade resistance". Since there are M countries, these two relationships form a system of $2M$ nonlinear equations that describe how each country i is positioned in terms of real trade costs T_{ij} vis à vis the entirety of its trading partners, both as an importer ($\tilde{P}_i$) and as an exporter ($\tilde{\Pi}_i$). It is relatively obvious that with complete symmetry of real trade costs, meaning $T_{ij} = T_{ji}$, we have $\tilde{P}_i = \tilde{\Pi}_i$ and the system reduces to M equations. We henceforth assume symmetry in real trade costs.

This completes the gravity model under bilateral purchasing power parity, i.e., the gravity norm. Note that mill prices of varieties produced in different countries, $\tilde{p}_i$, have disappeared since we have assumed a uniform required input $a = 1$ in terms of the factor bundle $g(\mathbf{v})$, as well as an equal minimum unit cost of $g(\mathbf{v})$, measured in terms of our numéraire currency 1. All variables, including exporter and importer country GDPs as well as world GDP, are measured in this currency.

Our maintained hypothesis now is that T_{ij} will be lower if countries i and j use a common currency, due to the microeconomic effects briefly discussed in the introduction. To identify this effect in an econometric estimation relying on gravity norm data, we would only need to introduce an indicator variable for country pairs with a common currency when specifying a relationship between T_{ij} and the relevant trade barrier variables, including the familiar gravity controls such as distance and contiguity. However, as we have emphasized in the previous section, the first decade of the euro has witnessed nominal cost conditions evolving in massive violation of (3). Hence, we cannot estimate the gravity norm model of trade. To arrive at a workable empirical approach, we must now develop an *augmented version* of the gravity model that allows for misalignment-induced deviations from the gravity norm.

3.2 The misalignment channel

To clarify our point, we first consider possible causes of implicit currency misalignment in a currency union. Deviations from the gravity norm may arise due to asymmetric shocks, or different shock absorption mechanisms across countries. Consider, for instance, different countries' response to asymmetric endowment or technology shocks, if they are subject to a downward rigidity of some nominal factor price, say the wage rate for low-skilled labor. Depending on the endowment shock, however, full employment may require a reduction in the unskilled wage rate, relative to other factor prices. One way to achieve this without a nominal wage cut is to allow for inflation of all factor prices. It is easy to see that this may give rise to misalignment.

More specifically, using v_{ik} to denote country i's endowment with factor k ($k = 1 \dots K$) and using subscripts to indicate gradients of the minimum unit-cost functions, full employment of all factors implies that *relative* factor prices satisfy the following $K-1$ equilibrium conditions:

$$\frac{c_k\left(\mathbf{w}_i\right)}{c_1\left(\mathbf{w}_i\right)}=\frac{v_{ik}}{v_{i1}} \qquad \text{for } k=2\dots K. \tag{12}$$

This simply states that for all possible factor pairs the cost-minimizing input ratios in production of aggregate output are in line with the corresponding relative endowments.[10] Suppose that the *common nominal anchor* requires $c(\mathbf{w})=1$, and assume that at time 0 we have $c\left(\mathbf{w}_j^0\right)=c\left(\mathbf{w}_i^0\right)=1$, with $\mathbf{w}_i^0$ and $\mathbf{w}_j^0$ expressed in common currency, and satisfying equilibrium conditions (12). Moreover, suppose that countries i and j are hit by asymmetric endowment shocks $\mathbf{v}_i^1-\mathbf{v}_i^0\neq\mathbf{v}_j^1-\mathbf{v}_j^0$, and assume that country j can absorb this through full employment factor prices $\mathbf{w}_j^1$ that satisfy $c\left(\mathbf{w}_j^1\right)=1$. A case of misalignment may then arise, if for country i a change in factor prices that satisfies both, (12) and $c\left(\mathbf{w}_i^1\right)=1$, is inconsistent with the downward rigidity of some wages. In order to achieve factor market equilibrium (12), country i may then allow for nominal factor prices that violate the nominal anchor in that $c\left(\mathbf{w}_i^1\right)>1$. This implies that $\tilde{E}_{ij}<1$. With E_{ij} tied down to 1 by the common currency, the outcome then is what we call an "implicit overvaluation" of country i's currency, $m_{ij}>1$.

What do bilateral trade flows look like, if there are such deviations from the gravity norm? We first rewrite the underlying demand equation (1), using actual exchange rates E_{ij} instead of PPP rates, but still expressing all right-hand side variables in the numéraire currency. First, note that in this equation we have $p_{ij}=E_{ij}T_{ij}c(\mathbf{w}_i)/\rho$. Expressing this in currency 1 gives $E_{j1}p_{ij}=E_{j1}E_{ij}T_{ij}c(\mathbf{w}_i)/\rho=E_{i1}T_{ij}c(\mathbf{w}_i)/\rho$. Moreover, given the definition of m_{ij} and $\tilde{E}_{ij}$, we have $E_{ij}=m_{ij}\tilde{E}_{ij}$ and therefore $E_{i1}c(\mathbf{w}_i)=m_{i1}c(\mathbf{w}_1)$. Hence, the country j price index, expressed in numéraire currency 1, emerges as

$$E_{j1}P_j=\frac{c(\mathbf{w}_1)}{\rho}\left[\sum_i N_i\left(m_{i1}T_{ij}\right)^{1-\sigma}\right]^{1/(1-\sigma)}=\tilde{P}_j\cdot\mu_j^{1/(\sigma-1)}. \tag{13}$$

In the second equality we have defined

$$\mu_j:=\frac{\sum_i \tilde{N}_i\left(T_{ij}\right)^{1-\sigma}}{\sum_i N_i\left(m_{i1}T_{ij}\right)^{1-\sigma}}, \tag{14}$$

a term that we shall subsequently refer to as *multilateral misalignment*. In turn,

[10]Remember that $c(\cdot)$ is the unit cost-function dual to $g(\mathbf{v})$, which defines the input bundle used in production, both for variable and for fixed inputs.

the country j c.i.f. price of a country i variety, again expressed in currency 1 and allowing for $m_{i1} \neq 1$, is written as

$$E_{j1}p_{ij} = m_{i1}T_{ij}c(\mathbf{w}_1)/\rho = \tilde{p}_i \cdot m_{i1}T_{ij}. \tag{15}$$

With currency misalignment, we must expect deviations of the macroeconomic equilibrium that is usually assumed in the gravity model. Disequilibrium may take the form of aggregate trade imbalance (external imbalance) or unemployment (internal imbalance), or some combination of both; see Corden (1994). In order to allow for such imbalances, we write the importing country j's aggregate expenditure as $\xi_j Y_j$, whence its current account balance is equal to $B_j = \left(1 - \xi_j\right) Y_j$. Moreover, using e_i to denote the exporting country i's employment ratio (applying equally for all of its factors), its actual number of firms is determined as

$$N_i = \varepsilon_i g(\mathbf{v}_i)/\left(f\sigma\right) = \varepsilon_i \tilde{N}_i. \tag{16}$$

Notice that while ξ_j may be above or below 1, the employment ratio ε_i is restricted to $\varepsilon_i \leq 1$. For any given country i, given its pattern of currency misalignment, we must expect that the two terms representing the macroeconomic imbalance, ξ_i and ε_i, are dependent on each other. For instance, overall undervaluation of i's currency, say measured through trade-weighted average value of m_{ij} across all j above 1, would tend to cause $\xi_i < 1$ and ε_i close to 1. Of course, macroeconomic imbalances also depend on macroeconomic policies pursued. For instance, a country with an overvalued currency tends to have $\varepsilon_i < 1$, but may still achieve full employment by expansionary policy that leads to a current account deficit, i.e., $\xi_i > 1$; see again Corden (1994). As will become apparent below, our results do not depend on the type of macroeconomic policies pursued.

Actual demand with misalignment and expressed in destination currency j is then $D_{ij} = \xi_j Y_j \left(P_j\right)^{\sigma-1} \left(p_{ij}\right)^{-\sigma}$. Due to homogeneity of degree zero in income and prices, we may also write $D_{ij} = E_{j1}\xi_j Y_j \left(E_{j1}P_j\right)^{\sigma-1} \left(E_{j1}p_{ij}\right)^{-\sigma}$. Moreover, from (7) we have $\tilde{Y}_j = \tilde{N}_j q_j c(\mathbf{w}_1)/\rho$, while $Y_j E_{j1} = \varepsilon_j \tilde{N}_j q_j m_{j1} c(\mathbf{w}_1)/\rho$, hence

$$Y_j E_{j1} = \varepsilon_j m_{j1} \tilde{Y}_j. \tag{17}$$

This allows us to establish the following relationship between actual demand D_{ij}

and gravity norm demand $\tilde{D}_{ij}$:

$$D_{ij} = \tilde{D}_{ij} \cdot (m_{i1})^{-\sigma} \mu_j m_{j1} \xi_j \varepsilon_j. \tag{18}$$

This equation identifies four possible channels through which currency misalignments may cause a deviation of a typical gravity-type demand function from the gravity norm. First, there is the direct overvaluation (or undervaluation) of the country of origin currency i through the term $m_{i1} > 1$ (or $m_{i1} < 1$), with elasticity $-\sigma$. Second, there is multilateral misalignment of all currencies μ_j, operating through the destination country j's price index. Notice that from the definition of μ_j in equation (14), overvaluation of third countries' currencies boosts exports from i to j. Third, there is the direct nominal income effect from overvaluation (undervaluation) of the importer currency j, meaning $m_{j1} > 1$ ($m_{j1} < 1$). And finally, there are the macroeconomic imbalances. If country j runs a current account deficit, meaning $\xi_j > 1$, this contributes to an increase in actual demand D_{ij}, compared to gravity norm demand $\tilde{D}_{ij}$. The opposite holds true if country j suffers from misalignment-induced unemployment, meaning $\varepsilon_j < 1$.

