Deciding to Enter a Monetary Union: The Role of Trade and Financial Linkages

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Abstract

This paper evaluates the role of trade and financial linkages in the decision to enter a monetary union. We estimate a two-country DSGE model for the U.K. economy and the euro area with financial intermediaries as in Gertler and Karadi (2011). We use the model to compute the welfare trade-offs from joining the euro. We compare the gains from trade that would occur after the adoption of the euro against the costs of relinquishing monetary policy, both conventional and unconventional. We also study the effects of the changes in the corporate risk premium observed during the recent crisis. We find that in tranquil times, when the risk premium volatility is low, the net welfare gain of joining the monetary union is 2.4 percent of life-time consumption. During financial crises, when there is a sharp increase in the volatility of the risk premium, joining a monetary union would lead to a net welfare loss of 2.2 percent of life-time consumption. The welfare analysis underscores the importance of financial stability to sustain a monetary union over time.

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1 Introduction

The effects of global financial crisis in Europe have revived the debate on the benefits and costs of belonging to the European Monetary Union (EMU). The recent crisis has been particularly long lasting in some southern European countries, leaving a large public and private debt overhang. This situation is making it difficult to provide additional fiscal stimulus and is forcing deleveraging in the banking sector. In addition, exchange rate policy cannot be used as a tool to correct competitiveness problems and increase growth through net exports. As a result, some economists and market commentators have suggested that the costs of belonging to the EMU (i.e., the euro area) might outweigh its benefits for some of its members.[1] The costs of belonging to the EMU are mostly related to the loss of monetary and exchange rate policy as an instrument for macroeconomic stabilization. These costs may be amplified by the lack of fiscal and labor market integration that are needed in an optimal currency area (Mundell, 1961). However, all the costs of a monetary union have to be assessed relative to the benefits brought about by lower transaction costs associated to having a common currency.

While this debate is taking place, the EMU has actually expanded since the beginning of the crisis: Malta and Cyprus joined in 2008, Slovakia in 2009, Estonia in 2011, and Latvia in 2014. In fact, all country members of the European Union (EU) are expected to participate in the EMU once the convergence criteria are fulfilled. Yet, some countries have made it clear that they are not interested in joining the EMU. Denmark and the United Kingdom (UK) were granted opt-out clauses in 1993 and 1997, respectively. Both countries consider that the decision of entering the EMU should be approved by a referendum. Sweden never fulfilled the conditions to adopt the euro, by not entering the European Exchange Rate Mechanism (ERM II), which requires keeping the country's exchange rate in a narrow band with the euro for two years.

In the UK, the government of prime minister Tony Blair set five economic tests to evaluate whether or not the country will benefit from adopting the euro in 1997.[2] The five economic tests were:

1. Are business cycles and economic structures compatible so that we and others could live comfortably with the euro interest rates on a

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[1] See Feldstein (2010) and Roubini (2011).
[2] See HM Treasury (1997).

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permanent basis?

2. If problems emerge is there sufficient flexibility to deal with them?

3. Would joining EMU create better conditions for firms making long-term decisions to invest in Britain?

4. What impact would entry into EMU have on the competitive position of the UK's financial services industry, particularly the City's wholesale markets?

5. In summary, will joining EMU promote higher growth, stability and a lasting increase in jobs?

The 1997 report determined that the UK did not satisfy the five economic tests. A follow-up 2003 report mentioned that, even though EMU membership could increase UK GDP between 5 and 9 percent, there was not a clear and unambiguous case for adopting the euro.[3] The current administration has pledged not to join the EMU over the course of the Parliament.[4]

In order to quantify the effects of joining the EMU, we focus on three main factors. The first one is the loss of monetary policy autonomy. Figure 1 illustrates the potential constraints that the UK economy would have faced if it had joined the EMU. Figure 1 plots the times series of the reference monetary policy rates set by the Bank of England (BoE) and the European Central Bank (ECB). In the recent period of financial turbulence (since 2007), the difference between the short-term interest has been less than one percentage point due to the synchronized effects of the Great Recession. The two reference rates have differed by more than 100 basis points quite often. For instance, between 2001 and 2005 the interest rate differential increased from 100 to 300 basis points. These differences are quite large and can have important macroeconomic effects on output and inflation.[5] If the British economy had followed the nominal interest rate to the level set by the

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[3]See HM Treasury (2003).

[4]On October 5, 2011, Prime Minister David Cameron stated in a speech at the annual conservative party conference the following: "*So let me say this: as long as I'm prime minister, this country will never join the euro*". Speech available at http://www.telegraph.co.uk/news/politics/david-cameron/8809209/David-Camerons-speech-to-Conservative-Party-Conference.html.

[5]For empirical evidence on the transmission mechanism of monetary shocks in the U.K. see DiCecio and Nelson (2007).

ECB, it would have been more difficult to stabilize domestic inflation and output over that period.[6] But joining a monetary union does not only imply losing the capability of conducting monetary policy with a Taylor-type interest rate rule. Since 2009, the UK has also been using Quantitative Easing (QE) policies to stimulate the economy. We also address this issue in the paper.

