The Dynamic Effects of a Currency Union on Trade

Paul R. Bergin  
Department of Economics, University of California at Davis, and NBER

Ching-Yi Lin  
Department of Economics, National Tsing Hua University

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Abstract

The response of trade to a monetary union is a dynamic process. An empirical study of the European monetary union finds that the extensive margin of trade in new goods responded several years ahead of EMU implementation and ahead of overall trade volume. A dynamic rational expectations trade model shows that aggressive early entry of new firms in anticipation is explainable as a rational forward-looking response to news. The model helps identify which types of trading frictions are reduced by a currency union, and shows how new entry can be affected by uncertainty about EMU.

Keywords: currency union, extensive margin of trade, trade costs

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Correspondence to Paul R. Bergin, Dept. of Economics, University of California at Davis, One Shields Ave., Davis, CA 95616 USA, prbergin@ucdavis.edu, fax (530) 752-9382, phone 530-752-0741. Ching-Yi Lin, Department of Economics, National Tsing Hua University, 101, Sec. 2, Kuang-Fu Road, Hsin Chu 30013 Taiwan, lincy@mx.nthu.edu.tw

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1. Introduction

One of the benefits promised for Europe's monetary union was increased trade among member countries. A currency union’s ability to increase trade has been one of the most debated questions in international macroeconomics, with recent empirical studies generally finding effects that are modest in size but statistically significant.¹ This paper studies the dynamics of these trade effects. It begins by identifying new stylized facts about the timing of effects at the various margins of trade.² Its theoretical contribution is to construct a dynamic rational expectations trade model that explains these dynamics as a rational forward-looking response to news. The theoretical model is used to interpret the empirical evidence and evaluate conjectures about how monetary unions lower trade costs.³

As motivation, the paper uses panel regressions of disaggregated trade data to study the dynamics of trade before and after the implementation of Economic and Monetary Union in Europe (EMU). Estimates indicate that the extensive margin (measured as the entry of new goods categories) responds surprisingly aggressively. There is a statistically significant rise in the extensive margin already four years ahead of actual EMU adoption, and ahead of any rise in overall trade in our main samples. The extensive margin appears to overshoot in its response, building up to a maximum shortly after the implementation of the monetary union and declining afterward, at which point the rise in overall trade volume catches up.

Some previous papers have discussed the need for dynamics to account for gradual adjustment to new trade opportunities, such as time to build to generate a sluggish response of new entry. But the evidence here is the opposite; rather than being sluggish, entry instead

¹ Initially very large estimates were found by Rose (2000) using data from monetary unions predating EMU; support for large estimates is found in Glick and Rose (2002) and Frankel and Rose (2002). For critiques of this view see Persson (2001) and Baldwin (2006). For a sampling of empirical studies of the EMU, see Micco, Stein, and Ordonez (2003), Baldwin and di Nino (2006), Flam and Nordstrom (2006), Berthou and Fontagne (2008), and Frankel 2010. Estimates for the effect on trade in the EMU range from 5% to 20%. Papers studying the effect of EMU on the extensive margin of trade, including Baldwin and di Nino (2006), Flam and Nordstrom (2006), and Berthou and Fontagne (2008), and Baldwin et. al. (2008), estimate a rise in the extensive margin in the range of 2% to 19%. Studies using firm level data, such as Fontagné, Mayer, and Ottaviano (2009) for a subset of countries, are less supportive of an extensive margin effect, depending on how it is measured and the control group used.

² While Micco, Stein and Ordonez (2003) consider the timing of overall trade effects, finding that effects begin in 1998, they do not consider the extensive margin. While Flam and Nordstrom(2006) measure the extensive margin for years prior to EMU, their objective is to compare the pre-EMU (1995-1998) period to post-EMU (2002-2005), taking the earlier period as a benchmark rather than considering the possibility that these early periods could themselves show an increase in the extensive margin. Berger and Nitsch (2008) study the dynamics of EMU trade effects empirically by including an EMU time-trend in gravity regressions.

³ For influential examples of models of this type, see Ghironi and Melitz (2005, 2007), Ruhl (2008), and Atkeson and Burstein (2008).
anticipates the future trade opportunities created by EMU. It is true that EMU did not become
certain until a year before adoption, with announcement in 1998 of those countries satisfying the
convergence criteria. However, when firms respond to shifts in expectations, the future profit
opportunities need not be known with certainty; a simple shift in probabilities of uncertain
events can induce changes in firm decisions. These facts suggest a need for trade models
augmented with expectations and forward looking behavior in response to news about the future.

The theoretical contribution of the paper is to construct a trade model to understand the
role of news and shifts in expectations. The model focuses on real variables and abstracts from
money and nominal exchange rates. Because the countries joining EMU previously belonged to
a system of mutually fixed exchange rates, EMU is not associated with a significant reduction
in exchange rate volatility, or a significant change in monetary policy rules or shocks. Instead
the model studies the adoption of a common currency as the elimination of trade costs of
various types, frictions associated with currency conversion or other reduction in the
significance of national borders. These trade frictions can take one of several forms in the
model: iceberg trade costs proportional to trade volume, fixed costs paid each period, and a
one-time sunk cost. The model studies the effect of an announcement about a future reduction
in these trade costs. The model differs from Ghironi and Melitz (2005) and most models in the
literature in assuming a distinct sunk cost for exporting, which makes the entry decision
forward looking and responsive to news.

The model includes two additional features which facilitate early entry. The first is the
assumption of a large number of potential entrants to the export market for any good, so that
the relevant entry condition for trade is that firm value is equated to the sunk cost of entry. This
choice is motivated by Abbring and Campbell (2010), which derives this standard entry
condition as the equilibrium outcome of a game among a group of potential entrants. This game
implies that a potential entrant does not have the luxury of delaying entry, because the next
potential firm in line will take its spot instead. Mechanically, this simply means that the
standard entry condition typically applied to domestic entry is applied here to entering the
export market.

The second additional feature is heterogeneity among goods in the sunk cost of entry.
Some goods are more difficult to introduce to a new market than others, due to marketing or
distribution costs, and those goods with lower sunk costs are introduced first. See Arkolakis
(2009) or Ruhl (2008) for models with heterogeneous sunk costs. In the present model, this
feature assures that early entrants motivated by expectations of future profits will not have those profits competed away by future entry of other firms.

This model is used to simulate the effects of news about various types of trade reforms. The main finding is that a reduction in iceberg costs of trade generate dynamics that are most consistent with the empirical facts outlined above. In contrast, news about reducing the sunk cost itself leads to an exit of firms prior to adoption rather than the early entry observed. Further, news about the fixed cost of trade fails to generate the observed rise in overall export volume upon adoption. Finally, a stochastic version of the model shows that substantial uncertainty about whether a future monetary union will actually be implemented need not preclude an entry response among firms.

This paper also relates to Costantini and Melitz (2008), which studied how firms may begin investment in technology innovation in anticipation of future trade opportunities. Burstein and Melitz (2011) study how an announcement of future liberalization may reduce the option value of waiting and thereby induce early entry. However, the extensive margin dynamics generated through option value effects tend to rise very gradually, with much of the new entry delayed until well after trade reform occurs. We conclude that this explanation may not be best suited to explaining our particular case, which exhibits an aggressive and even overshooting response in the extensive margin.

The next section of the paper discusses the empirical methodology and new stylized facts. Section three defines the model, and section four discusses simulation results.

2. Empirical Motivation

The study uses a panel dataset which covers exports at an annual frequency from 1973 to 2004. The trade data of 1973-2000 come from the NBER-UN World Trade Data set, developed by Rob Feenstra and Robert Lipsey, documented in Feenstra et al. (2005). The trade data after 2000 come from the UN Comtrade Data set, developed as the same way as in Feenstra et al. (2005). This data set computes annual bilateral trade flows at the four-digit Standard International Trade Classification, by performing a series of adjustments on UN trade data.

Following Hummels and Klenow (2005), the extensive margin is measured in a manner consistent with consumer price theory by adapting the methodology in Feenstra (1994).

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4 The data purchased from the UN for 1984-2000 only had values in excess of $100,000, for each bilateral flow. To be consistent, the cutoff of exports in this study is set as $100,000, which implies that goods are considered nontradable if an export value of the category is less than $100,000.
The extensive margin of exports from country $j$ to $m$, denoted by $EM^j_m$, is defined as

$$EM^j_m = \sum_{i \in I^j_m} \frac{X^W_{m,i}}{X^W_m}$$

(1)

where $X^W_{m,i}$ is the export value from the world to country $m$ of category $i$. $I^j_m$ is the set of observable categories in which country $j$ has positive exports to country $m$, and $X^W_m$ is the aggregate value of world exports to country $m$. The extensive margin is a weighted count of $j$’s categories relative to all categories exported to $m$, where the categories are weighted by their importance in world’s exports to country $m$.