Notice that we have described the entire pattern of bilateral over- or undervaluation of as many as M currencies by $M - 1$ misalignment terms. This reflects the well known fact that with M currencies there cannot be more than $M - 1$ independent exchange rates. Moreover, it is obvious that within this model the quantity of country j demand for country i's varieties is independent of which of the currency is used as a numéraire when expressing prices and incomes.

The next step is to move from demand of a certain country for a certain foreign variety to a general equilibrium relationship relating aggregate bilateral exports to gravity norm exports, as given in (10) as well as (9) and (11), and currency misalignments. First, note that in the absence of real trade costs, the term μ_j in equation (18) simplifies to

$$\mu_j = \frac{\sum_k \tilde{N}_k}{\sum_k N_k (m_{k1})^{1-\sigma}},$$

which is a constant that shifts demand in all pairs in the same way. Remember, however, that in this equation we must see $N_i = \varepsilon_i \tilde{N}_i$, with ε_i potentially below 1. This is an important insight. The trade effect of misalignment that runs through the multilateral dimension is the same for all bilateral trading relationships. However, in addition to the size of country j's trading partners i, their respective "distance" from country j as measured through its real trade costs T_{ij}, determines their weight in country j's multilateral misalignment effect μ_j. A further noteworthy feature is that domestic demand is also affected by misalignment

$$D_{ii} = \tilde{D}_{ii} \cdot (m_{i1})^{1-\sigma} \mu_i \xi_i \varepsilon_i, \tag{19}$$

where $(m_{i1})^{1-\sigma}$ is a direct effect, and μ_i is an indirect effect that captures misalignment with all trading partners.

Our variable of interest is the c.i.f.-value of bilateral exports, measured in country 1's currency. By analogy to (19), we aim at an expression that relates this to gravity norm exports as given in (10) above. As a first step, we write

$$X_{ij} = D_{ij} \varepsilon_i \tilde{N}_i E_{j1} p_{ij}. \tag{20}$$

The price p_{ij} is affected by misalignment. By definition, $\tilde{p}_i = c(\mathbf{w}_1)/\rho$, hence the mill price p_i in currency i is related to its gravity norm value according to $p_i = [c(\mathbf{w}_i)/c(\mathbf{w}_1)]\, \tilde{p}_i$. Moreover, by definition of bilateral purchasing power in equation (3) and the misalignment term in (4), we have $c(\mathbf{w}_i)/\, c(\mathbf{w}_1) = \tilde{E}_{1i} = E_{1i}/\, m_{1i}$. This last term may also be written as $E_{1i}/\, m_{1i} = m_{i1}/\, E_{i1} = m_{i1} E_{1i}$. All of this may be summarized by the following expressions for the c.i.f. price of a typical country i variety in country j, expressed in currency j:

$$p_{ij} = E_{ij} T_{ij} \frac{c(\mathbf{w}_i)}{c(\mathbf{w}_1)} \tilde{p}_i = E_{ij} E_{1i} m_{i1} T_{ij} \tilde{p}_i = E_{1j} m_{i1} T_{ij} \tilde{p}_i.$$

Converting back to the numéraire currency, we have $E_{j1} p_{ij} = m_{i1} T_{ij} \tilde{p}_i$, since $E_{j1} E_{1j} = 1$. Turning to aggregate exports as given in (20) and using (18), we have

$$X_{ij} = \tilde{D}_{ij} \mu_j \xi_j m_{j1} \varepsilon_j (m_{i1})^{-\sigma} \cdot \varepsilon_i \tilde{N}_i T_{ij} m_{i1} \tilde{p}_i.$$

Using $\tilde{D}_{ij} = \tilde{Y}_j \left(\tilde{P}_j\right)^{\sigma-1} (\tilde{p}_i T_{ij})^{-\sigma}$ and rearranging terms, we obtain

$$X_{ij} = \tilde{Y}_j \left(\tilde{P}_j\right)^{\sigma-1} (T_{ij})^{1-\sigma} \tilde{N}_i (\tilde{p}_i)^{1-\sigma} \cdot (m_{i1})^{1-\sigma} \mu_j m_{j1} \xi_j \varepsilon_i \varepsilon_j.$$

We now replace $\tilde{N}_i (\tilde{p}_i)^{1-\sigma} = \tilde{s}_i \left(\tilde{\Pi}_i\right)^{\sigma-1}$ from (8) in the previous subsection in this equation, which leaves us with

$$X_{ij} = \tilde{s}_i \left(\tilde{\Pi}_i\right)^{\sigma-1} (T_{ij})^{1-\sigma} \tilde{Y}_j \left(\tilde{P}_j\right)^{\sigma-1} \cdot (m_{i1})^{1-\sigma} \mu_j m_{j1} \xi_j \varepsilon_i \varepsilon_j. \tag{21}$$

Comparing this expression to equation (10), we finally arrive at an equation explaining the deviation of exports from the gravity norm as follows:

$$X_{ij} = \tilde{X}_{ij} \cdot (m_{i1})^{1-\sigma} \mu_j m_{j1} \xi_j \varepsilon_i \varepsilon_j. \tag{22}$$

We call equation (22) the "misalignment-augmented" gravity equation for bilateral trade between country j and i, whereby the "gravity norm" value of exports $\tilde{X}_{ij}$ is given in (10). In the empirical strategy implemented below, we shall make use of two alternative further formulations of this model. The first is obtained by dividing through $Y_i E_{i1} Y_j E_{j1} \xi_j$, making use of (17), thus getting rid of all variables that reflect policy preferences with respect to internal and external balance. Dropping the term $1/\tilde{Y}^W$ on the right, the core equation of our augmented gravity model then reads as follows:

$$\frac{X_{ij}}{Y_i E_{i1} Y_j E_{j1} \xi_j} = \left(\tilde{\Pi}_i \tilde{\Pi}_j\right)^{\sigma-1} (T_{ij})^{1-\sigma} (m_{i1})^{-\sigma} \mu_j. \tag{23}$$

Notice that we divide by the exporting country's *GDP*, but by the importing country's *expenditure*. This is in line with the fundamental idea of gravity: With an aggregate trade imbalance, the "economic mass" of a certain country in its role as an importer is adequately captured by its expenditure level, while for its role as an exporter it is captured by its GDP. We now call the left-hand side of (23) the *gravitational ratio of exports*.[11] Note also that equation (23) invokes our assumption, made above, that real trade costs are symmetric, $T_{ij} = T_{ji}$, whence $\tilde{P}_j = \tilde{\Pi}_j$. But this is not crucial for our main conclusions.

A remarkable aspect of equation (23) is that it involves no bilateral misalignment term. Multiple misalignments between all currencies are captured by variables that are either specific to the exporter country or the importer country, but not specific to the country-pair. We therefore refer to this equation as the *unilateral* misalignment-version of our gravity model. It allows us to state the following proposition on currency misalignments and trade in a gravity context.

[11] We introduce this term in order to emphasize a departure from existing literature. Empirical applications of the gravity equation invariably define the dependent variable as trade, relative to the product of both countries' GDPs, although a typical sample includes many countries with unbalanced trade.

Proposition 1 (decomposing bilateral misalignment) (i) *The effect of* bilateral *misalignments of real exchange rates on the gravitational ratio of exports may be decomposed into a pure exporter-country and a pure importer-country effect: the exporting country's* unilateral *misalignment vis à vis the numéraire currency, and the importing-country's misalignment-ridden* multilateral *resistance term, relative to its gravity norm multilateral resistance.* (ii) *Irrespective of whether there are real exchange rate misalignments or not, all parameters that drive the microeconomic channel of real trade costs T_{ij}, including the transaction cost effect of a common currency, may be consistently estimated by regressing the gravitational ratio of exports on the relevant trade barrier controls, provided that the estimation includes time-varying country-fixed effects that distinguish between a country's role as an exporter and importer, respectively.*

Proof. Part (i) follows from equation (23) where the exporter-country misalignment effect is $(m_{i1})^{-\sigma}$, and the importer-country effect is μ_j. This may be written as $\left(\hat{\mu}_j\right)^{\sigma-1}$, where $\hat{\mu}_j := \left(1/\mu_j\right)^{1/(1-\sigma)}$ measures multilateral misalignment in a way which is completely analogous to the CES price index of importing country j. From equations (13) and (14), it is relatively easy to verify that $\hat{\mu}_j$ is equal to $\left(E_{j1}P_j \middle/ \tilde{P}_j\right)^{\sigma-1}$, where $E_{j1}P_j$ and $\tilde{P}_j$ are the importing country's misalignment-ridden and the gravity norm multilateral resistance terms, respectively, both expressed in numéraire currency 1. Part (ii) of the proposition is a direct consequence of the fact that equation (23) decomposes bilateral misalignment into a pure exporter- and a pure importer-country effect.[12] ■

Equation (23) involves unobservable gravity norm variables, viz. the multilateral resistance terms $\tilde{\Pi}_i$ and $\tilde{\Pi}_j$ and multilateral misalignment $\hat{\mu}_j$. In our empirical strategy detailed in the next section, we make use of proposition 1 (ii) to obtain consistent estimates of T_{ij}, which we then use in order to compute these unobservables. This allows us to estimate the full unilateral version of our model as given in (23). However, such an estimation does not yet allow us to answer our key questions: Did the introduction of the Euro cause such misalignment-induced trade effects? Are they more prevalent if country pairs use the common currency than for pairs of countries with separate currencies?