The second element is the trade expansion that typically occurs after joining in a monetary union, due to lower transaction costs and disappearance of nominal exchange rate uncertainty.[7] Figure 2 shows the expansion of trade in the euro area, measured as trade with the euro area (imports and exports) as percent of GDP. From 1990 until 2002, the share of intraregional trade of the largest economies of the euro area (Germany, France, Italy and Spain) increased from 16 to 23 percent of GDP. This trade expansion vis-a-vis main EMU partners did not occur in the UK. We consider this expansion of trade as part of the benefits of joining a monetary union.[8]

The third key element of our analysis is the role of financial factors, as reflected in corporate risk premia. Figure 3 plots the CDS spreads of non-financial corporations in the UK, in the euro area core (Finland, France, Germany, and Netherlands) and in the euro area periphery (Italy, Portugal, and Spain) countries. In the first years of the global financial crisis, the CDS spreads of corporations in the core and periphery of the euro area were fairly similar and, more importantly, exhibited low volatility. Since 2010, a decoupling of the risk premium between the core and periphery of the EMU occured, while the UK risk premium was closely aligned with the core. The volatility of the risk premium in the periphery increased dramatically after 2011. The question thus becomes: would the UK risk premium behave as the core or as the periphery of the euro area? In this paper, we also evaluate the implications of changes in risk premia volatility in the decision of adopting the euro.

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[6]Entering the EMU may increase the synchronization of business cycles between the new member and the monetary union, reducing the costs of losing the ability to conduct monetary policy (Rose, 2008). However, the existing inflation differentials across EMU members indicate there is no full synchronization of business cycles. Rabanal (2009) provides with a DSGE-model-based evaluation of inflation differentials in the EMU.

[7]See Anderson and Wincoop (2004) and Rose (2008).

[8]We also calculated the ratio of the sum of imports and exports with the euro area, relative to the sum of total imports and exports, obtaining the same qualitative results in terms of trade expansion. Santos Silva and Tenreyro (2010) provide a literature review on all the costs and benefits discussed in the literature of optimal currency areas.

The objective of this paper is to contribute to the debate on the desirability to join the EMU, with a novel focus on financial factors. Our approach is to conduct this evaluation in an estimated dynamic stochastic general equilibrium (DSGE) model. The advantage of a fully-fledged DSGE model is that it can measure the impact of a change of policies (in this case, to join the euro area) on households' and firms' decisions, and hence it should be Lucas-critique free. The starting point of the analysis is a two-country version of the Smets and Wouters (2007) general equilibrium model with nominal and real rigidities, which is augmented with trade and financial linkages across countries. The model also includes financial frictions with a banking sector as in Gertler and Karadi (2011). The presence of an agency cost for bankers leads to an inefficient spread between the return to capital and the real risk-free interest rate, that can be partially undone with the use of unconventional monetary policies. This allows us to assess the welfare implications of the loss of both conventional and unconventional monetary policies if the UK joined the euro area. Parameter estimation is conducted with Bayesian methods and using data for the euro area and the UK.

Using the estimated DSGE model, we compare the gains from having lower transaction costs in a monetary union, with the costs of increased macroeconomic volatility due to the loss of monetary and exchange rate policy.[9] In our baseline calibration, we find that joining the euro area would generate a welfare loss of 0.5 percentage points of lifetime consumption. The costs of losing monetary policy independence outweight the benefits of lower barriers to trade brought about by the disappearance of nominal exchange rate volatility. Then, we consider two different hypotheses regarding the behavior of the risk premium after EMU membership. In a benign scenario where the volatility of the risk premium declines by half, welfare gains reach 2.4 percent of lifetime consumption, substantially increasing the benefits of joining the currency union. On the contrary, in a scenario of financial turbulence similar to what the euro area periphery countries faced during the crisis, the increase in the risk premium volatility generates a welfare loss of 2.2 percent of lifetime consumption. These results underscore the importance of promoting financial stability and fiscal prudence in a monetary union, which help to reduce macroeconomic country risk and to stabilize the risk premium over the business cycle.

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[9]This exercise complements in a more formal way, the 5 economic tests proposed by former British prime minister Tony Blair in 1997.

The paper is organized as follows. Section 2 describes the model. Section 3 discusses the Bayesian estimation and the business cycle properties of the model. Section 4 presents the welfare analysis. A sensitivity analysis is conducted in Section 5. Section 6 concludes.

2   The Model

This section presents the stochastic two country model that will be used to analyze linkages between the euro area and the UK. The model is a two-country version of a DSGE model similar to Christiano, Eichenbaum and Evans (2005) and Smets and Wouters (2003, 2007), where we include trade and financial linkages across countries. The model also includes financial frictions with a banking sector as in Gertler and Karadi (2011). The presence of an agency problem for bankers leads to an inefficient spread between the return to capital and the real risk-free interest rate, that can be partially undone with the use of unconventional monetary policies. We discuss the main functional forms and describe the most important frictions of the economy in this section. In the appendix, we provide a detailed derivation of the model.

We assume that there are two countries, home and foreign, of sizes n and $1-n$, respectively. Each country produces a continuum of differentiated retail goods, indexed by $h \in [0, n]$ in the home country and $f \in [n, 1]$ in the foreign country, which are traded internationally. These retail goods are used in the production of the final good that is used for domestic final consumption, investment, and government spending, and hence it is not traded across borders. The model also incorporates linear shipping costs of moving goods internationally. As it is typically done in the literature, we follow Samuelson (1954) and introduce "iceberg" shipping costs.[10] As we discuss throughout the paper, the main benefit of joining the currency area is that a fraction of these costs would disappear, leading to more trade creation and higher steady-state output.[11]

The model also includes several nominal and real frictions that are important to explain the data. We include habit formation in consumption,

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[10]For applications of international macroeconomics models with shipping costs see Obstfeld and Rogoff (2000), Ravn and Mazzenga (2004), and Kose and Yi (2006).