The corresponding intensive margin of exports from country $j$ to $m$, denoted as $IM^j_m$ is defined as

$$IM^j_m = \frac{X^j_m}{\sum_{i \in I^j_m} X^W_{m,i}}$$

(2)

where $X^j_m$ is the total export value from country $j$ to country $m$. The intensive margin is measured as $j$’s export value relative to the weighted categories in which country $j$ exports to country $m$. Therefore, multiplying the intensive margin by the extensive margin can get country $j$’s share of world exports to country $m$, $EXShare^j_m$:

$$EXShare^j_m = \frac{X^j_m}{X^W_m} = EM^j_m IM^j_m$$

(3)

The categories of goods exported might differ across exporters and change over time. With the same level of share of world exports to country $m$ at time $t$, the measurement implies that country $j$ would have a higher extensive margin measure if it exports many different categories of products to country $m$, whereas, it would have a higher intensive margin if country $j$ only export a few categories to country $m$.

First consider some preliminary summary statistics. Trade volume as a share of GDP in our dataset increased among EMU pairs by an average of 4.9 percentage points between 1998 and 2004. Interestingly, this is nearly the same increase if one takes 1990 as the starting point, 5.5%. In contrast, the average extensive margin among EMU countries experienced much of its rise prior to EMU: the percentage rise in average extensive margin was 5.7% from 1998 to 2004, but 13.2 % starting from 1990. Further, this is much larger than the increase in
the extensive margin among EU countries that did not belong to EMU, which increased only 0.8% from 1998 to 2004 and 4.2% starting from 1990. Fig. 1 plots the average log extensive margin among EMU country pairs. It shows that the rise in the extensive margin over time was not even; it seemed to accelerate in the send half of the 1990s, and it had periods of decline in the post EMU period. Of course, in order to evaluate the effect of EMU separately from other factors such as EU policies and business cycles, we need controls for these other factors. An effective means is by panel regressions which include controls for these factors and which include in the sample cases of countries that did not belong to EMU.

Separate panel regressions are run by regressing in turn the extensive margin, the intensive margin, and the exporter’s total share on the currency union status as well as controls. Controls include membership in the European Union, which entailed economic reforms that could be expected to raise bilateral trade themselves, as well as the standard set of variables representing country size and distance used in gravity trade models to explain bilateral trade. The benchmark regressions take the form:

$$Y_{jm,t} = \beta_0 + \beta_{1,EMU_{jm,t}} + \beta_{2,EU_{jm,t}} + \beta_{3,EUTrend_{jm,t}} + \lambda X_{jm,t} + \gamma F_{jm,t} + \phi \ i + \kappa EX + \omega LM + \varepsilon_{jm,t}$$

The model is estimated by ordinary least squares with robust standard errors clustered in export pair level, where $j$ is the exporter and $m$ is the importer. The dependent variables ($Y_{jm,t}$) will be either the logarithm of country $j$’s extensive margin of exports to country $m$, the logarithm of country $j$’s intensive margin, or the logarithm of share of world exports. Regressors include dummies for the currency union status, $EMU_{jm,t}$. A dummy for the European Union, $EU_{jm,t}$, is included to control the impact of a free trade area on export. However, the European Union may become a deeper agreement and increase the impacts over time, so $EUTrend_{jm,t}$ is included to control the EU effects on export through time. The regressor $X_{jm,t}$ is a set of variables that vary over time, which includes the logarithm of real GDP per capita of exporter $j$ relative to real GDP per capita of all countries who export to importer $m$, logarithm of exporter $j$’s population relative to real GDP per capita of all countries who export to importer $m$, a dummy variable indicating whether the two countries had a free trade agreement at time $t$. $F_{jm}$ is a set of variables that do not vary over time, such as the logarithm of distance between country $j$ and $m$, a common language dummy, a land border dummy. Also included is a time effect, $t$, to control for time-specific factors such as global shocks or business cycles.

To avoid omitting variables that may affect bilateral trade, two vectors of dummy variables, $EX$ and $IM$, are included indicating exporter and importer fixed effects. As Anderson
and van Wincoop (2003) proposed, country effects are included as controls for multilateral resistance. We decided to use separate country fixed effects for each country as exporter and importer, because in contrast with the related literature on trade flows, our dependent variable specifies the direction of trade.

We begin by reporting results for a sample of 15 European countries, including 3 countries which are not members of the monetary union.\(^5\) Initial results using country fixed effects are reported in the first three columns of Table 1. Joining EMU raised overall exports by 11.9\%, which is much smaller than the effects originally found by Rose but similar to those found by other researchers focusing on a European sample.\(^6\) The effect is slightly smaller in magnitude than the effect of entry into the EU. The first column indicates that the majority of this trade effect occurs at the extensive margin, which rises by 6.3\%. In fact, while the effect at the extensive margin is statistically significant, that at the intensive margin is not. This result emphasizes the importance of the extensive margin for understanding the trade effects of monetary unions. The remaining columns confirm that this result is robust to alternative sets of controls, such as country-year fixed effects to control for time-varying multilateral resistance in the determination of the trade pattern, and country-pair fixed effects to control for the bilateral tendency to trade instead of the multilateral resistance.

Table 2 reports results regarding the dynamics of these trade effects over time. The regression equation is augmented with leads and lags of the EMU indicator variable, to capture the effects of EMU before and after adoption.

\[
Y_{j,t} = \beta_0 + \sum_{s=3}^3 \beta_{s,t}EMU_{j,t+s} + \beta_2EU_{j,t} + \beta_3EUTrend_{j,t} + \lambda X_{j,t} + \gamma F_{j,t} + \phi t + \kappa EX + \omega IM + \epsilon_{j,t} \quad (4')
\]

The main finding is that the extensive margin rises well ahead of the actual adoption of the monetary union. All three sets of estimations agree on this point, all showing a statistically significant positive coefficient on all leads of the EMU indicator in their respective extensive margin regressions. The magnitudes of this effect are similar to those found in Table 1, tending to be somewhat smaller in years prior to EMU, and larger in years following actual adoption of EMU. The three sets of estimations vary among themselves regarding values of other coefficients. Overall trade rises one year ahead of EMU adoption under country fixed effects

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\(^5\) The countries included are Austria, Belgium-Luxembourg, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Netherlands, Portugal, Spain, Sweden, and United Kingdom. Ten of these joined the monetary union in 1999, and Greece joined in 2001. Denmark, Sweden, and United Kingdom did not join the monetary union.

\(^6\) The export share is 1.119 times higher (11.9\%) because \(\exp(0.112) = 1.119\); the extensive margin is 1.063 (6.3\%) because \(\exp(0.061) = 1.063\).
and country-pair fixed effects; trade rises earlier under country-pair fixed effects. The intensive margin is either insignificantly different from zero or negative in the run-up to EMU depending on the estimation, but tends to become significantly positive several years following implementation.

In order to get more precise estimates, we follow Frankel (2010) in expanding the data set to all available countries. The full country sample covers 148 countries after combining all the data sets, so we include all of these in the gravity regression above. We augment the regression equation with an additional indicator variable to control for currency unions other than EMU. Consequently, the EMU indicator variables remain specific to the monetary union in Europe, and the coefficients on these indicators can continue to be interpreted as the effect of EMU. Results are reported in Table 3. The additional data produce highly significant parameter estimates both for estimations using country fixed effects and country-year fixed effects, and there is a close correspondence in results between these two cases. We will focus on results for the latter estimation, as this controls for time-varying multilateral resistance, which past literature has emphasized as a potential source of bias.

Fig. 2 plots the regression coefficients arising from the time-varying fixed effects estimation. Estimates agree with the main conclusion of Table 2, showing a significant rise in the extensive margin in anticipation of EMU adoption, but estimates here offer greater precision and details about the dynamics. The extensive margin effect can now be seen to rise smoothly and gradually over time. Estimates are small and insignificantly different from zero for initial years, but the effect becomes significant starting four years prior to EMU adoption. This contrasts with the overall effect on trade, which does not become significant until much later, one or two years before EMU adoption depending on the criterion for significance. The magnitude of the extensive margin effect in these periods is also much larger than that on overall trade. This implies that the effect on the intensive margin of trade, the difference between overall and extensive margin, is actually negative. We can confirm that the difference between the two is statically significant, as Column 8 of Table 3 reports coefficients in the intensive margin regression, and shows that EMU dummies are significantly negative for all periods preceding EMU adoption.