In order to address these questions, we must bring bilateral cost-divergencies into the picture. This may be done by multiplying equation (22) by $(m_{j1}/m_{j1})^{\sigma}$.

[12]It should be noted that asymmetric fixed effects, as postulated by proposition 1, are dictated even if real trade costs are symmetric, as often assumed in the literature.

For easier reference, we denote cost divergence by

$$\bar{m}_{ij} := c(\mathbf{w}_i)/c(\mathbf{w}_j). \tag{24}$$

After some manipulation of terms, we obtain the following representation of the misalignment-augmented gravity model of trade:

$$\frac{X_{ij}}{Y_i E_{i1} Y_j E_{j1} \xi_j} = \left(\tilde{\Pi}_i \tilde{\Pi}_j\right)^{\sigma-1} (T_{ij})^{1-\sigma} (\bar{m}_{ij} E_{ij})^{-\sigma} (m_{j1})^{-\sigma} \mu_j. \tag{25}$$

We call this the *bilateral* misalignment-version of our gravity model, since it highlights the role of *bilateral* exchange rate misalignment $\bar{m}_{ij} E_{ij}$. Unsurprisingly, the cost divergence term $\bar{m}_{ij}$ and the nominal exchange rate enter symmetrically. Potentially, then, upward or downward trends in $\bar{m}_{ij}$ may be compensated by offsetting trends in E_{ij}, with trade left unchanged according to its gravity norm. Our key question now is whether fixing $E_{ij} = 1$ tends to cause *uncompensated* cost divergencies between member countries. If this is the case, then we may say that currency union causes trade to deviate from the gravity norm.[13]

The nominal factor prices $\mathbf{w}_i$ and $\mathbf{w}_j$ appearing in (24) are determined, jointly with the nominal exchange rate E_{ij}, though a complex interaction between the currency arrangement and the monetary policy regimes in countries i and j, and their institutions pertaining to nominal factor price determination, particularly wage formation. This same interaction also determines how nominal factor prices in these countries and their exchange rates respond to endowment shocks $\mathrm{d}\mathbf{v}_i$ and $\mathrm{d}\mathbf{v}_j$.[14] We represent this interaction through the following equation:

$$E_{ij} = (\bar{m}_{ij})^{\alpha_{ij}} \eta_i \eta_j. \tag{26}$$

This equation stipulates that the nominal exchange rate between i and j is determined by two country-specific effects and a country-pair-specific effect that represents the influence of bilateral cost divergence. The two terms η_i and η_j capture the influence of the respective country's general macroeconomic policy stance as regards

[13]In an empirical estimation of equation (25), if we were to allow for independent coefficients on $\bar{m}_{ij}$ and E_{ij}, then the estimates for these coefficients should be the same. Then, what is trivial in theory, viz. that cost divergence *may* be absorbed by nominal exchange rate adjustments, is borne out by the data. However, this does not mean that such adjustments will always take place when needed in order to compensate for trends in $\bar{m}_{ij}$.

[14]This connects to our earlier discussion where we have connected misalignment to endowment shocks. Our argument similarly applies, mutatis mutandis, to technology or productivity shocks.

the nominal exchange rate. Of course, equation (26) does not follow directly from any structural model of exchange rate determination. But it is a simple, yet flexible tool to incorporate nominal exchange rate formation in view of deviations from the gravity norm. As to the pair-specific effect captured by $(\bar{m}_{ij})^{\alpha_{ij}}$, this equation is not intended as a causality statement. Causality can go both ways. For instance, with respect to the EU, it is probably fair to say that in pre-euro-times $\bar{m}_{ij}$ has driven E_{ij}, and there was a hope that in euro-times we would have $E_{ij} = 1$ driving $\bar{m}_{ij}$, in line with what we call the gravity norm.

We have emphasized above that with C currencies there can be no more than $C - 1$ independent nominal exchange rates. Hence, the parameter α_{ij} cannot vary freely across all pairs. Nor can we hope to estimate pair-specific parameters α_{ij} with available data. To proceed towards an estimable framework, we formulate the following hypothesis:

$$\alpha_{ij} = \begin{matrix} \alpha_0 & \text{for non-euro zone country pairs} \\ \alpha_0 + \alpha_1 & \text{for euro zone country pairs.} \end{matrix} \tag{27}$$

The parameter α_0 captures the influence of bilateral cost-divergencies on bilateral nominal exchange rates for countries that have their own currencies, given the two countries macroeconomic policy regimes captured by η_i and η_j. The parameter α_1 takes care of the fact that E_{ij} is restricted to a value of 1, if countries i and j share the same currency. If $\alpha_0 = -1$ and $\alpha_1 = 0$, then we have neutrality of money: Whether countries have a common currency or not, cost divergencies do not affect trade. For countries with separate currencies, cost divergencies are perfectly offset by nominal exchange rate adjustments. And members of a currency union are able to avoid cost divergencies. Formally, this case implies $\mathrm{d}\bar{m}_{ij}/\bar{m}_{ij} = -\mathrm{d}E_{ij}/E_{ij}$, whence $\bar{m}_{ij}E_{ij}$ is a constant. If $\alpha_0 > -1$, then changes in cost-competitiveness are less than fully compensated for by nominal exchange rate changes. And if $\alpha_1 > 0$, then the common currency restriction makes a difference in that lack of exchange rate adjustment causes, or exacerbates, misalignment of the bilateral real exchange rate. This allows us to state the following proposition on the misalignment effect of a common currency in the gravity context.

Proposition 2 (misalignment effect of a common currency) (i) *Suppose nominal exchange rate determination satisfies (26) and (27). Then, in the bilateral version of the misalignment-augmented gravity model given in (25), we may replace* $(\bar{m}_{ij}E_{ij})^{-\sigma} = (\bar{m}_{ij})^{\beta_0+\beta_1 e_{ij}}\,\eta_i\eta_j$, *were* $e_{ij} = 1$ *indicates member countries of the cur-*

rency union. The coefficient $\beta_0 = -\sigma(1+\alpha_0)$ *measures the extent to which bilateral cost divergencies affect bilateral trade for countries with different currencies, while the coefficient* $\beta_1 = -\sigma\alpha_1$ *measures the differential effect caused by cost divergencies between countries who are members of a currency union.* (ii) *If these coefficients satisfy the condition* $\beta_0 + \beta_1 < \beta_0 < 0$*, then bilateral cost divergencies cause real exchange rate misalignment even for countries with separate currencies, but this misalignment effect is in any case stronger for countries who share the same currency.*

Proof. In view of (25), we may write $(\bar{m}_{ij}E_{ij})^{-\sigma} = \bar{m}_{ij}^{-\sigma(1+\alpha_{ij})}\eta_i\eta_j$, and in line with part (i) of the proposition we finally replace

$$\begin{aligned} (\bar{m}_{ij}E_{ij})^{-\sigma} &= (\bar{m}_{ij})^{\beta_0+\beta_1 e_{ij}}\,\eta_i\eta_j \\ \text{with} \quad \beta_0 &= -\sigma(1+\alpha_0) \quad \text{and} \quad \beta_1 = -\sigma\alpha_1. \end{aligned} \tag{28}$$

For part (ii), we simply need to recognize that $\beta_0 < 0$ implies $\alpha_0 > -1$, and that $\beta_1 < 0$ implies $\alpha_1 > 0$, as $\sigma > 1$ by assumption. Moreover, $\beta_0 + \beta_1 < 0$ implies $\alpha_0 + a_1 > -1$. Given our discussion preceding the proposition, this proofs part (ii). ■

In closing this section, we note one important point. In replacing as suggested in part (i) of proposition 2 we get rid of the nominal exchange rate E_{ij} in the gravity equation. This is intentional, since we do not want to control for the influence of nominal exchange rates on trade flows. Instead, our focus lies on cost divergencies $\bar{m}_{ij}$, and in estimating this version of the gravity equation we want to let the data tell us to what extent cost divergencies $\mathrm{d}\bar{m}_{ij}$ are absorbed by exchange rate adjustments.

4 Empirical implementation and results

4.1 Data and estimation method

Our estimation relies on a panel of 20 OECD countries for the years from 1995 through 2007 - a common setup in this type of literature.[15] The data stem from

[15] The countries included are: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Japan, Korea, Netherlands, Norway, Portugal, Spain, Sweden, United Kingdom, and United States. The time span was chosen with data quality considerations in mind. In particular, Baldwin (2006) discusses weaknesses of pre-1993 trade data for European countries. We drop data for the years 1993 and 1994 to avoid having to control for the effect of EU accession of some countries - a choice that does not affect our results except for adding clarity

standard sources: trade data are taken from the IMF Direction of Trade Statistics (DoTS), and gravity controls including GDPs stem from CEPII. As a proxy for nominal cost conditions in domestic currency, $c(\mathbf{w}_i)$, we use the total-economy unit labor cost from the OECD that we have already described in section 2. Using total economy values seems reasonable, given the multiple linkages between sectors in the production of traded goods. That is, we allow for the cost of non-traded intermediates to affect the competitiveness of traded goods sectors. However, running our regressions using manufacturing unit labor cost, we find that all major results are robust to this variation of the data input. For all calculations and simulations we choose the US dollar as the numéraire currency, but the results of course do not hinge on this choice.