[11]The reduction in "iceberg" costs captures not only the lower transaction costs associated with engaging in international trade with only one currency, but also the benefits of a decrease in nominal exchange rate volatility.

adjustment costs to investment, staggered price setting with indexation, and staggered wage setting. Our benchmark model assumes that there is local currency pricing for goods that are shipped internationally. In addition, we assume that there is an incomplete asset market structure at the international level: agents only have access to one non-contingent bond that is denominated in foreign-country currency. Finally, we introduce a financial friction which consists in an agency problem between bankers and depositors, along the lines of Gertler and Karadi (2011). The model incorporates 16 shocks because in the econometric section we are interested in explaining 13 observable variables. Including more shocks than variables allows to overcome misspecification problems, and to study which shocks are relevant to explain the data. Unless specified in the text, all shocks follow zero-mean AR(1) processes in logs.

2.1 Households, International Assets Markets, and Staggered Wage Setting

In each country, there is a continuum of infinitely lived households, that obtain utility from consuming the final good and disutility from supplying hours of labor. Within each household, there are two types of agents: bankers and workers. At any point in time, a fraction $(1 - f)$ of household members are bankers, and a fraction f are workers. Each banker manages a domestic financial intermediary that takes deposits from domestic households and finances domestic investment projects. Every period, a fraction θ_N of bankers stay in their position, while a fraction $(1 - \theta_N)$ become workers. In the same period, the same number $(1-f)(1-\theta_N)$ move from being workers to bankers. This assumption keeps the fractions of bankers and workers constant, and it is necessary to avoid bankers accumulating too much retained earnings and thus, making financial frictions irrelevant.

In the home country, households are indexed by $j \in [0, n]$ and their lifetime utility function is:

$$E_0 \sum_{t=0}^{\infty} \beta^t D_{c,t} \left[\log \left(C_t^j - b C_{t-1} \right) - D_{n,t} \frac{\left(N_t^j \right)^{1+\eta}}{1+\eta} \right], \tag{1}$$

where $\beta \in [0, 1]$ is the discount factor, $b \in [0, 1]$ is the external habit parameter, and $\eta > 0$ is the inverse elasticity of labor supply with respect to

the real wage. $D_{c,t}$, and $D_{n,t}$ denote intertemporal and intratemporal preference shocks.[12] Households can save domestically in government bonds and in bank deposits, which are perfect substitutes and pay the same nominal interest rate. We introduce international incomplete markets in a simple and tractable way, following Benigno (2009). The budget constraint of home-country households is given by:

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\begin{aligned}
& P_t C_t^j + B_t^j + NER_t D_t^j + T_t \qquad\qquad\qquad\qquad\qquad (2) \\
& = \; R_{t-1} B_{t-1}^j + R_{t-1}^* \Psi\left(\frac{NER_{t-1} D_{t-1}}{Y_{t-1} P_{t-1}}\right) U_{t-1} NER_t D_{t-1}^j + W_t^j N_t^j + \Pi_t^j,
\end{aligned}
$$

where B_t^j and D_t^j denote holdings of the domestic and foreign currency denominated bonds, R_t is the home country gross nominal interest rate and R_t^* is the foreign country gross nominal interest rate. NER_t is the nominal exchange rate expressed in units of domestic currency needed to buy one unit of foreign currency and P_t is the price level of the final good. T_t are lump-sum taxes that are used to finance government spending.

Home-country households also face a cost of undertaking positions in the foreign bonds market. The $\Psi\left(.\right)$ function captures this cost and depends on the aggregate real holdings of the foreign assets in the entire economy, and therefore is taken as given by individual households.[13] We also include an exogenous shock (U_t) to the function $\Psi\left(.\right)$, which helps explains deviations from the uncovered interest rate parity condition. For this reason, we call this shock the "uncovered interest rate parity" (UIP) shock. The risk sharing condition, which forms the basis of the real exchange rate determination under incomplete markets, reads:

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E_t\left(\Lambda_{t,t+1}^* \frac{P_t^*}{P_{t+1}^*}\right) = E_t\left(\Lambda_{t,t+1} \frac{NER_{t+1} P_t}{NER_t P_{t+1}}\right) \Psi\left(\frac{NER_t D_t}{Y_t P_t}\right) U_t, \qquad (3)
$$

where $\Lambda_{t,t+1} = \frac{C_t - bC_{t-1}}{C_{t+1} - bC_t} \frac{D_{c,t+1}}{D_{c,t}}$ is the ratio of marginal utilities of consumption between t and $t+1$, and starred variables denote foreign-country counterparts to domestic variables. As is standard in international macroeconomic

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[12] See Primiceri et al. (2006).