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7 Data on world trade flows come from the NBER-UN World Trade data set. Data on real GDP and population come from the World Bank’s World Development Indicators. Geographical, distance, and historical information come from Rose’s (2004) data set.
The figure also shows that the dynamics change after EMU adoption. The extensive margin effect reaches its maximum about 3 years after adoption, and then falls in remaining years. At this point the overall trade effect nearly catches up with the extensive margin. Overall trade and the extensive margin rise 44% and 55% respectively. This is larger than the estimates from the European country sample in Table 2, though still much smaller than estimates of currency union effects from the work of Rose. These larger values do correspond with those found in Frankel (2010), which argued that an expanded data set, in terms of time an countries, is helpful in detecting EMU effects. The narrowing of the difference between extensive margin and overall trade after EMU adoption is confirmed by the fact that the intensive margin coefficients are no longer significantly negative.

We conduct several checks for robustness of our results. First, countries planning to join EMU were required to participate in the ERM system of fixed exchange rates for several years prior to EMU, and it is possible that exchange rate stability might have promoted trade during those years. Table 4, columns (1-3) reports results for the regression in the full sample when controls are introduced for exchange rate volatility and the exchange rate regime. Volatility of the nominal exchange rate between countries \( j \) and \( m \) is measured as the standard deviation of the first difference of the logarithm of the monthly exchange rate between the two countries. Indicators are included for whether the countries had a direct exchange rate pegged as part of a fixed exchange rate regime such as the EMS/ERM, or whether there was an indirect peg between the pair because both pegged to the same third country.8 Results are very similar to those in the preceding table, and all of our conclusions still hold: the extensive margin rises prior to the period of EMU implementation, it rises more than overall trade, and it tapers off after EMU implementation.

A second concern is if our measure of EU and EU trend might not capture the dynamics of EU implementation after 1992, so that part of what we pick up as effects preceding EMU might be actually lagged effects of EU integration. One reason to hope this is not a serious problem is the fact that we obtained our result also in the smaller sample of 15 EU countries, where any lingering effects of EU implementation should be common to all members and be picked up by the year fixed effect rather than the EMU dummies. As an additional check, we add in as a control an index created by the European Commission to track the progress of EU implementation and market integration after 1992. The Internal Market Index created by the

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8 We use the classifications of Klein and Shambaugh (2006).
European Commission is a composite of 12 indicators such as telecommunication costs and foreign direct investment flows. We use the summary of this measure created by Berger and Nitsch (2008), which sets the initial value in the base year 1992 at 20, and adds ten points for each doubling of the index. Fig. 3 shows the progression of market integration in the years after 1992. Table 4 reports regression results, which are similar to those in Table 3. EMU begins to have strongly significant effects on the extensive margin four years prior to EMU implementation, and has effects on overall trade just one year prior to implementation. Once again the extensive margin effects peak shortly after the period of implementation, and then decline. Note that like the EU indicator, the EU market integration index has a positive effect only at the intensive margin.9

In the online appendix, we demonstrate robustness for alternative country samples.

3. Theoretical Model

Consider a model of two symmetric countries, home and foreign, which trade with each other. Engaging in trade involves paying several types of trade costs: iceberg costs, fixed costs each period, and a one-time sunk cost. The model differs from Ghironi and Melitz (2005) and most models in the literature in assuming a distinct sunk cost for exporting, which makes the entry decision forward looking.10

Although the model is motivated by study of a monetary union, the model focuses on real variables and abstracts from money and nominal exchange rates. Because the countries joining EMU previously belonged to a system of mutually fixed exchange rates, EMU is not associated with a reduction in exchange rate volatility, or any significant change in monetary policy rules or shocks. Instead the model studies the adoption of a common currency as the elimination of trade costs associated with currency conversion or other reduction in the significance of national borders.

3.1 Goods market structure

Final demand \( (D) \) in the home country is an aggregate of \( n_\mu \) varieties of home goods and

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9 When we introduced dynamic dummies for EU adoption or for NAFTA, analogous to what we do for EMU in our main results, we did not find evidence of an anticipation effect like that for EMU. EMU might be different from these other trade reforms in that an extensive information campaign made sure awareness of the future monetary union was widespread, as all residents in the economies would be affected by the currency transition.

varieties of export goods from the foreign country. The aggregator is CES, with a potentially distinct elasticity between home and foreign goods aggregates (φ), and among varieties from a given country (μ).

\[
D_t = \left( \theta^\phi (D_{Ht})^{\phi-1} + (1-\theta)^\phi (D_{Ft})^{\phi-1} \right)^{\phi}\frac{\phi}{\phi-1} 
\]

(5)

where

\[
D_{Ht} \equiv n_{Ht}^{\gamma-\mu} \left( \int_0^{n_{Ht}} (d_{Ht}(i))^{\mu-1} \, di \right)^{\mu-1} = n_{Ht}^{\gamma} d_{Ht}(i) 
\]

(6)

and

\[
D_{Ft} \equiv n_{Ft}^{\gamma-\mu} \left( \int_0^{n_{Ft}} (d_{Ft}(j))^{\mu-1} \, dj \right)^{\mu-1} = n_{Ft}^{\gamma} d_{Ft}(j) 
\]

(7)

for homogeneous firms. Following Benassy (1996), the parameter γ indicates the degree of love for variety, in that γ-1 represents the marginal utility gain from spreading a given amount of consumption on a basket that includes one additional good variety in a symmetric equilibrium.

The corresponding price indexes are:

\[
P_t = \left( \theta (P_{Ht})^{\gamma-\mu} + (1-\theta) (P_{Ft})^{\gamma-\mu} \right) \frac{1}{1-\mu} 
\]

(8)

where

\[
P_{Ht} = n_{Ht}^{\gamma-\mu} \left( \int_0^{n_{Ht}} (p_{Ht}(i))^{1-\mu} \, di \right)^{1-\mu} = n_{Ht}^{\gamma-\mu} p_{Ht}(i) 
\]

(9)

\[
P_{Ft} = n_{Ft}^{\gamma-\mu} \left( \int_0^{n_{Ft}} (p_{Ft}(i))^{1-\mu} \, di \right)^{1-\mu} = n_{Ft}^{\gamma-\mu} p_{Ft}(i) 
\]

(10)

for homogeneous firms, where P is the aggregate domestic country price level, \(P_{Ht}\) is the price index of the home good, \(P_{Ft}\) is the price (to domestic residents) of the imported foreign good.

These imply relative demand functions for domestic residents:

\[
\frac{D_{Ht}}{D_t} = \theta \left( \frac{P_{Ht}}{P_t} \right)^{\gamma} \]

(11)

\[
\frac{D_{Ft}}{D_t} = (1-\theta) \left( \frac{P_{Ft}}{P_t} \right)^{\gamma} \]

(12)

and

\[
\frac{d_{Ht}(i)}{D_{Ht}} = \left( \frac{p_{Ht}(i)}{p_{Ht}} \right)^{\mu} n_{Ht}^{\gamma I-\gamma} = n_{Ht}^{\gamma I} 
\]

(13)
\[ \frac{d_{F_t}(i)}{D_{F_t}} = \left( \frac{p_{F_t}(i)}{p_{F_t}} \right)^{-\mu} n^{\mu(x-1)-\gamma} = n^{\gamma}. \]  \hspace{1cm} (14)

Analogous conditions apply to the foreign country. Note that under symmetry

\[ n_{Ht} = n_{Ft}^* \text{ and } n_{Ht}^* = n_{Ft}. \]

### 3.2 Home household problem

The representative home household derives utility from consumption \((D)\) and disutility from labor \((L)\). Households derive income by selling their labor \((L)\) at the nominal wage rate \((W)\), receiving real profits from home firms \((\Pi)\). There is no international asset trade, so trade is balanced between the two countries.

Household optimization for the home country may be written:

\[ \max E_0 \sum_{t=0}^{\infty} \beta U (D_t, L_t) \]

subject to the budget constraint:

\[ P_t D_t = W_t L_t + \Pi_t, \]

where

\[ U_t = \frac{D_t^{-\rho}}{1-\rho} - \frac{L_t^{1+\psi}}{1+\psi}. \]

Optimization implies a labor supply condition:

\[ \frac{W_t}{P_t D_t^\psi} = L_t^\psi, \]  \hspace{1cm} (15)

An analogous problem and first order conditions apply to the foreign household.

### 3.3 Home firm problem

There are two distinct types of home firms, those selling in the domestic market and those that engage in export.\(^{11}\) We will follow Alessandria and Choi (2007) in normalizing the set of domestic firms to a mass of unity \((n_{Ht} = 1)\), and focus on the entry decision of export firms. There is free entry into the export market with a one period lag subject to a one-time

\(^{11}\) The specification that firms can entry directly into the global market without first passing through a phase of selling just in the domestic market differs from the usual specification in the trade literature. This specification instead reflects the findings of the large empirical literature in managerial economics studying “born global” firms. See Oviatt and McDougall (2005) for a summary of this expansive literature, which notes that an increasing number of new firms in a wide range of industries and countries are international from inception.
sunk cost specific to a good, \( K_{Ht}^*(i) \). Home exports to the foreign market are subject to a fixed export cost each period \( F_{Ht}^* \), in units of labor, as well as a proportional iceberg trade cost, \( \tau_{Ht}^* \).