There are two general issues relating to the appropriate method of estimation that we should like to discuss at the outset. The first relates to the fundamental point, made by Baier and Bergstrand (2007), that trade policy is not exogenous to trade. In our case as well, one might argue that the likelihood of two countries having a common currency is endogenous to bilateral trade levels. Indeed, bilateral openness to trade is one of the macroeconomic criteria of the theory of optimum currency areas (OCA); see McKinnon (1963). To the extent that this criterion does indeed determine the emergence of currency unions, the common currency variable (dummy) will itself be in structural dependence on trade. Following the reasoning of Baier and Bergstrand (2007), ignoring this endogeneity would result in an upward-bias in the coefficient indicating the trade effect of a common currency. However, as forcefully argued by Wyplosz (2006), the formation of the European Monetary Union (EMU) was certainly not guided by the theory of optimum currency areas, hence structural endogeneity can safely be ruled out. But it might still be argued that the countries eligible for EMU at the time had bilateral trade flows exceeding their "natural" gravity levels, for various reasons unrelated to the theory of OCA. We would then have the same upward-bias in the estimate, due to an omitted variable that is correlated with the currency union variable. To guard against this possibility, we will follow Baier and Bergstrand (2007) in estimating our gravity model on first differences of our panel data.

The second issue relates to the usual procedure of estimating the above gravity equations by means of log-linearization and then applying OLS. Silva and Tenreyro

in the exposition.

(2006) have pointed out that OLS in general leads to biased estimates.[16] They argue for a weighted non-linear least squares estimator, where the weights happen to coincide with those of the Poisson pseudo-maximum likelihood (PPML) regression. An important drawback of PPML is that pair-specific unobserved heterogeneity cannot be controlled for, which is potentially important in explaining selection into euro membership; see the discussion on estimating in first differences to eliminate the endogeneity problem above. Regarding stage two, our main coefficient of interest will be the interaction term $\beta_1 e_{ij}$. In non-linear models, the sign, size and significance level of coefficients on interaction terms are difficult to interpret; see **?**. We therefore rely on linear estimation models in both stages, controlling for pair-specific unobserved heterogeneity by means of a first difference transformation.[17]

4.2 Microeconomic effects

We first identify the parameters that drive the microeconomic channel. Subsequently, we shall use these parameters to construct the unobservables required to estimate the misalignment channel. Following proposition 1, equation (23) allows us to consistently estimate the trade cost elasticity of the euro, alongside other determinants of the trade cost term T_{ij}. The corresponding estimation equation is given by

$$\ln \frac{X_{ijt}}{Y_{it}E_{i1t}Y_{jt}E_{j1t}\xi_j} = \alpha e_{ijt} + \varrho \text{RTA}_{ijt} + \nu_{ij} + \nu_{it} + \nu_{jt} + u_{ijt}, \tag{29}$$

where RTA_{ijt} measures common membership in a regional trade agreement,[18] ν_{ij}, ν_{it} and ν_{jt} denote comprehensive sets of pair fixed effects, exporter-and-time effects and importer-and-time effects, and u_{ijt} denotes an error term which is assumed iid.

[16] More specifically, Silva and Tenreyro (2006) argue that the variance of the error term is likely to be correlated with country size and trade cost. Since the expected value of the logarithm of a random variable also depends on higher moments of the density, this leads to a violation of stochastic independence between the regressors and the error term in the log-linear regression equation. As a result, the OLS estimator is no longer consistent. A further reason for PPML is the presence of zero trade flows. In our sample, however, there are no zero trade flows.

[17] Recent gravity applications using linear regression models include Martin et al. (2008) and Head et al. (2010). In our linear model, the euro-dummy coefficient is small and does not enter significantly; see below. This finding is in line with Silva and Tenreyro (2010) who employ PPML on data similar to ours and conclude that there is no positive microeconomic effect. We have also experimented with PPML. Results are similar to those reported in column OECD93 in their Table 1 and are available upon request.

[18] First-differencing of our data removes all regional trade agreements with no time variation in membership between 1995 and 2007, such as the European Union (EU) and the North American Free Trade Agreement (NAFTA). Given out country sample, the only remaining RTA is the Australia-US free trade agreement.

The estimated semi-elasticity $\hat{\alpha}_1$ measures by how much bilateral trade increases through the real trade cost channel when both trading partners join the euro zone, compared to non-euro country pairs.[19] All other terms on the right-hand side of (23) are captured by fixed effects.

We estimate equation (29) using two alternative approaches. The first is a fixed effects (FE) estimator, where the pair fixed effect is ν_{ij} eliminated by means of a within-transformation. The second is to use a first difference (FD) estimator, which eliminates all pair-specific effects. Table 2 reports the estimation results for α and ϱ. Both approaches reveal euro-dummy coefficients that are very small in magnitude and do not enter the regression with conventional significance levels. This is in line with the related literature, which typically reports zero or tiny coefficients, not exceeding 2 percent.[20]

Table 2: **The microeconomic channel**

	FE	FD
Both in euro zone (α)	0.00559	-0.0147
	(0.29)	(-0.40)
Both in RTA (ϱ)	-0.115	-0.0718
	(-1.42)	(-0.71)
N	4940	4560
R^2	0.789	0.332

Notes: FE and FD mean fixed effects and first differences, respectively. The sample includes $19 \times 20 = 380$ country pairs over the period 1995 to 2007. The dependent variable is bilateral exports scaled by exporter's GDP and importer's expenditure. Cluster-robust t-statistics are in parentheses. Both regressions include comprehensive sets of exporter-and-time effects and importer-and-time effects (all not shown). Based on an F-test, we cannot reject joint significance of the pair fixed effects in column (1).

In appendix A, we include the pair fixed effects directly and trace the estimates $\hat{\nu}_{ij}$ back to the dyadic trade barrier variables. This allows us to identify the elasticities of real trade cost T_{ij} with respect to these barriers. However, given equation

[19] Specifically, the estimated percentage increase of trade due to the euro is equal to $(\exp(\hat{\alpha}_1) - 1) \times 100$.

[20] The literature usually employs a pair fixed-effects model in combination with "role-specific" (or asymmetric) country-and-time dummies. Role-specific means that the dummies distinguish between a country's role as an exporter and an importer. For a summary of the effects reported in the literature, see Baldwin et al. (2008).

(23), doing so requires that we impose a numerical value for the trade elasticity $\sigma - 1$. We set $\sigma = 5$ and $\sigma = 10$, which are the lower and upper bound, respectively, of the range suggested in Anderson and Van Wincoop (2003). Using all of this information, we finally construct a full matrix of estimated bilateral trade costs $\hat{T}_{ij}$, which are numerical representations of all time-invariant trade barriers for each country pair in the sample. Knowing $\hat{T}_{ij}$, we may exploit equilibrium conditions underlying (23) in order to calculate numerical values of the gravity norm multilateral resistance terms $\tilde{\Pi}_i$ and $\tilde{\Pi}_j$ as well as the multilateral misalignment term μ_{jt}. Details of these calculations are relegated to appendix A.

4.3 Misalignment channel

Based on numerical values of gravity norm variables, we are now in a position to estimate the misalignment channel which is responsible for deviations of trade volumes from the gravity norm, as suggested by our augmented gravity model (23). In particular, we are able to ask the question raised in the introduction: Does bilateral divergence in relative cost competitiveness exert an effect on trade among euro area countries that does not exist for countries outside a fixed exchange rate arrangement? Put differently, is euro area trade particularly affected by the fact that euro member countries cannot adjust their internal exchange rates in order to compensate for shock absorptions that are inconsistent with a common nominal anchor?

Invoking proposition 2 above, we answer this question by testing whether the effect of bilateral cost divergence, i.e. $c(\mathbf{w}_i)/c(\mathbf{w}_j) \neq 1$, on bilateral exports is *different* for within euro area trade flows, compared to trade involving countries outside the currency union. Note that equation (26) allows for such misalignment to be present also in non-euro-area trade flows. Our maintained hypothesis draws on proposition 2, and it simply states that, whatever the misalignment-induced trade effect from cost divergence between trading partners outside the euro zone, this effect is larger for trade between euro member countries which are bound together by a common nominal anchor. It must also be noted that our point is not to demonstrate the trade effect of real exchange rate variations as such. Instead, our contribution is to quantify the extent to which the euro has caused misalignment-induced trade effects.

In order to test our key hypothesis, we now run the following regression in first differences across time:

$$\begin{aligned}\Delta \ln \frac{X_{ijt}}{Y_{it}E_{i1t}Y_{jt}E_{j1t}\xi_j} &= \alpha\Delta e_{ijt} + \varrho\Delta\text{RTA}_{ijt} + \beta_0\Delta\ln\bar{m}_{ijt} \\ &+\beta_1\Delta\ln\bar{m}_{ijt}\times e_{ijt} + \gamma_1\Delta\ln m_{j1t} + \gamma_2\Delta\ln\mu_{jt} \\ &+\delta\Delta\ln\left(\tilde{\Pi}_i\tilde{\Pi}_j\right) + \nu_t + u_{ijt}. \end{aligned} \qquad (30)$$

This equation is based on proposition 2 above. The term $\Delta\bar{m}_{ijt} \equiv \Delta\ln[c(\mathbf{w}_i)/c(\mathbf{w}_j)]$ denotes the log-change in bilateral cost divergence as defined in (24). Note that first-differencing eliminates all observed time-invariant dyadic effects ν_{ij}, such as geographical distance, a common border etc. It also eliminates all unobserved effects, like cultural proximity, as well as time-invariant monadic effects. We have added a comprehensive set of time effects ν_t.[21]

The first set of estimation results is found in table 3, with a row-wise presentation of estimated coefficients, and with columns separating different specifications and country samples. All specifications include time fixed effects ν_t, but these are not reported. Column (1) is based on a specification that imposes $\beta_1 = 0$ and uses information from the simulation exercise for $\sigma = 5$, estimated on all country pairs in the sample.