[13] This cost induces stationarity in the net foreign asset position. See Schmitt-Grohé and Uribe (2003) for applications in small open economy models, and Benigno (2009) in two-country models.

models, the risk sharing condition under incomplete markets equates the expected payoffs of investing in each currency, using the expected growth in the marginal rate of substitution, and taking into account the cost $\Psi(.)$. We define the real exchange rate as the ratio of final goods prices, expressed in common currency:

$$RER_t = \frac{NER_t P_t^*}{P_t}. \tag{4}$$

Households obtain labor income from supplying labor to intermediate goods producers, for which they receive a household-specific nominal wage, W_t^j, and receive profits from financial and non-financial firms, Π_t^j. As in Erceg, Henderson, and Levin (2000; henceforth EHL), we assume that each household is a monopoly supplier of a differentiated labor service, N_t^j. The household sells this service to intermediate goods producers. The elasticity of substitution across types of labor is ε_w. Households set wages in a staggered way with a Calvo-type restriction. In each period, a fraction $1 - \theta_w$ of households can reoptimize their posted nominal wage. The assumption of complete markets within each country allows to separate the consumption/saving decisions from the labor supply decision (see EHL).[14]

2.2 Domestic Financial Intermediaries

As in Gertler and Karadi (2011), we assume that bankers run a domestic financial intermediary that channels funds from depositors to intermediate goods producers. Bankers obtain funds from households, for which they pay an interest rate of R_t, and lend funds to intermediate goods producers to finance investment projects, for which they require a return on capital R_t^K. We assume that bankers do not engage in cross-border deposit or investment activities, but only provide financial intermediation services to domestic households and capital goods producers.[15] The intermediary balance sheet is given by

$$Q_t S_t = N_t^W + B_t,$$

where S_t is credit to firms, Q_t is the price of loans, B_t are deposits from households, and N_t^W is the financial intermediaries net worth, which evolves

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[14]In order to keep notation simple, we do not make the structure of the complete domestic asset markets explicit.

[15]See Dedola, Karadi and Lombardo (2012) for a two-country DSGE model with financial intermediaries that can take deposits and make investments in both countries.

as:

$$\begin{aligned} N_t^W &= (R_t^K)Q_{t-1}S_{t-1} - R_{t-1}B_{t-1} \\ &= (R_t^K - R_{t-1})Q_{t-1}S_{t-1} + R_{t-1}N_{t-1}^W. \end{aligned}$$

Absent financial frictions, the return to capital and to debt instruments would be the same and financial intermediaries would make zero profits. We introduce a financial friction as in Gertler and Karadi (2011), and assume that any given period bankers can divert a fraction λ of assets for personal profit. Knowing this, depositors will only supply funds to the intermediary if the following incentive constraint is satisfied:

$$\begin{aligned} V_t &= \max E_t \sum_{i=0}^{\infty}(1-\theta_N)\theta_N^i\beta^{i+1}\Lambda_{t,t+1+i}\left[(R_{t+i+1}^K - R_{t+i})Q_{t+i}S_{t+i} + R_{t+i}N_{t+i}^W\right] \\ &\geq \lambda Q_t S_t. \end{aligned}$$

That is, the value of the financial intermediary is larger than the value of the funds that can be diverted. This friction will lead to a positive spread between the return to capital and the deposit rate $(R_t^K - R_{t-1})$. As shown by Gertler and Karadi (2011), when the constraint binds the following relationship holds:

$$Q_t S_t = \phi_t N_t^W, \tag{5}$$

where ϕ_t is the leverage ratio, which is common to all bankers and is given by

$$\phi_t = \frac{\eta_t}{\lambda - \nu_t}. \tag{6}$$

η_t is the marginal value of the bank's net worth, holding its portfolio $(Q_t S_t)$ constant, and ν_t is the marginal value of expanding assets holding net worth (N_t^W) constant:

$$\begin{aligned} \eta_t &= E_t\left\{(1-\theta_N)\beta\Lambda_{t,t+1}R_t + \theta_N\beta\Lambda_{t,t+1}z_{t,t+1}\eta_{t+1}\right\} \tag{7} \\ \nu_t &= E_t\left\{(1-\theta_N)\beta\Lambda_{t,t+1}(R_{t+1}^K - R_t) + \theta_N\beta\Lambda_{t,t+1}\chi_{t,t+1}\nu_{t+1}\right\}, \end{aligned}$$

where $\chi_{t,t+1} = Q_{t+1}S_{t+1}/Q_tS_t$, is the growth rate of assets and $z_{t,t+1} = N_{t+1}^W/N_t^W$ is the growth rate of net worth.

Finally, the evolution of aggregate net worth can be decomposed between "surviving" bankers from last period, and "new" bankers entering the business at time t:

$$N_t^W = N_t^E + N_t^N. \tag{8}$$

Surviving bankers' net worth is given by

$$N_t^E = \theta_N [(R_t^K - R_{t-1})\phi_{t-1} + R_{t-1}] N_{t-1}^W \exp(\varepsilon_t^{nw}), \tag{9}$$

where we include a "net worth" shock that can affect the bankers' balance sheet position, spreads and the macroeconomy. ε_t^{nw} is an iid normally distributed shock. The start-up funds for new bankers are given by

$$N_t^N = \omega Q_t S_{t-1}. \tag{10}$$

This concludes the discussion of the financial sector in the model, that we will use for estimation. In Section 4.2, we describe the role of unconventional monetary policies, and how some of the relationships in (33)-(38) change.

2.3 Non-Financial Firms

The model has intermediate goods, retail goods, final goods, and capital goods.