It is assumed that fraction \( \delta \) of firms must exogenously exit the market each period.

Production for all firms is linear in labor:

\[
y_i^*(t) = AL_i^*(i).
\]  

(16)

where \( A \) represents technology common to all production firms in the country.

Firm value may be represented as the discounted sum of future profits, \( \pi_{H,i}^*(t) + v_{H,i}^* \):

\[
v_{H,i}^*(t) = E_i \left\{ \sum_{\tau=1}^{\infty} \left( \beta (1 - \delta)^\tau \right) \frac{u_{c,t+\tau}}{u_{c,t}} \pi_{H,i,t+\tau}^*(i) \right\},
\]

which is represented in the model by specifying

\[
v_{H,i}^*(t) = E_i \left\{ \left( \beta (1 - \delta) \right) \frac{u_{c,t+1}}{u_{c,t}} \left( v_{H,i,t+1}^*(i) + \pi_{H,i,t+1}^*(i) \right) \right\},
\]

(17)

and

\[
\pi_{H,i}^*(t) = \left[ \left( p_{H,i}^*(t) - \frac{W_i}{A(1 - \tau_{H,i}^*)} \right) d_{H,i}^*(t) - W_i F_{H,i}^* \right] / P_i.
\]

(18)

Future profits are discounted by the stochastic discount factor of domestic households, \( \beta \frac{u_{c,t+1}}{u_{c,t}} \), which are assumed to own the firms. Maximizing this firm value implies the usual price setting behavior as a markup over marginal cost:

\[
p_{H,i}^*(t) = \frac{\mu}{\mu - 1} \frac{W_i}{A(1 - \tau_{H,i}^*)}.
\]

(19)

New firms deciding to enter the market in period \( t \) begin to produce goods in \( t+1 \). It is assumed that for each good there is an unbounded mass of potential entrants. Abbring and Campbell (2010) show that in this setting the usual entry condition equating firm value to sunk cost can be derived as an equilibrium condition arising from a game among these potential entrants:

\[
v_{H,i}^*(t) = K_{H,i}^*(t) \frac{W_i}{P_i A}.
\]

(20)
Mechanically, this specification differs from the standard trade literature only in that the standard entry condition typically applied to domestic entry is here applied to entry into the export market. Abbring and Campbell (2010) provide an intuition for why this specification should be useful in capturing the aggressive anticipatory response of entry observed in our data. This game implies that if a firm is offered the opportunity of entry, it does not have the luxury of waiting to enter at a later date, as some other potential firm will enter instead and take their place. Use the fact that all firms are identical in their profits to write $v_{H,t}^* = v_{H,t}^*(i)$ and $\pi_{H,t}^* = \pi_{H,t}^*(i)$.

New entrants augment the existing stock of firms in the market:

$$n_{H,t}^* = (1 - \delta)(n_{H,t-1}^* + n e_{H,t-1}^*)$$  \hspace{1cm} (21)$$

Regarding firms selling in the domestic market, monopolistic price setting implies:

$$p_{H,t}^*(i) = \frac{\mu W_i}{\mu - 1 A}$$  \hspace{1cm} (22)$$

### 3.4. Sunk cost specification

We allow sunk costs to vary by good, reflecting the fact that some goods are easier to introduce to a new market than are others. Following Ruhl (2008), suppose a distribution of sunk costs $G(K_{H,t}^*) = (K_{H,t}^*/K_{H,\text{max}}^*)^\chi$, where $K_{H,\text{max}}^*$ is an upper bound on the sunk cost, and $\chi$ characterizes heterogeneity. Denoting the full set of potential exported goods as $n_{H,\text{max}}^*$ and the set of entrants at the end of a period as $n x_{H,t}^* = n_{H,t}^* + n e_{H,t}^*$, we write $n x_{H,t}^* = G(K_{H,t}^*) n_{H,\text{max}}^*$, which implies the sunk cost of the marginal entrant ($i = n x_{H,t+1}^*$) rises with the fraction of potential goods that are in the market: $K_{H,t}^*(n x_{H,t+1}^*) = (n x_{H,t+1}^*/n_{H,\text{max}}^*)^{1/\chi} K_{H,\text{max}}^*$. The entry condition (20) then can be rewritten in terms of the marginal good:

$$v_{H,t}^*(n x_{H,t+1}^*) = K_{H,\text{max}}^* \left( \frac{n x_{H,t+1}^*}{n_{H,\text{max}}^*} \right)^{1/\chi} \frac{W_i}{A P_i}.$$  \hspace{1cm} (23)$$

This implies that as the range of exported goods expands into goods that are harder to introduce, new entrants demand higher expected profits in order to compensate for the higher sunk cost.

---

12 Bilbiie, Ghironi and Melitz (2007) also prove in a closed economy model that this entry condition implies no option value of waiting to enter.
An alternative interpretation of this model feature is a congestion externality for firm entry, as has been used by Das and Das (1996), Lewis (2009), and Berentsen and Waller (2009). As more firms enter, the cost of doing so increases due to an imperfectly elastic supply of a factor specific to product entry such as advertising, or due to increased search frictions.

3.5 Market clearing and equilibrium

Market clearing for the home goods market requires:

\[ n_{H,i} d_{H,i}(i) + n_{H,i}^* \frac{d_{H,i}^*(i)}{1 - \tau_{H,i}} = Y_i, \]  

where \( Y_i = \int_0^{n_{H,i}} y(i) \, di + \int_0^{n_{H,i}} \frac{y(i)}{1 - \tau_{H,i}} \, di \). Labor market clearing requires:

\[ L_i = \frac{Y_i}{A} + n_{H,i}^* F_{H,i}^* + \left( \frac{1 + \chi K_{H_{\text{max}}}^*}{A \chi} \left( \frac{n_{H,i}^*}{\chi} \right)^{\alpha/\chi} \left( \left( n_{H,i}^* + n_{e_{H,i}}^* \right)^{\alpha/\chi + 1} - n_{H,i}^{\alpha/\chi + 1} \right) \right). \]  

Balanced trade requires:

\[ P_{H,i} D_{H,i}^* = P_{F,i} D_{F,i}. \]  

Equilibrium is a sequence of the following 35 variables: \( D, P, d_{H(i)}, d_{F(i)}, p_{H(i)}, p_{F(i)} \).

3.5 Parameter values

The macro parameters are taken at standard real business cycle values: \( \rho = 1 \) (log utility), \( \psi = 1 \) (unitary labor supply elasticity), \( \mu = 6 \) (implying a price markup of 20%), and \( \beta = 0.96 \) to
represent an annual frequency. The elasticity of substation between home and foreign goods is calibrated at $\phi = 3$, the median estimate from Broda and Weinstein (2006). The choice of $\delta = 0.10$ follows Ghironi and Melitz (2005) to match data on the annual job destruction rate of 10%. In the presence of trade costs, a preference setting of $\theta = 0.5$ implies trade share in GDP is 30%, which is representative for EU counties (European Commission, 2006).

Trade cost parameter values are based on outside studies. The steady state iceberg cost $\bar{\tau}_H$ is set to 0.20, as used in Obstfeld and Rogoff (2000). Fixed costs are chosen so that export firms represent 21% of all firms (from Ghironi and Melitz, 2005), requiring $\bar{F}_H^\gamma = 0.16$. Alessandria and Choi (2007) indicate that sunk costs represent 12.6% of export firm sales. Scaling this by the share of GDP exported and the share of firms exporting that are noted above, this implies value for sunk costs in our model of $\bar{K}_H^\gamma = 0.189$. The parameter $\chi$ is set at 0.190, the values implied by the calibration in Ruhl (2008) for the common value of productivity among our firms ($A = 1$). The maximum number of exporters, $n_{H,\text{max}}$, is assumed to be twice the number of exporters in the initial steady state of the model ($\bar{n}_H$); the maximum sunk cost in the distribution, $K_{H,\text{max}}$, is taken to be $\bar{K}_H^\gamma$, defined above, scaled by $2^{\gamma \chi}$. This implies the sunk cost follows $K_{H,j}^\gamma = \left(\frac{n_{H,j}^*}{\bar{n}_H}\right)^{\chi \gamma} \bar{K}_H^\gamma$, so that in steady state when $n_{H,j+1}^* = \bar{n}_H$, we have the logical result that $K_{H,j}^* = \bar{K}_H^\gamma$.