Before turning to our main results, consider the effect of trade costs. Results are reported in the last two rows. The euro as a common currency does not appear to have a significantly positive effect on bilateral trade through the microeconomic channel. Indeed, the estimated coefficient $\hat{\alpha}$ in the first row implies a microeconomic effect of about 2%, but it does not bear any statistical significance. This corroborates the result obtained above, and we repeat that it is in line with existing literature. The insignificant RTA-coefficient from table 2 is corroborated as well.

Our estimation yields a negative coefficient estimate for the importer-country's misalignment with respect to the numéraire currency, $\Delta\ln m_{j1t}$, which is perfectly in line with our theoretical model; see equation (25). The importer's multilateral misalignment, $\Delta\ln\mu_{jt}$, does not enter significantly in column (1), although the sign is as expected. The reason for the large standard error is that multilateral misalignment has a strong linear relationship to other regressors; see table 10 in the appendix. In the light of equation (25), we expect $\hat{\delta}$ to be equal to $\sigma - 1$. Indeed,

[21] In view of (26) which represents our underlying view of nominal exchange rate behavior, first differencing also controls for the macroeconomic policy variables η_i and η_j, if these are time-invariant. Recall that in line with proposition 2 above we drop E_{ijt}, in order to let the data tell us about the behavior of nominal exchange rates, relative to cost divergencies.

$\hat{\delta}$ turns out to be in the expected range, we gives us confidence in our estimation approach. $\hat{\beta}_0 < 0$ indicates that bilateral cost divergence induces a divergence from the gravity norm for the average country pair.

Table 3: **Misalignment channel: Baseline specification**

	$\sigma = 5$		$\sigma = 10$	
	(1)	(2)	(3)	(4)
Bilateral cost divergence (β_0)	-0.308**	-0.258*	-0.309**	-0.259*
	(-2.46)	(-1.89)	(-2.45)	(-1.88)
Euro-induced misalign. (β_1)		-0.384*		-0.381*
		(-1.90)		(-1.88)
Importer misalign. (γ_1)	-0.634***	-0.640***	-0.614***	-0.617***
	(-5.24)	(-5.30)	(-5.54)	(-5.59)
Multilateral misalign. (γ_2)	0.048	0.0504	0.0204*	0.0211*
	(1.50)	(1.57)	(1.66)	(1.72)
Price index (δ)	4.108***	4.111***	9.561***	9.578***
	(2.87)	(2.88)	(2.99)	(3.00)
Both in euro zone (α)	0.0225	0.0225	0.0227	0.0227
	(0.99)	(0.98)	(1.00)	(0.99)
Both in RTA (ϱ)	-0.0472	-0.0472	-0.0461	-0.0461
	(-1.05)	(-1.04)	(-0.99)	(-0.98)

Notes: Estimation method: First Differences. The sample includes $19 \times 20 = 380$ country pairs over the period 1995 to 2007. The dependent variable is bilateral exports scaled by exporter's GDP and importer's expenditure. t-statistics are in parentheses. ***, **, and * indicate significance at 1%, 5%, and 10%, respectively. All regressions include time effects (all not shown).

Our main hypothesis regarding the misalignment channel receives a first treatment in column (2) in 3, where β_1 is unrestricted. Rows one and two turn to proposition 2 above, reporting coefficient estimates $\hat{\beta}_0$ and $\hat{\beta}_1$, respectively. The interpretation of these coefficients is that an x percent loss in bilateral cost competitiveness of country i vis à vis country j lowers country i's exports to country j by $(\beta_0 + \beta_1) \times x$ percent if i and j are both members of the euro zone, and by $\beta_0 \times x$ percent otherwise. The estimates in column (2) support our hypothesis that for trade between member countries a loss in bilateral cost competitiveness feeds into a stronger negative trade effect than for non-members. Note that from the first row we clearly cannot reject the hypothesis that $\beta_0 < 0$. Thus, for trade with or between non-member countries cost divergence is not fully absorbed by nominal exchange rate adjustments either. However, our key point relates to the result that $\beta_1 < 0$ at the 10 percent significance level. Invoking proposition 2, we may thus conclude from column (2) of table 3 that the euro, while not making much of a difference in the microeconomic channel, has exerted a significant misalignment-induced trade effect. Importantly, identifying an insignificant microeconomic channel does not tell us the whole story.

To explore robustness, we also test our main hypothesis on a sample where price indices and multilateral misalignment come from a simulation that imposes $\sigma = 10$. The results are reported in columns (3) and (4). Interestingly, $\hat{\delta}$, the estimated coefficient on the simulated price index, is again close to $\sigma - 1$, while all other coefficients are remarkably stable. Hence, our estimation results do not seem to hinge on the exact choice of the trade elasticity $1 - \sigma$ in stage one. A further noteworthy aspect is that setting $\sigma = 10$ renders coefficients $\hat{\gamma}_2$ on the multilateral misalignment term that are significant significant at the 10% level and have the expected sign.

Against the backdrop of limited variation in the simulated misalignment term $\ln \mu_{jt}$, we reformulate our model so that this term disappears altogether. Following Martin et al. (2008), we look at exports of country i to any destination country j, relative to exports of some other country k to that same country of destination. As a result, all importer-specific effects cancel out and we get rid of country j's unilateral and multilateral misalignment terms as well as its price index and its cost misalignment term in equation (30). Importantly, we choose the "denominator country" k among the initial members of the euro zone. Writing x_{ij} for the left-hand side of equation (25), this approach leads to

$$\frac{x_{ij}}{x_{kj}} = \left(\frac{\tilde{\Pi}_i}{\tilde{\Pi}_k}\right)^{\sigma-1} \left(\frac{T_{ij}}{T_{kj}}\right)^{1-\sigma} \left(\frac{\bar{m}_{ij} E_{ij}}{\bar{m}_{kj} E_{kj}}\right)^{-\sigma} . \tag{31}$$

Simplifying and using (26) and (28), which represent our underlying hypotheses regarding nominal exchange rate formation, the last term on the right-hand side of this equation may be written as

$$(\bar{m}_{ik} E_{ik})^{-\sigma} = \frac{\eta_i}{\eta_k} (\bar{m}_{ik})^{\beta_0 + \beta_1 e_{ik}} . \tag{32}$$

In principle, the interpretation of the coefficients β_0 and β_1 is as in proposition 2 above, but now the misalignment is between two competing countries of export supply. Differing cost divergencies between the two exporting countries and the importing country j cannot both be absorbed at the same time by exchange rate adjustments, if i and k are both members of the euro area. Suppose these two countries start out from a gravity norm equilibrium in their trade with country j. Our main hypothesis then states that $\Delta \ln \bar{m}_{ik} = \Delta \ln c(\mathbf{w}_i) - \Delta \ln c(\mathbf{w}_k) > 0$ leads to a situation where the gravity norm is necessarily violated. As regards exchange rate adjustment vis à vis currency j, the common currency will seem an overvalued or undervalued currency, depending on whether it is judged from country i's cost perspective or country k's cost perspective, relative to country j. Of course, the situation may also be a combination of both. Indeed, it might even seem an overvalued (undervalued) currency judged from either of the two exporting countries, but the overvaluation (undervaluation) will then be more (less) pronounced for country i than for country k. Thus, the hypothesis represented by equation (32) above is independent of the type of misalignment, if any, between the destination country j and any one of the two exporting countries i and k.

In levels, the estimation equation for the "ratio approach" is as follows:

$$\begin{aligned} \ln \frac{x_{ijt}}{x_{kjt}} &= \delta \ln \frac{\tilde{\Pi}_{it}}{\tilde{\Pi}_{kt}} + \alpha(e_{ijt} - e_{kjt}) + \varrho\,(rta_{ijt} - rta_{kjt}) \\ &\quad + \beta_0 \Delta \ln \bar{m}_{ikt} + \beta_1 \Delta \ln \bar{m}_{ikt} \times e_{ikt} + \nu_t + u_{ijt} \end{aligned} \qquad (33)$$

Note that all importer-country-specific effects cancel out, and any k-specific fixed effect (including η_{kt}) is absorbed by the year dummies, since we use a single denominator country for all relative export ratios x_{ijt}/x_{kjt}. Again, we include a set of time dummies ν_t in the estimation. As above, α captures the microeconomic trade effects, while the β_0 and β_1 capture the macroeconomic channel. A positive trade effect of the euro through the microeconomic channel implies $\alpha > 0$.[22] A misalignment-induced trade effect of the common currency through the macroeconomic channel implies $\beta_1 < 0$, in line with proposition 2 above.

We estimate the ratio equation (33) on first differences of our data, by complete analogy to (30) above. We provide the results for each initial euro zone country from our sample as a denominator country k.[23] Table 4 presents the estimation

[22] If i and k are both members of the euro area, then $e_{ij} - e_{kj} = 0$, reflecting the fact that they face the same transaction costs in trade with country j, no matter whether j is a member or not. Notice that by construction of our approach, k is a euro country. Thus, if j is a member, then $e_{ij} - e_{jk} = 0$ if i is a member, and $e_{ij} - e_{jk} = -1$ if i is outside the euro zone. Hence, a positive trade effect of the euro through the microeconomic channel implies $\alpha_3 > 0$.

[23] Obviously, with 11 initial member countries of the euro zone, the number of possible denomi-

results from this "ratio methodology". In the first line, we find scattered evidence in favor of a significant transaction cost effect on trade. However, with only 3 out of 10 estimates being positive and significant, we see little reason to revise our earlier conclusion of an insignificant microeconomic channel.