2.3.1 Final good producers and "iceberg" costs

A continuum of final goods producers firms purchase a composite of differentiated retail home goods, $Y_{H,t}$, and foreign goods, $Y_{F,t}$, to produce a homogeneous final good product. A fraction τ of imported intermediate inputs are lost in transit between the two countries. This functional form for transportation costs was first proposed by Samuelson (1954), and is also known in the literature as "iceberg costs". Therefore, the production of the final good is given by:

$$Y_t = \left\{ \omega^{\frac{1}{\theta}} Y_{H,t}^{\frac{\theta-1}{\theta}} + (1-\omega)^{\frac{1}{\theta}} \left[(1-\tau) Y_{F,t} \right]^{\frac{\theta-1}{\theta}} \right\}^{\frac{\theta}{\theta-1}}, \tag{11}$$

where ω denotes the fraction of home-produced goods that are used for the production of the final good, and θ denotes the elasticity of substitution between domestically produced and imported intermediate goods in both countries. The composites $Y_{H,t}$ and $Y_{F,t}$ include the continuum of home and foreign retail goods, aggregated with a CES function with elasticity of substitution ε_p. A higher rate of transportation costs τ, or an increase in the elasticity of substitution θ raises the home bias in the economy. Also, everything else equal, increased τ reduces steady-state output. In the Bayesian

estimation of the model we fix the parameters ω and θ, and then estimate τ. The price level for the final good is:

$$P_t = \left\{ \omega \left(P_{H,t} \right)^{1-\theta} + (1-\omega) \left[P_{F,t}/(1-\tau) \right]^{1-\theta} \right\}^{\frac{1}{1-\theta}} ,$$

where $P_{H,t}$ and $P_{F,t}$ denote the prices of the composites of domestic and foreign retail goods.

2.3.2 Capital Producers

At the end of each period, capital producers buy capital from intermediate goods producers, and the final good in order to produce more capital. The value of a new unit of capital is Q_t, which as we show below it also equals the price of loans. Capital accumulation dynamics are given by the following expression:

$$K_t = (1-\delta) V_t K_{t-1} + \left[1 - \Phi \left(\frac{I_t}{I_{t-1}} \right) \right] I_t. \tag{12}$$

where δ denotes the rate of depreciation and the adjustment cost function, $\Phi(.)$, is an increasing and convex function as in Smets and Wouters (2003). Furthermore, in the steady state, $\overline{\Phi} = \overline{\Phi'} = 0$ and $\overline{\Phi''} = \psi > 0$. The capital accumulation expression also includes a capital quality shock (V_t).

2.3.3 Intermediate Goods Producers

In each country, there is a continuum of intermediate goods producers, each producing a homogeneous good that is sold to retailers for differentiation. Intermediate goods producers purchase capital from capital producers, and need to borrow an amount S_t to purchase an amount of capital K_t. There are no financial frictions in the relationship between retail firms and domestic financial intermediaries. Therefore:

$$Q_t K_t = Q_t S_t$$

The production function of intermediate goods in the home country is given by

$$Y_t^M = (A_t X_t N_t)^{1-\alpha} (V_t K_{t-1})^\alpha , \tag{13}$$

where α is the share of capital in the production function. The above production function has two technology shocks and the capital quality shock

introduced above (V_t). The first technology shock, X_t, is a world technology shock, that affects the two countries the same way: it has a unit root in logs, as in Galí and Rabanal (2005), Lubik and Schorfheide (2006), and Rabanal and Tuesta (2010). In addition, there is a labor-augmenting country-specific technology shock, A_t, that evolves as an $AR(1)$ process in logs. Let P_t^M denote the (real) price of the intermediate good (normalized by the final good price P_t). Then, the (real) return to capital is given by:

$$\frac{R_t^K}{P_t} = \frac{\alpha P_t^M Y_t^M / K_{t-1} + (1-\delta) V_t Q_t}{Q_{t-1}}$$

2.3.4 Retail Firms, Nominal Price Rigidities and Local Currency Pricing

In the home country, a continuum of retail firms indexed by $h \in [0, n]$, purchase the intermediate good and differentiate it into a continuum of home and foreign differentiated retail goods. Each retail firm sells its product, $Y_{H,t}(h)$, to domestic and foreign final goods producers, who use it to produce $Y_{H,t}$ and $Y_{H,t}^*$, and faces a downward sloping demand with elasticity ε_p. Having paid a price P_t^M for each unit of intermediate good, and differentiated it by repackaging it at a negligible cost, retail firms choose the price that maximizes discounted profits subject to a Calvo-type restriction with indexation to last period's sector-specific inflation. We also assume local currency pricing (LCP) for goods that are shipped internationally. Hence, with probability $1 - \theta_H$ a firm chooses a price for the domestic market and a price for the foreign market, each price quoted in the destination market currency. Hence, there is price stickiness in each country's imports prices in terms of local currency, and the law of one price (excluding iceberg costs) holds in the steady state, but not outside of it. Additionally, we assume that the prices of each firm that cannot reoptimize in a given period is indexed to last period's inflation rate in each destination market with coefficient λ_H. Therefore, the coefficients of the two Phillips curves for each country (domestic inflation and exports inflation) have the same coefficients (θ_H, λ_H), but they differ across countries. In the foreign country, foreign inflation and imports inflation are governed by parameters $(\theta_F^*, \lambda_F^*)$.