4. Numerical Examples

The primary experiment studied is a drop in iceberg trade costs announced in year 1 that will occur in year 8, which we will refer to as period $T$. The timing represents the signing of the Maastricht treaty in 1992, formalizing plans to begin a common currency seven years later in 1999. The size of the shock is calibrated so that exports rise by the 12% magnitude observed in the empirical section, which requires a drop in iceberg trade costs from 0.20 to 0.16. Figures report impulse responses in log deviations from steady state.

13 Ruhl (2008) introduces sunk cost heterogeneity in order to explain the entry of small exporters, which requires a correlation of sunk cost heterogeneity with productivity heterogeneity. The purpose here is different, and introducing Ruhl’s productivity heterogeneity would not be solvable using our current methods. We borrow the specification and calibration of sunk cost heterogeneity from Ruhl for convenience. The result is robust to alternative calibrations of the parameters.
4.1. Model with constant sunk costs

To demonstrate the surprisingly important role played in this model by time-varying sunk costs, we first present an experiment that shuts down this part of the model by setting $\chi = 0$. Fig. 4 shows that there is no effect on overall trade or the number of exporting firms in anticipation of the monetary union; both rise first in period 8 where trade costs actually fall.

This may seem surprising, since one might think that firms would be willing to pay the one-time sunk cost of entry as soon as they begin to expect a rise in profits in future periods. But intuition comes from examining the entry condition combining (17) and (20)

$$v_{H,t}^* = E_t \left\{ \beta (1 - \delta) \frac{u_{t+1}^{H,t+1}}{u_{t,t}^*} \left( v_{H,t+1}^* + \pi_{H,t+1}^* \right) \right\} = \frac{K_{H,t}}{P_t}. \quad (27)$$

The general principle is that under free entry, an expectation of future trade cost reduction does not predict a rise in discounted future profits per firm, because additional firms will enter in future periods to soak up any extra profits that are anticipated. Begin by considering firm decisions in period $t=T-1$ for entry in period $t+1=T$: firms will progressively enter this period until discounted profits per firm are driven down to the point that they just barely cover the sunk cost of entry with no extra profits left over. Because the sunk entry cost in $T-1$ is the same as in all previous periods, entry guarantees that the value of discounted profits per firm must also be the same as in previous periods. Now consider the firm decision one period earlier, in period $t=T-2$ for entry in $T-1$. Firms anticipate the equilibrium in the next period, and realize there will be no extra profits per firm, so there is no additional benefit to entry. Conversely, extra entry in period $T-1$ would lower single-period profits in that period because monetary union has not begun and sales have not yet risen. New entry in period $T-1$ would imply a fall in profits per firm in that initial period, so entry in $T-1$ implies a stream of profits that will not cover the sunk cost of entry. The fact that firms correctly anticipate future entry that eats up extra future profits that might have compensated for lower profits in the initial periods before monetary union removes the incentive to enter in any earlier period.

Experiments described in the appendix show that this problem cannot be resolved by introducing firm productivity heterogeneity of the type modeled in Ghironi and Melitz (2005) or learning by doing. The intuition regarding productivity heterogeneity is that in Ghironi and Melitz (2005) firms do not know before paying the sunk cost whether they will have high or low productivity, so they expect that their future profits will be the same as that for later
entrants. As in the previous experiment, firms expect future entry will bid down profits to the point of just covering sunk costs of those future entrants. So early entry in periods of lower or negative initial profits cannot be justified by an expectation of higher than average future profits for those early entrants.

The appendix also reports an experiment where firms learn by doing, in that exporting in previous periods lowers fixed costs in subsequent periods. Learning by doing has been used in the macroeconomic literature for other purposes such as generating endogenous persistence\(^\text{14}\). One might think an expectation of lower future costs would make firms more willing to enter during initial periods of low profits in periods before EMU implementation. But this incentive also applies to firms that enter later in the period of implementation. Because they too are willing to enter with a lower level of initial period profits, there is greater entry in the period of implementation, which brings down the equilibrium level of profit per firm in that period. This offsets the incentive for early entry prior to implementation.

4.2 Benchmark Model

Fig. 5 reports impulse responses for the benchmark model, including time varying sunk costs. The figure indicates significant entry investment immediately in the period where the shock is announced, leading to a larger number of firms starting already in the second period. Profits fall in the initial period, as new entrants divide up the given export sales among more competitors. But entry occurs nonetheless, because the fall in current profits is compensated by higher future profits for these firms with low sunk costs. As the date of the shock approaches, yet further firms enter, as there are a smaller number of periods of lower profits before the higher single-period profits begin in period \(T\), making the present value of entry positive for a wider subset of the distribution of goods. Note also that the response in overall exports differs from that of the number of firms, in that it does not rise significantly prior to the actual shock. This coincides nicely with the empirical evidence reported earlier that the extensive margin responded to EMU several years ahead of overall exports. The reason is that while the extensive margin is driven mainly by sunk costs and forward looking behavior, the demand for imports is driven primarily by the relative price and hence by iceberg trade costs in that period.

There are some additional general equilibrium effects at work shaping the dynamics of entry. As shown in Fig. 5, wages and consumption rise by similar percentages after the

\(^{14}\) See for example Johri and Lahiri (2008).
liberalization. The fact that wages remain low in the period prior to liberalization means that sunk costs of entry are lower than they will be in the future. This should induce a greater degree of entry activity in this period, even greater than in future periods after the liberalization has taken effect, which should induce overshooting of the extensive margin relative to the long run level. However, this effect is masked by the fact that consumption rises at the same time as wage, and consumption enters the discounting of future profits in the firm’s value function. The expectation of lower marginal utility of consumption in periods after the liberalization compared to the present period lowers the valuation of profits in those periods, reducing entry. This latter general equilibrium effect can be filtered out by recalibrating the curvature of utility at $\rho=0$. This case may be practically relevant in that it reflects what firm behavior would be if firms did not discount profits using household marginal utility. Fig. 6 shows that this case does generate some overshooting in the extensive margin.

Next, the model is used to evaluate the effects of cuts in alternative trade costs. Fig. 7 reports the result of a cut in the average level of sunk cost of exporting ($K_H^s$ and $K_F^s$) by 5% in period 8, announced in period 1. Entry actually falls in the periods after the announcement rather than rises. As seen in the figure, there is a rise in entry after period 8, and because sunk cost reduction has only a small effect on trading volume, this lowers the level of expected future profits per firm. Because firms anticipate this future reduction in profits, it discourages entry in the periods prior to implementation when sunk costs are still high. This fall in entry in anticipation of trade liberalization is at odds with the empirical evidence, and suggests that EMU does not raise trade primarily by lowering sunk costs.

Fig. 8 studies the effect of a shock lowering by 5% the fixed cost of trade ($F_{H,t}$ and $F_{F,t}$) in period 8, announced in period 1. This shock does predict a rise in entry prior to the shock. But it fails to predict the sizeable rise in exports; exports rise only a third as much has the rise in entry, as the extra trade arises solely from love for variety. Further, trade rises in periods prior to the trade cost cut, as it is driven by the love of variety and hence moves in sync with the extensive margin. These failures indicate that EMU likely does not work primarily through lower fixed costs of trade.

**4.3. Uncertainty about future monetary union**
Although the Maastricht Treaty already in 1992 set a date for monetary union, there was uncertainty about the final list of countries until announced in 1998. Our empirical results suggest that there was entry of new exporting firms based upon an uncertain prospect for a future monetary union. The model must be made stochastic in order to study entry under uncertainty. Assume that trade costs follow the following stochastic process:

\[
\begin{align*}
\left( \log \tau_{Ht} - \log \bar{\tau}_{Ht} \right) &= \epsilon_i,
\left( \log \tau_{Ft} - \log \bar{\tau}_{Ft} \right) &= \epsilon_i,
\left( \epsilon_i^*, \epsilon_i^* \right) &\sim N(0, \sigma I).
\end{align*}
\]

Shocks are independently normally distributed with zero mean and benchmark standard deviation of $\sigma$. The experiment now will be a shift in the mean of the distribution of trade costs, $\bar{\tau}_{Ht}$ and $\bar{\tau}_{Ft}$, from the value 0.2 for the first seven periods and then drop to 0.16 in all future periods, and this shift in distribution is fully anticipated by all agents. Although the mean of the distribution shifts in a way fully anticipated by agents, there is still uncertainty about the realized value of trade costs in a given period, as shocks make trade costs fluctuate around the mean. The stochastic model will be solved for a second order approximation. The trajectory of all endogenous variables are solved for a sequence of 50 draws for the shocks, and the mean over simulations is reported. We simulate the benchmark version of the model with heterogeneity in sunk as reported in Fig. 5 previously.