As in all previous estimations, bilateral cost divergence and the interaction term appear with negative coefficients which are statistically significant. Thus, the earlier result of a significant misalignment channel for trade effects of the euro is corroborated by this approach. Comparing the results in more detail, we find the coefficients to be almost twice the size of the values in table 3, a phenomenon known from the literature on this approach; see Martin et al. (2008). Comparing across columns, we find that choosing different reference countries does not change the estimates a lot. There is one exception: Choosing Ireland annihilates the significance of the misalignment channel.

4.4 Country-specific euro effects

Given the diverse picture of vastly different unit labor cost developments across member countries of the euro that we have presented in section 2 above, what do our estimation results imply for individual members' euro-related trade experience? In this section we want to answer this question by applying sample values for bilateral cost-divergence to our estimated coefficients $\hat{\beta}_0$ and $\hat{\beta}_1$. We report cumulative effects over the period 1999 - 2007, aggregating over all euro trading partners. Given the insignificant coefficient estimates for the conventional trade cost channel of the euro effect, we treat this channel as non-existent. More specifically, for each original member country i, we compute

$$\frac{\Delta_{07-99} x_{i,\text{eur}}}{x_{i,\text{eur},99}} \approx \left(\hat{\beta}_0 + \hat{\beta}_1\right) \sum_{j \neq i}^{\text{eur}} \psi_{ij,07} \Delta_{07-99} \ln \bar{m}_{ij} \quad \text{where } \psi_{ij,07} := x_{ij,07} \Bigg/ \sum_{j \neq i}^{\text{eur}} x_{ij,07}$$

$$\frac{\Delta_{07-99} x_{\text{eur},i}}{x_{\text{eur},i,99}} \approx \left(\hat{\beta}_0 + \hat{\beta}_1\right) \sum_{j \neq i}^{\text{eur}} \zeta_{ij,07} \Delta_{07-99} \ln \bar{m}_{ji} \quad \text{where } \zeta_{ij,07} := x_{ij,07} \Bigg/ \sum_{j \neq i}^{\text{eur}} x_{ij,07} \ .$$

nator countries is 10.

Table 4: **Misalignment channel: Ratio approach**

	(1) AUT	(2) BEL	(3) FIN	(4) FRA	(5) DEU	(6) IRE	(7) ITA	(8) NLD	(9) PRT	(10) ESP
Bilateral cost divergence (β_0)	-0.620***	-0.547***	-0.717***	-0.546***	-0.699***	-0.742***	-0.633***	-0.487***	-0.551***	-0.532***
	(-3.60)	(-3.40)	(-4.32)	(-3.59)	(-5.03)	(-3.45)	(-4.13)	(-3.30)	(-3.43)	(-3.18)
Euro-induced misalignment (β_1)	-0.671***	-0.936***	-0.545**	-0.881***	-0.528***	-0.152	-0.651***	-1.126***	-0.991***	-0.751***
	(-2.95)	(-3.78)	(-2.11)	(-3.54)	(-3.87)	(-0.62)	(-2.66)	(-5.17)	(-3.18)	(-2.93)
Exporter price index (δ)	7.401***	6.097***	7.883***	6.996***	7.633***	6.240***	6.630***	6.141***	5.480**	5.766***
	(3.47)	(3.28)	(4.15)	(3.73)	(4.43)	(2.81)	(3.66)	(3.51)	(2.53)	(3.16)
Both in euro zone (α)	0.0866*	-0.0225	0.00958	-0.0216	0.0413*	0.0680**	0.0233	0.0382	-0.000317	0.00729
	(1.96)	(-0.90)	(0.40)	(-0.79)	(1.67)	(2.27)	(0.88)	(1.44)	(-0.01)	(0.29)
Both in RTA (ϱ)	-0.128***	-0.00872	-0.0195	-0.0906	-0.0353	0.0512	-0.00448	-0.0343	0.105	-0.00462
	(-5.74)	(-0.21)	(-1.53)	(-1.14)	(-0.85)	-1.1	(-0.06)	(-0.54)	-0.89	(-0.05)
N	4332	4332	4332	4332	4332	4332	4332	4332	4332	4332
R^2 0.0644	0.0583	0.0426	0.0442	0.0304	0.0564	0.0363	0.15	0.056	0.0362	

Notes: Estimation method: First differences. The sample includes $19 \times 19 = 361$ country pairs over the period 1995 to 2007. The dependent variable is relative bilateral exports scaled by exporter's GDP and importer's expenditure. The reference country is listed at the top of each column. Cluster-robust t-statistics are in parentheses. ***, **, and * indicate significance at 1%, 5%, and 10%, respectively. All regressions include time effects (not shown).

The first line looks at the intra-euro export side of country i, while the second looks at its intra-euro imports. In both lines, summation is over all fellow member countries. We thus compute the misalignment-induced percentage changes in the gravitational export and import ratios, respectively, over the entire time span since introduction of the euro covered by our sample.[24] Completely analogous calculations may be carried out for trade with non-euro trading partners by using the parameter estimate $\hat{\beta}_0$ instead of $\hat{\beta}_0 + \hat{\beta}_1$ and summing up over non-euro trading partners. In a situation with $\hat{\beta}_0 \neq 0$, which is conveyed by the ratio approach, this would refer to imperfectly absorbed cost-divergencies even outside of a currency union.

Note that the gravitational ratios of exports and imports are asymmetric. Although $\Delta \ln \bar{m}_{ij} \equiv -\Delta \ln \bar{m}_{ji}$, the two calculations above do not lead to symmetric results, since whenever countries have unbalanced trade, we have $\psi_{ij} \neq \zeta_{ji}$.[25] Importantly, the numbers reported do not take into account that trade is differently important, measured as a percent of GDP, for different countries. Indeed, normalizing bilateral trade flows by the joint size (or "mass") of the trading partners is the main idea behind applying gravity. Obviously, the percentage changes of the conventional ratios of exports or imports to GDP are larger than the changes in the gravitational ratios by an amount equal to the percentage change in the trading partners GDPs or expenditures.

Table 5 presents calculated misalignment-induced effects for within euro area trade for each of the original euro member countries (plus Greece), both for its imports and its exports. Notice that this table looks only at the misalignment channel, reflecting the fact that we have not obtained a significant euro-coefficient in the transaction cost channel.[26] We report results only for the estimated coefficients $\hat{\beta}_0$ and $\hat{\beta}_1$ as given in column (2) of 3, which assumes a value of $\sigma = 5$ for the underlying simulation of the gravity norm variables. The relevant parameter estimates are almost the same for $\sigma = 10$, hence the country-specific trade effects will hardly vary across these sets of estimates. The effects using the estimates reported for the ratio approach are correspondingly larger, but are not presented in Table 5.

[24]It should be noted that this is but a rough approximation, since we apply log-linearization for a discrete, large change. We use "current period" weights calculated for 2007.

[25]Country i's value of exports to country j is normalized by the product of its GDP and the importing country's expenditure. Vice versa for the value of its imports from country j; see the definition of the gravitational export ration on the left-hand side of (23).

[26]This does not affect our results with respect to the country-specificity of the trade effects, however, given the additive nature of the two trade effect channels in the interaction setting. For example, if the euro effect is measured as the pure trade cost effect and estimated at around 2 percent as in Baldwin (2010), the numbers in table 5 would simply increase by 2 each.

Table 5: **Misalignment-induced effects on within euro-area trade**

Country	Exports	Imports
Austria	4.45	-4.23
Belgium	0.30	-3.09
Finland	2.96	-2.82
France	-0.01	0.06
Germany	11.28	-11.96
Greece	-7.94	7.40
Ireland	-9.29	9.50
Italy	-3.36	3.89
Netherlands	-3.04	2.55
Portugal	-2.44	1.77
Spain	-4.76	5.78

Notes: Time Period: 1999–2007. The columns show the percentage changes in the gravitational export and import ratios, respectively, implied by sample values of bilateral cost-divergencies if applied to our estimates of parameters $\hat{\beta}_0$ and $\hat{\beta}_1$. We use coefficients from table 3: $\hat{\beta}_0 + \hat{\beta}_1 = -0.258 - 0.384 = -0.642$. Values for Greece take account of the fact that it joined the euro area in 2001.

Of course, since currency misalignment is a zero sum "experiment", we expect a pattern of positive and negative effects across countries. Indeed, the picture is one of strong asymmetry. For Germany the euro has lead to a strong positive effect on exports well above 10 percent. This is mirrored by a negative import effect of about the same magnitude. Next come Austria and Finland, with a misalignment-induced boost in the gravitational export ratio equal to somewhat above 4 and somewhat below 3 percent, respectively. The only other country with a positive effect on exports is Belgium, but the effect is hardly above zero for exports, although for imports the effect is much stronger, above 3 percent.

All other countries see their overall intra-euro exports reduced by this channel. This holds in particular for Ireland and Greece, with exports down by more than 9 and almost 8 percent, respectively. It is tempting to argue that this partly reflects the large role that Germany plays as a trading partner for most other euro countries, but note, again, that we are looking at the gravitational ratio of exports, where the trade flows in both directions are expressed relative to the economic mass of both countries. Indeed, the role of Germany in this ratio is reduced by the fact that it has run large trade surpluses while many other countries have run trade deficits. Hence, the mere size or importance of countries cannot explain the results, even in part. The story is really one of enormous real undervaluation of the "German euro "that has accumulated over the time span considered.

What are we to conclude from table 5? In the policy debate it is sometimes argued, usually without much reasoning, that Germany has gained the most from the euro because of its high export orientation. Presumably, policy makers who argue this way would welcome table 5 as empirical evidence that substantiates their point. However, such an interpretation is grossly misleading. It is a mercantilistic interpretation. One way to read this table is that the euro has ushered in i) an increase (reduction) in German manufacturing exports (imports) and ii) a reorientation of German manufacturing exports towards euro partner countries as well as a reorientation of its imports towards non-euro countries. The opposite conclusion holds for most of the other countries.