2.4 Closing the Model

In order to close the model, we impose market-clearing conditions for all types of home and foreign retail intermediate goods, and the labor and asset markets. For all aggregate intermediate goods, we need to take into account the size of the countries and transportation costs. For the final good, the market clearing condition in the home country is the usual:

$$Y_t = C_t + I_t + G_t Y_t. \tag{14}$$

We define GDP_t as aggregate production in the intermediate good sector:

$$GDP_t = Y_t^M.$$

We introduce an exogenous government shock for each country (G_t, G_t^*) which is expressed in terms of the government spending-to-final good production ratio. We assume that both governments run a balanced budget every period (i.e. $G_t Y_t = T_t$ and $G_t^* Y_t^* = T_t^*$). Finally, we assume that both countries follow a monetary policy rule that targets deviations of domestic CPI inflation and real GDP growth from their steady-state values, that we normalize to zero:

$$\frac{R_t}{R} = \left(\frac{R_{t-1}}{R}\right)^{\varphi_R} [(P_t/P_{t-1})^{\varphi_\pi} (GDP_t/GDP_{t-1})^{\varphi_y}]^{1-\varphi_R} \exp(\varepsilon_t^m), \tag{15}$$

where ε_t^m is an *iid* monetary policy shock.

This concludes the description of the estimated two-country model. When we discuss the different policy options below, we also detail how the model changes to incorporate the alternative policy regimes.

3 Bayesian Estimation

3.1 Data

We estimate the model using quarterly data for the UK and the euro area, between 1984 and 2008. We choose the beginning of the sample to coincide with a period of stronger anti-inflationary stance in Europe. The end-date is convenient to avoid the period of zero interest rates in the UK, for which our model cannot provide a good characterization. We use six domestic macro-economic series per country, and the bilateral real exchange rate, making

a total of 13 observable variables. For each country we use: real per capita GDP growth, real per capita consumption growth, real per capita investment growth, real wage growth, CPI inflation and a short-term interest rate.

Our data sources are as follows. For the euro area, we obtain real GDP, real consumption, real investment, real wages, the Harmonized Index of Consumer Prices (HICP), and the short-term interest from the ECB's Area Wide Model (AWM). We obtain population series from Eurostat. Since this series is annual, we use linear interpolation to transform it to quarterly frequency. For the UK, we obtain national accounts data (real GDP, real consumption and real investment) from the Office for National Statistics. The relevant measure for consumer prices is the Retail Price Index (RPI), obtained from the Office for National Statistics. This series provides a longer time span than the HICP (which is only available since 1995). For nominal wages, we use average earnings for the whole economy (including bonus), also produced by the Office for National Statistics. We compute real wages as nominal wages divided by the RPI. We use the Bank of England's Repo Rate as a measure of short-term interest rates. Population for the UK is also obtained through Eurostat, and transformed to quarterly frequency using linear interpolation. Finally, for the bilateral measures, we construct the real exchange rate of the UK pound sterling against the euro using the nominal exchange rate in UK pounds per euro, and multiplying it by the HICP of the euro area and dividing it by the RPI of the UK.

3.2   Model Dynamics and Data Transformations

Since we have assumed that the model has a world technology shock with a stochastic trend, then real output, consumption, capital, investment, real wages, and the level of government spending inherit the same property and are non-stationary in levels. In order to render these variables stationary in the model, we divide them by the level of world technology. Real marginal costs, hours, inflation, interest rates, the real exchange rate and all other international relative prices are stationary. We obtain the model's dynamics by taking a log-linear approximation to the steady state values with normalized variables, zero inflation and balanced trade. We denote by lower case variables percent deviations from steady state values. Moreover, variables with a tilde have been normalized by the level of world technology to render them stationary. For instance, for consumption, $\widetilde{c}_t = \frac{\widetilde{C}_t - \widetilde{C}}{\widetilde{C}}$, where $\widetilde{C}_t = \frac{C_t}{X_t}$.

To estimate the model, we transform the series as follows. Since the

model has a productivity shock with a stochastic trend, real variables are non-stationary in the model, but first-differencing makes them stationary. We apply the same treatment to their counterparts in the set of observable variables, which is also enough to make them stationary. The relationship between the same variable in the transformed model and in the data is as follows. For real consumption, for example:

$$\Delta \widetilde{c}_t = \Delta c_t - \varepsilon_t^x$$

where $\Delta \widetilde{c}_t$ is consumption growth in the model and Δc_t is consumption growth in the data. ε_t^x is the innovation to the unit root technology process in logs, $log(X_t)$. The same reasoning applies to all other real variables. To compute per capita real GDP, consumption and investment growth rates we take logs and first differences of the raw (per capita) data. To compute real wage growth rates we also take logs and first differences.

To compute inflation rates we also take logs and first differences of the relevant price level series. We use nominal interest rates in levels because they are a stationary variable in the model and in the data. To make interest rates quarterly, we divide them by 400. We use as observable variable the bilateral real exchange rate in logs and first differences. We demean all variables prior to estimation.

Let Ω denote the vector of parameters that describe preferences, technology, the monetary policy rules, and the shocks in the two countries of the model. The vector of observable variables consists of $\varkappa_t = \{\Delta gdp_t, \Delta gdp_t^*, \Delta c_t, \Delta c_t^*, \Delta i_t, \Delta i_t^*, \Delta p_t, \Delta p_t^*, \Delta rw_t, \Delta rw_t^*, r_t, r_t^*, \Delta rer_t\}$. The home country is the UK and the foreign country is the euro area. Hence all variables and parameters with a star belong to the euro area. We express all variables as deviations from their sample mean. We denote by $L\left(\{\varkappa_t\}_{t=1}^T \mid \Omega\right)$ the likelihood function of $\{\varkappa_t\}_{t=1}^T$.