For a setting of $\sigma = 0$, where there is no uncertainty in the model, the mean trajectories of variables are very similar to Fig. 5, as should be expected. The maximum rise in overall trade (in period 8) is 8.7% and the rise in the number of firms is 2.1%. As the value of $\sigma$ is increased, the degree of uncertainty about future trade cost levels progressively rises. Given random fluctuations in trade costs in periods after as well as before the date set for EMU adoption, firms know it is possible that the realization of trade costs may not be smaller in a post EMU period than a period before EMU. For example, for the setting of $\sigma = 0.010$ the probability that trade cost in the period after EMU implementation will be lower than the period of the announcement is 64%. In other words there is a 36% chance that trade costs will

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Let $\tau_{H< T}^*$ represent trade cost in a period before the date of expected EMU implementation and $\tau_{H>T}^*$ represent trade cost in periods after. The difference $\tau_{H>T}^* - \tau_{H<T}^*$ is normally distributed with mean
not fall in the period of EMU implementation. The second order solution of the model indicates that this uncertainty dampens somewhat the maximum impact of the EMU announcement, but the effect is very modest. Under $\sigma = 0.010$ the impact on the number of exporting firms remains at 98% of its impact under no uncertainty, and the trade volume rise is unaffected.

As $\sigma$ is progressively raised the probability of a trade cost fall after EMU progressively falls. For very large $\sigma$ the model approaches its limit of a 50/50 chance of trade costs falling, which approximates an expectation that EMU will not take place or not be effective. Fig. 9 plots what fraction of the impact under certainty survives for various levels of uncertainty. Trade volumes appear to be unaffected by the uncertainty. The extensive margin is affected noticeably only for very high degrees of uncertainty, as the probability of lower trade costs reaches close to the limit of 50%, with very minimal impacts otherwise.

One reason that uncertainty may have small effects could be the choice of a lower value of $\rho$, the coefficient of relative risk aversion, at unity. We can consider a larger degree of risk aversion at $\rho = 3$, which is at the upper range of risk aversion typically considered in the DSGE literature. The results for this setting are also reported in Fig. 9. Trade volume is little affected by uncertainty. The extensive margin now is affected for somewhat lower degrees of uncertainty, with the impact reduced to 96% of its maximum for a probability (of trade cost reduction) of 64%, and the impact is reduced to 84% for a probability of 57%. Again the impact is reduced near zero as the probability approaches its limit of 50%. The results support the conclusion that firms will respond strongly to the possibility of trade cost reduction, even if there is a good deal of uncertainty about whether that future trade cost reduction will actually take place.

5. Conclusion

A currency union’s ability to increase international trade is one of the most debated questions in international macroeconomics. This paper employs a DSGE model to study the dynamics of these trade effects. First, original empirical work with data from the European monetary union finds that the extensive margin of trade (entry of new goods) responds ahead of the intensive margin (increased trade of existing goods). The number of products being traded

$\bar{\tau}_{ht>0} - \bar{\tau}_{ht<0} = -0.035$ and standard deviation $\sqrt{2} \sigma = \sqrt{2} \times 0.1 = 0.141$. The probability that $\hat{\tau}_{ht>0} - \hat{\tau}_{ht<0} > 0$ is 0.691.
begins to rise several years prior to the currency union adoption, peaking near the time of adoption and attenuating somewhat thereafter. A DSGE model indicates that this dynamic response in firm entry is explainable as a rational forward-looking response to a news shock about a future monetary union which is expected to lower iceberg (ie. proportional) trade costs, and where entry in the foreign market involves a one-time sunk cost that is heterogeneous across goods. The model indicates that alternative explanations for a currency union trade effect, that it lowers the sunk cost or a fixed but repeated cost of trade, are inconsistent with the dynamics of the extensive margin evidence.

The finding that the extensive margin of trade anticipates implementation of a monetary union implies that some of the welfare gains, which work through love of variety in utility, rely upon expectations of a monetary union and precede its actual adoption. This suggests that gains from EMU may rely in part upon expectations for the union’s credibility for the future.
6. References


Arkolakis, K. 2009. Market penetration costs and the new consumers margin in international trade, mimeo, Yale University.


Ruhl, Kim J. 2008. The international elasticity puzzle, mimeo, University of Texas Austin.
Table 1: Gravity regressions with EMU indicator, European sample

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<th>Dependent Variable</th>
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** indicates significance at 1% level, * at 5%, and + at 10%. Data cover 1973-2004, 15 EU countries.

Table 2. Gravity regressions with EMU lag and lead indicators, European sample

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<th>Dependent Variable</th>
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** indicates significance at 1% level, * at 5%, and + at 10%. Data cover 1973-2004, 15 EU countries.
Table 3: Gravity regressions with EMU lag and lead indicators, full country sample

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| EMU_3ahead         | 0.492** | -0.097 | 0.394** | 0.028 | 0.054 | 0.082 | 0.374** | -0.240** | 0.133+
|                    | (0.090) | (0.061) | (0.077) | (0.090) | (0.087) | (0.093) | (0.091) | (0.062) | (0.076) |
| EMU_2ahead         | 0.516** | -0.091 | 0.425** | 0.010 | 0.055 | 0.065 | 0.393** | -0.229** | 0.165* |
|                    | (0.094) | (0.065) | (0.079) | (0.091) | (0.087) | (0.093) | (0.094) | (0.066) | (0.077) |
| EMU_1ahead         | 0.558** | -0.062 | 0.496** | -0.008 | 0.087 | 0.079 | 0.444** | -0.181** | 0.263** |
|                    | (0.097) | (0.068) | (0.080) | (0.091) | (0.088) | (0.094) | (0.097) | (0.068) | (0.081) |
| EMU_0ahead         | 0.571** | -0.082 | 0.490** | -0.029 | 0.067 | 0.037 | 0.510** | -0.227** | 0.283** |
|                    | (0.099) | (0.069) | (0.081) | (0.092) | (0.088) | (0.094) | (0.100) | (0.069) | (0.081) |
| EMU_1after         | 0.665** | -0.108 | 0.558** | 0.011 | 0.054 | 0.064 | 0.553** | -0.133+ | 0.420** |
|                    | (0.102) | (0.071) | (0.084) | (0.092) | (0.089) | (0.095) | (0.104) | (0.072) | (0.085) |
| EMU_2after         | 0.559** | -0.036 | 0.523** | -0.104 | 0.121 | 0.017 | 0.580** | -0.139+ | 0.440** |
|                    | (0.107) | (0.074) | (0.086) | (0.093) | (0.089) | (0.096) | (0.105) | (0.073) | (0.086) |
| EMU_3after         | 0.590** | -0.030 | 0.560** | -0.131 | 0.132 | 0.001 | 0.613** | -0.133+ | 0.480** |
|                    | (0.110) | (0.077) | (0.091) | (0.094) | (0.090) | (0.097) | (0.107) | (0.075) | (0.090) |
| EMU_4after         | 0.403** | 0.141+ | 0.544** | -0.187+ | 0.256** | 0.069 | 0.432** | -0.037 | 0.395** |
|                    | (0.121) | (0.077) | (0.098) | (0.103) | (0.099) | (0.106) | (0.117) | (0.079) | (0.099) |
| EMU_5after         | 0.409** | 0.158+ | 0.567** | -0.255* | 0.281** | 0.026 | 0.433** | -0.067 | 0.367** |
|                    | (0.124) | (0.080) | (0.100) | (0.104) | (0.099) | (0.107) | (0.120) | (0.082) | (0.102) |
| Custrict           | 1.000** | -0.020 | 0.980** | 0.042 | 0.183+ | 0.225* | 0.974** | -0.042 | 0.932** |
|                    | (0.143) | (0.093) | (0.170) | (0.103) | (0.099) | (0.106) | (0.144) | (0.091) | (0.168) |
| Regional           | 0.720** | 0.423** | 1.144** | -0.019 | 0.213** | 0.194** | 0.648** | 0.434** | 1.082** |
|                    | (0.109) | (0.073) | (0.115) | (0.040) | (0.038) | (0.041) | (0.111) | (0.073) | (0.115) |
| EU                 | -0.490** | 0.253** | -0.237** | 0.093** | 0.179** | 0.272** | -0.525** | 0.314** | -0.211** |
|                    | (0.080) | (0.052) | (0.084) | (0.035) | (0.034) | (0.036) | (0.081) | (0.052) | (0.075) |
| EU_Trend           | -0.055** | 0.028** | -0.027** | -0.010** | 0.027** | 0.017** | -0.055** | 0.025** | -0.030** |
|                    | (0.005) | (0.003) | (0.005) | (0.002) | (0.002) | (0.002) | (0.005) | (0.003) | (0.005) |

** indicates significance at 1% level, * at 5%, and + at 10%.
Table 4: Gravity regressions with EMU lag and lead indicators, full country sample, with time-varying measures of European market integration, country-year fixed effects