A further very important point is that the trade effects reported in table 5 must *not* be seen as indicating benefits on an equal footing with benefits generated by additional trade, if any, that comes about through the microeconomic channel. Lower transaction costs represent savings in real resource cost that are immediately welfare enhancing. In a world characterized by monopolistic competition, these welfare effects accrue to consumers in the importing countries.[27] In contrast, the trade effects through the misalignment channel are not driven by any savings in real resource use. Additional German exports are hard-won by lower factor rewards, unless lower unit cost reflect an increase in total factor productivity (improvements in technology). Indeed, one might even argue that the appropriate welfare interpretation of table 5 is one of terms of trade improvements for countries exhibiting a positive import- and a negative export effect, and vice versa for the other countries.

[27]It is worth mentioning that the conventional welfare gains from lower transaction costs arise on infra-marginal trade, i.e., even if there is no additional trade, as suggested by our results. However, the additional gains from trade usually emphasized by new trade theory do require additional trade at the margin: variety effects, scale effects, pro-competitive effects and productivity (selection) effect; see Baldwin (2010).

4.5 Robustness checks

We use this subsection to dispel some further issues and to substantiate the robustness of our main results from the previous section. A first concern regards the specific group of euro area countries and potential selection bias. It is often argued that the euro area countries are no random selection and that estimates aiming to uncover any difference towards a comparison group simply pick up structural differences. To test for selection bias, we simply ask whether the euro area members already had a different responsiveness to cost divergence in the years leading up to the currency union. We split the sample into pre-euro and euro-years, and we repeat our estimation of equation (30) on both sub-periods, but for the pre-euro we interact the misalignment variable with an indicator variable for *future* euro membership. Obtaining similar coefficient estimates for the interaction term for both sub-periods would clearly indicate presence of a selection bias. Reassuringly, however, we find that the opposite is true. The estimates of β_0 and β_1 in table 6 reveal that for both, $\sigma = 5$ and $\sigma = 10$, in pre-euro times future euro-membership does not exert any significant interaction effect with bilateral cost-divergence, whereas actual membership in the euro-era quite clearly does. Notice that the estimated induced misalignment for euro countries in the post 1999 regressions is very close to $\hat{\beta}_0 + \hat{\beta}_1$ reported in table 3.

In a further robustness check, we add symmetric country-and-time effects to the model, symmetric meaning that the dummy variable makes no distinction between a country as an exporter and an importer. These dummy variables control for all symmetric country-specific influences that vary over time, including the gravity norm price indices.[28] In large part, table 7 replicates table 3, an important difference being that the coefficient estimate on cost divergence for all countries, $\hat{\beta}_0$, is no longer significantly different from zero. Importantly, however, our main hypothesis continues to receive support from the results obtained.

Finally, we use unit labor costs for the manufacturing sector rather than economy-wide unit labor costs. One could argue that only cost divergence originating directly from the tradable sector is important. We have, however, argued above that input linkages beyond manufacturing are generally important for the tradable good sector's competitiveness. Nevertheless, we re-run our regressions with such unit labor costs obtained solely from manufacturing. The coefficient on the price index is somewhat below its expected value, while the coefficient on bilateral cost divergence is

[28] Remember that we have assumed $T_{ij} = T_{ji}$, whence $\tilde{P}_j = \tilde{\Pi}_j$.

Table 6: **Misalignment channel: pre- and post-euro era**

	$\sigma = 5$		$\sigma = 10$	
	(1)	(2)	(3)	(4)
	pre 1999	post 1999	pre 1999	post 1999
Bilateral cost	-0.395	-0.172	-0.39	-0.172
divergence (β_0)	(-1.58)	(-1.27)	(-1.56)	(-1.27)
Euro-induced	-0.166	-0.572***	-0.167	-0.556**
misalign. (β_1)	(-0.48)	(-2.62)	(-0.48)	(-2.56)
Importer	-0.574***	-0.842***	-0.540***	-0.781***
misalign. (γ_1)	(-3.51)	(-5.99)	(-3.59)	(-6.78)
Multilateral	0.0761	0.0827*	0.0314	0.0301*
misalign. (γ_2)	(1.37)	(1.95)	(1.42)	(1.84)
Price index (δ)	6.006**	3.981***	13.58**	9.572***
	(1.99)	(2.8)	(1.98)	(3.07)
N	1444	2888	1444	2888
R^2	0.101	0.0176	0.100	0.0180

Notes: Estimation method: First Differences. The dependent variable is bilateral exports scaled by exporter's GDP and importer's expenditure. Cluster-robust t-statistics are in parentheses. ***, **, and * indicate significance at 1%, 5%, and 10%, respectively. All regressions include time effects and controls for common membership in the euro zone and in an RTA (all not shown).

slightly higher than in table 3; compare columns (1) and (2). The coefficient on the interaction term is positive, but significant only at the 15% level.[29] A reason could be that we do not take into account the importance of the manufacturing sector for a country's competitiveness. An easy way to do so is to include country-and-time effects. We have seen that the presence of country-and-time effects in a sample for total-economy-wide unit labor costs renders the coefficient on bilateral cost divergence insignificant and reverses the signs of importer misalignment and multilateral misalignment; see table 7. The same happens in the sample with manufacturing labor costs. Importantly, the interaction terms enters significantly in column (4), which lends support on our main hypothesis.

[29] The p-value is 0.122.

Table 7: **Misalignment channel: Country-and-time effects**

	$\sigma = 5$		$\sigma = 10$	
	(1)	(2)	(3)	(4)
Bilateral cost divergence (β_0)	0.0908 (0.71)	0.132 (0.96)	0.0554 (0.44)	0.0997 (0.73)
Euro-induced misalign. (β_1)		-0.332* (-1.72)		-0.346* (-1.80)
Importer misalign. (γ_1)	0.318* (1.74)	0.306* (1.69)	0.184 (1.21)	0.177 (1.16)
Multilateral misalign. (γ_2)	-0.0495 (-0.99)	-0.0453 (-0.90)	0.00155 (0.09)	0.00281 (0.16)
Both in euro zone (α)	-0.0147 (-0.39)	-0.0147 (-0.39)	-0.0147 (-0.39)	-0.0147 (-0.39)
Both in RTA (ϱ)	-0.0718 (-1.41)	-0.0718 (-1.40)	-0.0718 (-1.38)	-0.0718 (-1.37)
N	4560	4560	4560	4560
R^2	0.352	0.352	0.351	0.352

Notes: Estimation method: First Differences. The dependent variable is bilateral exports scaled by exporter's GDP and importer's expenditure. Cluster-robust t-statistics are in parentheses. ***, **, and * indicate significance at 1%, 5%, and 10%, respectively. All regressions include country-and-time effects (all not shown).

5 Summary and concluding comments

Joining a currency union involves a cost in that it implies the loss of an independent monetary policy. Having lost monetary autonomy, some countries might find it difficult to absorb macroeconomic shocks in ways that are consistent with the common nominal anchor set by the common monetary policy. In the case of the euro, it also implies enforced stress on fiscal discipline and rules of conduct. Facing these costs, countries that join a currency area will always hope for a boost in intra-union trade that might compensate for the hardships.

The literature to date has tried to estimate the trade effect of common currencies without any reference to macroeconomic imbalances caused by monetary union. In this paper, we argue that this is a problem. Loss of monetary autonomy implies that divergence in nominal cost competitiveness cannot be absorbed through

Table 8: **Misalignment channel: Manufacturing unit labor costs**

	Time effects		Country-and-time effects	
	(1)	(2)	(3)	(4)
Bilateral cost divergence (β_0)	-0.342*** (-4.16)	-0.303*** (-3.49)	0.102 (1.05)	0.143 (1.39)
Euro-induced misalign. (β_1)		-0.194 (-1.55)		-0.212* (-1.78)
Importer misalign. (γ_1)	-0.511*** (-5.31)	-0.513*** (-5.33)	0.380** (2.27)	0.374** (2.24)
Multilateral misalign. (γ_2)	0.00073 (0.03)	0.00234 (0.1)	-0.0766* (-1.83)	-0.0729* (-1.74)
Price index (δ)	2.636*** (3.01)	2.631*** (3.00)		
Both in euro zone (α)	0.0249 (1.08)	0.0249 (1.09)	-0.0147 (-0.39)	-0.0147 (-0.39)
Both in RTA (ϱ)	-0.0501 (-1.24)	-0.0501 (-1.20)	-0.0718 (-1.45)	-0.0718 (-1.43)

Notes: Estimation method: First Differences. The dependent variable is bilateral exports scaled by exporter's GDP and importer's expenditure. Cluster-robust t-statistics are in parentheses. ***, **, and * indicate significance at 1%, 5%, and 10%, respectively. All regressions include country-and-time effects (all not shown).

nominal exchange rate movements, which may lead to misalignments of real exchange rates. Such misalignments, in turn, trigger sizable trade effects. Specifically, countries with deteriorating labor cost competitiveness face a decrease in their exports to countries better able to observe the macroeconomic restriction of common nominal anchor. The overall trade effect then emerges from a combination of the conventional microeconomic channel that operates through savings in trade cost, and a macroeconomic channel driven by multiple misalignments of bilateral real exchange rates. The macroeconomic channel introduces substantial heterogeneity across member countries in the trade effects generated by the common currency. This heterogeneity is masked by uniform estimates based on the microeconomic channel alone.