3.3   Estimation: Priors and Posteriors

We employ standard Bayesian estimation techniques (An and Schorfheide, 2007). We specify priors over the model's parameters $\Pi(\Omega)$ and obtain the posterior distribution of the parameters $\mathcal{P}\left(\Omega \mid \{\varkappa_t\}_{t=1}^T\right)$ using the Metropolis-Hastings algorithm with 125,000 draws. To reduce the number of parameters to be estimated, we fix a few parameters that are weakly identified with the set of observable variables (see Table 1).

[Insert Table 1 here]

We set the discount factor to $\beta = 0.995$. The depreciation rate, δ, is set equal to 0.025 per quarter, which implies an annual depreciation on capital equal to 10 percent. We set α equal to 0.36. We set the elasticity of substitution across types of labor, ε_w, and across types of goods, ε_p, equal to 6 and 11, respectively, as it is standard in the DSGE literature. We set the steady-state ratio of government expenditures over GDP, equal to 0.33, which is higher than the typical calibration for the United States, but more in line with European averages. We calibrate the elasticity of substitution between home and foreign goods to 1, which corresponds to a Cobb-Douglas production function for final goods (11), which is a widely used assumption in international macroeconomics.[16] In a counterfactual exercise, we will set θ equal to 5, more in line with long-run estimates of elasticities of substitution, to evaluate the steady-state effects of changes in the iceberg transportation costs.[17] We set the fraction of imported goods, $1 - \omega$, equal to 0.15, which is in line with the imports for the EMU/GDP ratio in the UK. We set the size of the UK economy to 0.2, based on the relative GDP sizes. Finally, we calibrate ω^*, such that given the values of ω and n, trade between the UK and the euro area is balanced. This value is quite similar to the ratio of imports from UK/euro area GDP in the data. Finally, we calibrate the level of the external premium between the return to capital and the riskless rate to 1% (in annualized terms).

The remaining parameters of the model are estimated. Tables 2 and 3 give an overview of the prior distribution of the estimated parameters, that we denote by $\Pi(\Omega)$. We use Beta distributions for parameters bounded between 0 and 1. For parameters assumed to be positive we use a Gamma distribution, and for unbounded parameters or if we want to use very informative priors, we use normal distributions. We center the priors to values that are typically used in calibrated exercises, or in previous estimations (such as Smets and Wouters, 2003, for the euro area). We set the prior mean for the habit parameter to 0.5, which is close to the findings of Smets and Wouters (2003) for the euro area. We set the labor disutility coefficient η prior mean to 1, which implies a quadratic cost for labor disutility, which is a standard assumption in macroeconomic models (see Galí and Monacelli,

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[16]We also estimated θ, and found that the posterior mean was very close to 1. Details are available upon request.

[17]See Imbs and Méjean (2011).

2005). For the transportation costs we set $\tau = 0.10$ as the mean prior, which is the estimate of transportation costs for the U.S. calculated by Feenstra (1996) and Hummels (2001). For the parameters that measure the degree of financial frictions, we set the prior probability for the survival probability of bankers to 0.95, and the steady-state leverage ratio to 4. Both values are close to the calibration in Gertler and Karadi (2011).[18] We set the prior mean for the Calvo lottery for prices and wages to 0.75, implying average durations of 4 quarters for price and wage contracts, as in the prior of Smets and Wouters (2003). The prior for price indexation is a Beta centered at 0.5 with a relatively large standard deviation, implying a prior that is close to a uniform distribution, as in Rabanal and Rubio-Ramírez (2005). The prior means for the coefficients of the Taylor Rule are similar to the original formulation, although our rule includes output growth instead of the output gap, and also interest rate smoothing. Finally, we let most parameters be different across countries except those related to the investment adjustment cost (ψ) and the iceberg cost (τ). Since we assume that the production function is the same across countries, including the capital share of output (α), it makes sense to keep the assumption of common technologies and costs to both countries.

Posterior distributions for the structural parameters of the benchmark economy are shown in Table 2, while Table 3 presents the posterior distributions related to the AR(1) coefficients and standard deviations of the shocks. Most parameter estimates are very similar to previous studies, in particular those of the euro area, so we only briefly comment on those.[19] Interestingly, parameter estimates are not so different across the UK and the euro area, suggesting that the economic structures are quite similar. This similarity implies low costs of adopting a common currency. On the other hand, the parameters of the shock processes are more different, which suggests that if they were to remain the same after a possible monetary union, then the costs of not being able to respond to domestic shocks and allow the exchange rate to absorb foreign shocks would be quite high.

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[18] Gertler and Karadi (2011) calibrate the probability of bankers survival to 0.972. We face a technical problem when we use this value as a prior mean for θ_N and θ_N^* when using a Beta distribution. If we want to allow a reasonable range of parameters, increasing the standard deviation of the prior leads to a high prior density for values very close to one, effectively pushing the estimates towards one. In order to avoid this problem, we set the prior mean to a lower value of 0.95.

[19] See Adolfson et al. (2007) and Rabanal and Tuesta (2010).

The posterior mean estimates for the external habit formation parameters are roughly in line with previous studies ($b = 0.66$ for the UK and 0.41 for the euro area), while the same holds for the inverse elasticities of labor supply ($\eta = 0.86$ and $\eta^* = 0.8$). The estimated posterior mean of the parameter χ, that measures the elasticity of the interest rate premium with respect to net foreign assets is quite low, 0.01, and hence suggests that the UK and the euro area enjoy a high degree of financial integration. For emerging economies García-Cicco et al. (2010) find a value close to 3. Next, we find that the parameter measuring shipping costs of all sorts due to international trade has a posterior mean of 0.1, which is essentially the prior mean. Perhaps, more disaggregated data on trade flows would be needed to obtain more information about this parameter. The posterior estimates for the survival probability of bankers are lower than the priors (0.91 in the UK and 0.86 in the euro area), which suggests that the net worth processes are less persistent than in the calibrated model of Gertler and Karadi (2011). On the other hand, the estimates of the steady-state leverage ratio are close to 4, as in Gertler and Karadi (2011). The fact that the priors and posteriors are quite similar suggests that the use of financial data could provide more information to identify the parameters relating to financial frictions.