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Controls for Exchange Rate Volatility and Regime</th>
<th>Index of European Market Integration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1) EXT (2) INT (3) OVER</td>
<td>(4) EXT (5) INT (6) OVER</td>
</tr>
<tr>
<td>EMU_7ahead</td>
<td>0.105 (-0.119*) -0.013</td>
<td>0.138* (-0.138* 0.001)</td>
</tr>
<tr>
<td></td>
<td>(0.087) (0.054) (0.074)</td>
<td>(0.081) (0.053) (0.070)</td>
</tr>
<tr>
<td>EMU_6ahead</td>
<td>0.142 -0.141+ 0.000</td>
<td>0.145+ (-0.147* -0.001)</td>
</tr>
<tr>
<td></td>
<td>(0.090) (0.055) (0.074)</td>
<td>(0.083) (0.053) (0.071)</td>
</tr>
<tr>
<td>EMU_5ahead</td>
<td>0.130 -0.147** -0.017</td>
<td>0.107 -0.139** -0.033</td>
</tr>
<tr>
<td></td>
<td>(0.091) (0.056) (0.073)</td>
<td>(0.081) (0.053) (0.069)</td>
</tr>
<tr>
<td>EMU_4ahead</td>
<td>0.311* -0.219* 0.092</td>
<td>0.312* -0.219* 0.093</td>
</tr>
<tr>
<td></td>
<td>(0.090) (0.061) (0.077)</td>
<td>(0.095) (0.064) (0.076)</td>
</tr>
<tr>
<td>EMU_3ahead</td>
<td>0.375* -0.249** 0.126</td>
<td>0.330* -0.227** 0.103</td>
</tr>
<tr>
<td></td>
<td>(0.091) (0.061) (0.077)</td>
<td>(0.094) (0.064) (0.076)</td>
</tr>
<tr>
<td>EMU_2ahead</td>
<td>0.400** -0.221** 0.179*</td>
<td>0.298* -0.191* 0.106</td>
</tr>
<tr>
<td></td>
<td>(0.095) (0.067) (0.080)</td>
<td>(0.096) (0.067) (0.076)</td>
</tr>
<tr>
<td>EMU_1ahead</td>
<td>0.452** -0.168* 0.284*</td>
<td>0.311* -0.128+ 0.183*</td>
</tr>
<tr>
<td></td>
<td>(0.099) (0.069) (0.085)</td>
<td>(0.096) (0.068) (0.079)</td>
</tr>
<tr>
<td>EMU_0ahead</td>
<td>0.506** -0.229** 0.277**</td>
<td>0.337* -0.153* 0.184*</td>
</tr>
<tr>
<td></td>
<td>(0.102) (0.069) (0.083)</td>
<td>(0.095) (0.068) (0.077)</td>
</tr>
<tr>
<td>EMU_1after</td>
<td>0.548** -0.134+ 0.414**</td>
<td>0.342* -0.042 0.300*</td>
</tr>
<tr>
<td></td>
<td>(0.106) (0.073) (0.087)</td>
<td>(0.095) (0.070) (0.079)</td>
</tr>
<tr>
<td>EMU_2after</td>
<td>0.575** -0.143+ 0.7433**</td>
<td>0.324* -0.030 0.294*</td>
</tr>
<tr>
<td></td>
<td>(0.107) (0.073) (0.089)</td>
<td>(0.094) (0.070) (0.078)</td>
</tr>
<tr>
<td>EMU_3after</td>
<td>0.605** -0.131+ 0.474*</td>
<td>0.302* 0.004 0.307*</td>
</tr>
<tr>
<td></td>
<td>(0.110) (0.075) (0.092)</td>
<td>(0.093) (0.071) (0.079)</td>
</tr>
<tr>
<td>EMU_4after</td>
<td>0.428** -0.040 0.387**</td>
<td>0.079 0.116 0.195*</td>
</tr>
<tr>
<td></td>
<td>(0.119) (0.080) (0.101)</td>
<td>(0.106) (0.078) (0.088)</td>
</tr>
<tr>
<td>EMU_5after</td>
<td>0.430** -0.072 0.358**</td>
<td>0.025 0.110 0.135</td>
</tr>
<tr>
<td></td>
<td>(0.123) (0.083) (0.104)</td>
<td>(0.104) (0.078) (0.087)</td>
</tr>
<tr>
<td>EU</td>
<td>-0.526* 0.309** -0.217*</td>
<td>-0.771* 0.393* -0.378*</td>
</tr>
<tr>
<td></td>
<td>(0.081) (0.052) (0.075)</td>
<td>(0.109) (0.065) (0.089)</td>
</tr>
<tr>
<td>EU trend</td>
<td>-0.055* 0.025* -0.030*</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.005) (0.003) (0.005)</td>
<td></td>
</tr>
<tr>
<td>Direct Peg</td>
<td>0.072 0.223** 0.295*</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.070) (0.059) (0.083)</td>
<td></td>
</tr>
<tr>
<td>Indirect Peg</td>
<td>-0.028 -0.073** -0.101*</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.027) (0.023) (0.033)</td>
<td></td>
</tr>
<tr>
<td>Exch. Rate Volatility</td>
<td>-0.101* 0.162* 0.064</td>
<td>-0.102** 0.167* 0.065</td>
</tr>
<tr>
<td></td>
<td>(0.038) (0.027) (0.040)</td>
<td>(0.039) (0.028) (0.040)</td>
</tr>
<tr>
<td>Market Integ. Index</td>
<td></td>
<td>-0.024** 0.013** -0.011**</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.004) (0.003) (0.004)</td>
</tr>
</tbody>
</table>

** indicates significance at 1% level, * at 5%, and + at 10%.
Fig. 1. Plot of the average extensive margin measure (in logs) for EMU country pairs

Fig. 2. EMU indicators over time
(Full country sample, time-varying fixed effects)

\[ t = \text{year of EMU adoption (1999 for most)} \]
* significant at 1%; + significant at 5%.
Fig 3. Index of EU market integration

Fig 4: Response to an anticipated permanent symmetric fall in iceberg trade costs, model with constant sunk cost

Shock: fall in iceberg cost from 0.2 to 0.16 in period 8, announced in period 1.

Benchmark parameter settings, except $\chi = 0$. 
Fig 5: Response to an anticipated permanent symmetric fall in iceberg trade costs, benchmark model

Shock: fall in iceberg cost from 0.2 to 0.16 in period 8, announced in period 1.

Fig 6. Overshooting in extensive margin under $\rho = 0$

Shock: fall in iceberg cost from 0.2 to 0.16 in period 8, announced in period 1.
Fig. 7. Response to an anticipated future permanent fall in sunk cost

Shock: fall in iceberg cost from 0.2 to 0.16 in period 8, announced in period 1.
Fig 8. Response to an anticipated future symmetric fall in fixed cost

Shock: fall in fixed cost by 5% in period 8, announced in period 1.

Fig 9. Effect of uncertainty

Note: The figure plots the rise in trade volume and extensive margin in period 8 as fractions of the values achieved by each under no the case of no uncertainty. The bottom axis indicates the probability that the draw of stochastic iceberg trade costs in a period after the fall in distribution mean will be lower than before the fall in distribution mean.
Appendix:

A1. Additional robustness checks

Here we report on the robustness of our results to using alternative country samples. In addition to the European Union Sample of 15 countries, we considered adding 3 European countries not in the EU (Iceland, Norway, and Switzerland), or alternatively adding 3 non-European countries (United States, Canada, Japan), and a sample of all developed countries in the database. Our all-country sample nests each of these subsamples. For each sample we estimated our basic regression, as well as the specification including exchange rate volatility and exchange rate regime indicators, and a specification including the European market integration index. In addition, we also estimated a specification that included dynamic dummies for EU membership before and after EU implementation in 1992, analogous to what we estimate for EMU membership in the benchmark specification. Table A1 summarizes the robustness of our empirical claims for the various samples and regression specifications. Our main conclusions, regarding an early and significant extensive margin response are robust for almost all samples and specifications, as is the result that the extensive margin effect decays after EMU implementation. The results regarding the effects of EMU on overall trade are somewhat less robust, as is the result that the magnitude of extensive margin effects is larger than that for overall trade.

A2. Productivity heterogeneity

One might think that productivity heterogeneity might be able to substitute for sunk cost heterogeneity in facilitating early entry. If some firms are more productive than others, these firms will have profits even after less productive firms enter in later periods, which would justify immediate entry of the most productive firms. We follow the convention for modeling firm heterogeneity under a sunk cost as discussed in Ghironi and Melitz (2005), hereafter GM. Firms pay the sunk cost of entry before knowing their productivity draw, so that the sunk cost decision depends upon expectations of productivity, that is, firm averages.16 Our model differs from GM in that we wish to specify a sunk cost associated with the exporting decision not just

---

16 An alternative would be to allow firms to pay the sunk cost after knowing their productivity draw as in Ruhl (2008). This would greatly amplify the complexity of model solution, as one would need to track the productivity levels of all firms at all periods, rather than taking aggregate variables as functions of average productivity as in Ghironi and Melitz (2005). We consider the possibility of heterogeneity known at the time of entry later in the paper, where heterogeneity takes a form that does not pose this problem for model solution.
firm entry into the domestic market. As in the benchmark model above, this is facilitated by assuming that exportable and domestically consumed goods are produced by distinct sectors populated by two distinct sets of firms, so that firm creation in the export sector is synonymous with entry into the export market.