We develop an extended gravity equation, which allows us to disentangle the microeconomic and the macroeconomic channels for trade effects of a common currency in a unified framework. We define trade effects from the microeconomic channel as shifts in what we call the "gravity norm" bilateral trade volumes, and macroeconomic effects as deviations from this norm, arising because lack of nominal exchange rate adjustments causes implicit under- or overvaluations of the common currency. Our empirical strategy for bringing this model to the data involves two steps. In step one we identify the microeconomic channel, which also allows us to compute unobserved gravity norm levels of trade. In step two, we use these computations in order to estimate the full "misalignment-augmented" gravity equation which includes a nominal cost-divergence term for any two trading partners as an explanatory variable. Of crucial importance, we interact this term with the dummy-variable indicating euro membership, in order to test the key hypothesis that such divergence has different implications for trade between euro-area member countries, compared to countries that have independent currencies and, thus, the option of nominal exchange rate adjustment.

Our results from applying this setup to the euro area confirm the aforementioned worries. Implicit misalignment is found to exert a significant influence on bilateral exports for euro-area countries. In particular, we find an increase in the misalignment index (representing implicit overvaluation of the currency) by 10% to reduce exports between 2.5% and 9% on average. Furthermore, in line with existing literature, we do not find strong evidence of a positive trade cost effect of the euro. Combining our estimates for the macroeconomic channel with the actual developments of bilateral misalignments since the start of the currency union, a disaggregate picture emerges which reveals substantial country heterogeneity. For Germany, the trade effects came about asymmetrically from euro-induced misalignment, boosting exports beyond the gravity norm, while boosting imports beyond this norm (and reducing exports below) for most of the other members of the euro zone. Indeed, our results indicate that in the recent history of the euro, these misalignment effects have dwarfed the conventional effects running through the trade cost channel. Furthermore, the resulting differential export performances across euro members are likely to have contributed to the build up of important macroeconomic imbalances between them.

In a broader perspective, we see three important conclusions from our study. First, given the empirical significance of the currency misalignment channel, countries considering to join the euro, or any other currency union, should not expect a sizable and balanced increase in their exports and imports to and from other union members. Most of the trade effects will depend of their relative competitiveness performance. Moreover, they are likely to be affected by "implicit currency misalignment" that derives from asymmetric shocks, or from asymmetric mechanisms of nominal shock absorption, in the face of a common nominal anchor. Even if a certain country expects to remain in line with the nominal anchor which is set by the union monetary policy, it will still be affected by other countries' inability, or unwillingness, to do the same. Secondly, a low effect of the euro on quantities traded does not mean that there are no cost-savings from introducing the euro. The larger part of cost savings operates not through additional trade, but through less costly transactions in existing trade volumes, i.e., through first order "rectangular" welfare effects. Finally, countries should avoid falling victim to mercantilistic thought when contemplating entry into the euro area. From a static welfare perspective, asymmetric misalignment effects that boost exports are akin to adverse terms of trade effects.

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A Description of simulation exercise

Real bilateral trade costs can be decomposed into (i) time-varying and (ii) time-invariant elements. Clearly, common membership in the euro area varies over time. Our estimation results suggest that the euro has no significant effect on real trade costs. We can therefore ignore common membership in the euro area when constructing the matrix of real bilateral trade costs. Typically, common membership in a regional trade agreement (RTA) is time-varying, too. Beyond the European Union (EU), our sample comprises the North American Free Trade Agreement (NAFTA) and the Australia-United States Free Trade Agreement (AUSFTA), which came into force in 1994 and 2005, respectively.[30]

Time-invariant elements of bilateral trade costs may comprise geographical distance and dummies for contiguity, common language, colonial ties, common legal origin, and common membership in EU and NAFTA. We obtain the corresponding trade cost elasticities from regressing the pair dummies on the time-invariant trade cost determinants along with sets of exporter and importer fixed effects and dividing the coefficients through $(1-\sigma)$ to get rid of the trade elasticity.

Table 9 reports the results for $\sigma = 5$ (our benchmark specification) and $\sigma = 10$.[31] Distance enters positively as a larger distance rises bilateral trade costs. Contiguity, sharing the legal origin, and being a EU member reduce bilateral trade costs. Common language and NAFTA membership do not lead to a significant drop in real trade costs.

Following Feenstra (2004), we specify bilateral trade costs as

$$T_{ij} = (\text{Dist}_{ij})^{\theta_0} \exp \sum_h \theta_h (1 - z_h), \tag{34}$$

where θ_0 is the elasticity of trade costs in distance (Dist) and θ_h is the corresponding semi-elasticity corresponding to binary trade cost components z_h.

Given symmetry of bilateral trade costs, $T_{ij} = T_{ji}$, equation (11) describes a system of 20 equations, which require information on the gravity norm GDP shares $\tilde{s}_i = \tilde{Y}_i / \sum_i \tilde{Y}_i$. Equation (17) implies $\tilde{Y}_{it} = Y_{it}E_{i1t}/(\epsilon_{it}m_{i1t})$. $Y_{it}E_{i1t}$ is actual GDP in US dollar which we take from CEPII. Data on nominal cost conditions

[30] As our sample starts in 1995, the RTA dummy in stage one only absorbs variation in joint AUSFTA membership, while joint EU and NAFTA membership is captured by country pair fixed effects.

[31] As a memo, the last column contains the untransformed estimated coefficients.

Table 9: **Trade cost elasticities**

	(1) $\sigma = 5$	(2) $\sigma = 10$	(3) Memo
Both in EU	-0.413***	-0.184***	1.653***
	(-6.80)	(-6.80)	(6.80)
Both in NAFTA	-0.0638	-0.0284	0.255
	(-0.82)	(-0.82)	(0.82)
Distance	0.123***	0.0545***	-0.491***
	(5.28)	(5.28)	(-5.28)
Contiguity	-0.109***	-0.0486***	0.438***
	(-3.10)	(-3.10)	(3.10)
Common language	0.013	0.0058	-0.0522
	(0.44)	(0.44)	(-0.44)
Colonial ties	0.085	0.0378	-0.34
	(0.91)	(0.91)	(-0.91)
Common legal origin	-0.119***	-0.0530***	0.477***
	(-6.77)	(-6.77)	(6.77)
N	343	343	343
R^2	0.988	0.988	0.988

Notes: Estimates obtained from regressing pair dummy coeffients received from estimation of equation (29) on time-invariant trade cost components and dividing through $(1 - \sigma)$. The last column reports the untransformed coefficients. Note that 37 pair dummies are in the estimation of equation (29) due to collinearity. All regressions include exporter and importer fixed effects. Cluster-robust t-statistics are in parentheses. ***, **, and * indicate significance at 1%, 5%, and 10%, respectively.

and employment ratios stem from the OECD. With the data at hand, we compute gravity norm GDP shares and numerically solve for gravity norm price indices. Using equation (8), we compute the gravity norm mass of firms $\tilde{N}_{it}$ up to the time-invariant multiplier $(\tilde{p}_i)^{1-\sigma} = c(\mathbf{w}_{i1})/\rho$. Then, the actual mass of firms follows from equation (16). Having these figures at hand, we can use equation (14) to compute the multilateral misalignment term μ_{it}. Table 10 reports the results of regression multilateral misalignment on all other regressors. In all regressions, the R^2_μ is "close" to one. Hence, multilateral misalignment has a strong linear relationship to the other regressors, which translates into an estimated standard error that is too large.

Table 10: **The dependence of multilateral misalignment on other regressors**

	(1)	(2)	(3)
	Total economy		Manuf.
	$\sigma = 5$	$\sigma = 10$	$\sigma = 5$
Bilateral cost divergence	0.621***	1.483***	0.717***
	(13.49)	(14.51)	(16.72)
Importer misalignment	2.457***	4.781***	2.174***
	(43.01)	(37.18)	(36.03)
Price index	-1.114***	-1.114***	-0.533
	(-2.66)	(-8.09)	(-1.08)
Both in euro zone	-0.00177	-0.0153	-0.0104**
	(-0.41)	(-1.65)	(-2.19)
Both in RTA	0.0135	-0.0205	-0.0217
	(0.48)	(-0.13)	(-0.71)
Year 1996	0.0356***	0.450***	0.0471***
	(5.97)	(32.85)	(7.04)
Year 1997	0.0171	0.566***	0.0177
	(1.51)	(36.26	(1.32)
Year 1998	0.0337***	0.406***	0.100***
	(3.46)	(25.85	(10.86)
Year 1999	0.0438***	0.453***	0.0545***
	(4.51)	(26.57	(4.55)
Year 2000	-0.117***	-0.0669***	-0.198***
	(-7.60)	(-2.65)	(-9.71)
Year 2001	0.00206	0.295***	-0.0372***
	(0.26)	(22.54)	(-3.02)
Year 2002	0.113***	0.620***	0.212***
	(20.59)	(31.89)	(31.84)
Year 2003	0.217***	0.885***	0.215***
	(22.97)	(28.82)	(21.88)
Year 2004	0.128***	0.599***	0.183***
	(21.14)	(30.83)	(24.69
Year 2005	-0.0112*	0.189***	-0.0351***
	(-1.90)	(16.17)	(-4.61)
Year 2006	-0.0437***	0.0219*	-0.0697***
	(-7.15)	(1.92)	(-7.31)
N	4560	4560	4560
R^2_μ	0.942	0.924	0.919

Notes: Estimation method: First Differences. The dependent variable is multilateral misalignment. Cluster-robust t-statistics are in parentheses. ***, **, and * indicate significance at 1%, 5%, and 10%, respectively. All regressions include a constant (not shown).