For firms in the export sector, a firm-specific productivity term \( z \) augments production: 
\[
y_t(i) = A(z(i)) L_t(i).
\]
Following GM, firm productivity is assumed to follow a Pareto distribution with shape parameter \( k \) and lower bound \( z_{min} \): 
\[
G(z) = 1 - (z_{min}/z)^k.
\]
Productivity averages can be computed:
\[
\bar{z} = \left[ \int_{z_{min}}^{\infty} z^{\mu-1} dG(z) \right]^{1/\mu-1} = z_{min}\{k/[k - (\mu - 1)]\}^{1/(\mu - 1)}.
\]
Aggregates in the export sector can be computed as functions of this average productivity, as if the export sector consisted of \( n_{hi} \) firms each with the average productivity computed above. Because firms choose to pay the sunk cost of entry before drawing their productivity, the export entry decision is specified:
\[
\bar{v}_{H,t} = K_{H,t} \frac{W}{P_t A_t},
\]
where average firm value is specified
\[
\pi_{H,t} = E \left\{ \sum_{i=1}^{n_{hi}} \left( \beta(1-\delta)^i - \frac{u_{i,t+1}}{u_{c,t}} \bar{v}_{H,t} \right) \right\}.
\]
(A1)

Parameter choices follow GM, setting \( z_{min} \) to 1 and choosing \( k \) so that the standard deviation of firm size, which equals \( 1/(k - \mu + 1) \), is 1.67 to match evidence on the firm size distribution.

Fig. A1 reports the impulse response to the pre-announced reduction in iceberg trade cost considered above. As in the previous model without firm heterogeneity, the figure shows there is no rise in the number of exporting firms in periods prior to the trade cost reduction. The intuition is that firms do not know before paying the sunk cost whether they will have high or low productivity, so heterogeneity has no impact on the sunk cost decision above. Firms considering the possibility of early entry expect to have the same productivity as later entrants, so they expect that their future profits will be the same as that for later entrants. Firms expect future entry will bid down profits to the point of just covering sunk costs of those future

---

\[ ^{17} \] Average profits and prices are specified
\[
\pi_{H,t} = \left[ \left( \bar{p}_{H,t} - (W_t/A_t \bar{z} (1-\tau_{H,t})) \right) \bar{d}_{H,t} \right] / P_t \quad \text{and} \quad \bar{p}_{H,t} = \frac{\mu}{\mu - 1} A_t \bar{z} (1-\tau_{H,t}).
\]
entrants. So early entry in periods of lower or negative initial profits cannot be justified by an expectation of higher than average future profits for those early entrants.

A3. Learning by doing

Consider finally the possibility of learning by doing, whereby firms become more efficient at producing if they engaged in production and export previously. In the present context, one might expect that if exporting firms become more efficient from experience, this might induce firms to enter prior to EMU implementation, so that they are prepared to take greater advantage of these trade opportunities when they arise later.

Learning by doing will be modeled here in terms of the fixed cost of production, $F$. Firms that were previously producing and active in the export market have acquired experience that lowers their fixed cost in future periods. For simplicity we assume there is a one-time permanent reduction in fixed costs of a given export firm by fraction $\zeta$ starting in the firm’s second period of production.

This implies modifying firm value as follows for home exporters:

$$v_{H,t}^*(i) = \left(\beta(1-\delta)^t\right)^{H,t} \pi_{H,t}^*(i) + E_t \left\{ \sum_{s=2}^{\infty} \left(\beta(1-\delta)^s\right)^{H,t} \pi_{H,t}^*(i) \right\}, \quad (A2)$$

where profits in a firm’s initial period of existence is specified as:

$$\pi_{H,t}^*(i) = \left[ \left( p_{H,t}^*(i) - \frac{W_F}{A_t(1-\tau_{H,t})} \right) d_{H,t}^*(i) - W_F F_{H,t}^* \zeta / P_t. \right] \quad (A3)$$

Likewise for foreign exporters. The labor market clearing condition needs to be augmented to account for the extra fixed costs, which use labor:

$$A_L = Y_t + \left( ne_{Ht}^* + \zeta(n_{Ht}^* - ne_{Ht}^*) \right) F_{H,t}^* + ne_{H,t}^* K_{H,t}^* \quad (A4)$$

Fig. A2 reports impulse responses for the usual cut in iceberg trade costs used in earlier simulations. Again results show there is no entry prior to the period of implementation. It is true that learning by doing makes firms more willing to enter during initial periods of low

---

18 Learning by doing is typically introduced by specifying marginal costs of production as a negative function of past output levels. This version is not possible in the context of a sunk cost of entry, as it would lead to a proliferation of state variables. We would have to keep track of each generation of new entrants over all past periods, and how long they have been present in the market, in order to specify their marginal costs. This would produce a complex cross-sectional distribution of marginal costs that would be difficult to aggregate over.
profits in periods before EMU implementation. But this incentive also applies to firms that enter later in the period of implementation. Because they too are willing to enter with a lower level of initial period profits, there is greater entry in the period of implementation, which brings down the equilibrium level of profit per firm in that period. Firms contemplating entry in earlier periods anticipate this additional future entry and the resulting lower future profits. This offsets the incentive for early entry, resulting in no extra entry in early periods.
Table A1: Robustness Checks

<table>
<thead>
<tr>
<th>EU15 Sample</th>
<th>Extensive margin effects of EMU:</th>
<th>Overall trade effects of EMU:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benchmark</td>
<td>Significant pos. before t</td>
<td>Significant pos. before t</td>
</tr>
<tr>
<td>Exch. Rates</td>
<td>Overall trade effects of EMU:</td>
<td>Significant pos. before t</td>
</tr>
<tr>
<td>EU15+3 Sample</td>
<td>Significant positive in t</td>
<td>Significant positive in t</td>
</tr>
<tr>
<td>Benchmark</td>
<td>Decline after t</td>
<td>Significant positive in t</td>
</tr>
<tr>
<td>Exch. Rates</td>
<td>EM larger than overall in t</td>
<td>Significant positive in t</td>
</tr>
<tr>
<td>EU Dynamics</td>
<td>EM earlier than overall</td>
<td>Significant positive in t</td>
</tr>
<tr>
<td>EU Index</td>
<td></td>
<td></td>
</tr>
<tr>
<td>18 developed Sample</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Benchmark</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exch. Rates</td>
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<tr>
<td>EU Dynamics</td>
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<td></td>
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<tr>
<td>EU Index</td>
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<tr>
<td>All Developed Sample</td>
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<tr>
<td>Benchmark</td>
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<tr>
<td>Exch. Rates</td>
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<td>EU Index</td>
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<tr>
<td>All Countries</td>
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<tr>
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<td></td>
<td></td>
</tr>
<tr>
<td>EU Index</td>
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<td></td>
</tr>
</tbody>
</table>

Rows represent various country samples and regression specifications. Columns represent our various empirical claims. Each cell represents a set of 3 estimations (CFE for country fixed effects, CPFE for country pair fixed effects, CYFE for country year fixed effects), and records which estimation was robust for that empirical claim for that sample/specification. Note that results for the EU15 and all country samples can vary slightly from those in the preceding tables, as the estimations here include EMU dynamic dummies for all years in the sample, whereas estimations reported in the tables limit dummies to the leads and lags listed in the tables.
Fig. A1. Productivity heterogeneity: Response to an anticipated permanent symmetric fall in iceberg trade costs

Shock: fall in iceberg cost from 0.2 to 0.16 in period 8, announced in period 1.
Benchmark parameter settings, except $x_i = 1$. 

Shock: fall in iceberg cost from 0.2 to 0.16 in period 8, announced in period 1.
Benchmark parameter settings, except $x_i = 1$. 

vi
Fig. A2: Learning by doing: ($\zeta = 2/3$)
(Response to an anticipated permanent symmetric fall in iceberg trade costs)

Shock: fall in iceberg cost from 0.2 to 0.16 in period 8, announced in period 1.
Benchmark parameter settings, except $\chi = 1$. 

Shock: fall in iceberg cost from 0.2 to 0.16 in period 8, announced in period 1.
Benchmark parameter settings, except $\chi = 1$. 

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