Our point estimates imply stronger nominal rigidities in wage-setting than in price-setting: the posterior mean for the Calvo lottery for price setting implies that prices are reset on average about every 3 quarters, while wages are reset about every 5 quarters in both the UK and in the euro area. These estimates are somewhat lower than in Smets and Wouters (2003) for the euro area. The posterior mean of the price indexation parameter is much smaller than the mean value of the prior distribution, and makes backward looking behavior negligible. Estimates of the Taylor rules are also similar to what has been obtained in previous studies. However, they suggest a stronger anti-inflationary stance in the UK with respect to the euro area (Taylor rule reaction of inflation estimates are 1.63 versus 1.45). This difference, while not quantitatively large, is important when we measure the costs of joining the euro area.

[Insert Table 2 here]

[Insert Table 3 here]

Table 3 shows that the shocks processes are quite different across countries. In particular, TFP shocks are more persistent in the UK, while the intertemporal preference shocks are more persistent in the euro area. The persistence of all other shocks is quite similar, including the low persistence of the intratemporal shock. The volatility of the government spending, intertemporal preference and monetary shocks is larger in the UK, while the volatility of the TFP shock is larger in the euro area. In order to better understand how well the model fits the data and what shocks in the model drive which variables, Table 4 presents the standard deviation of the observable variables implied by the model, using the posterior mean of the estimated parameters. In the data, most UK variables are more volatile than their euro area counterparts. In particular, consumption growth is about 50 percent more volatile than in the euro area, while investment growth is three times as much. Inflation and real GDP growth are also more volatile in the UK while real wage growth and nominal interest rate are as volatile in the UK as in the euro area. The model is able to replicate these facts qualitatively, although it overpredicts the volatility of some real variables, in particular real GDP growth in both countries.

Next, we analyze which shocks drive the behavior of the main variables. Table 4 presents the variance decomposition of all variables when the model is evaluated at the posterior mean. We have aggregated the shocks as follows: TFP (including transitory and permanent TFP shocks), capital quality, preference (intertemporal and intratemporal shocks), government spending, monetary, the UIP shock and the net worth shocks. We aggregate the shocks for each category across countries, to save space. While not shown explicitly in Table 4, the fraction of variance for each variable explained by shocks in the other country is always negligible: the international transmission of shocks is fairly small in the model.

First, we find the usual "exchange rate disconnect", in the sense that RER fluctuations are driven by the UIP shock (79.9 percent of its variance is driven by this shock), while the UIP shock explains very little of the volatility of all other macro variables. Second, monetary policy shocks explain an important fraction of the variance of real GDP growth in the euro area (32.5 percent) as well as inflation in the euro area (19.2 percent), while they explain less than 9 percent for both variables in the UK. Third, government spending shocks represent a significant fraction of real GDP growth volatility in the UK (18.0 percent) while they are a smaller fraction in the euro area (6.8 percent). Capital quality shocks explain a large fraction of the volatility of

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real GDP and investment growth, while preference shocks are more important for consumption. TFP shocks explain an important fraction of the volatility of inflation, real wages and real GDP in both countries. Interestingly, the shocks to net worth have a minor role in explaining the volatility of any variable.[20]

[Insert Table 4]

4   Policy Analysis: Welfare Gains from Entering a Monetary Union

This section uses the estimated model to evaluate under what conditions will the UK benefit from joining the euro area. In Subsection 4.1, we discuss the steady-state effects of entering the EMU derived from lower transaction costs. In Subsection 4.2, we discuss the business cycle effects of joining a monetary union and not being able to use conventional and unconventional monetary policies in the UK Subsection 4.3 complements the analysis with a discussion of impulse-responses. Subsection 4.4 presents additional robustness exercises from changing some key parameter values.

We emphasize three key factors that will impact the welfare of households in the UK:

1. The loss of independent monetary policy in a monetary union: entering a monetary union increases output and inflation volatility because monetary conditions in the EMU as a whole will not generally fit UK needs. This loss also involves not being able to use QE policies such as the ones the Bank of England enacted during the crisis. The additional volatility generated by losing an independent monetary policy results in welfare losses.

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[20]We also estimated a version of the model with investment-specific technology shocks as in Smets and Wouters (2003) instead of the net worth shocks. We found that the contribution of investment-specific technology shocks was negligible, with the capital quality shocks being more important in driving macroeconomic fluctuations.

2. The increase of trade due to lower transaction costs. The empirical literature finds that there is an expansion in trade for the country that joins a currency area (Rose, 2008). There are uncertainties associated with the magnitude of this trade expansion. In the welfare analysis, we model the trade expansion as a reduction in transaction costs. In our model, this reflects all possible transactions costs related to trade. This is a steady-state effect that will increase consumption and production in the UK. Its effects on volatility are quantitatively very small.

3. Changes in the corporate sector risk premium. The risk premium in the Euro Area for corporations (measured using CDS spreads) moves dramatically over the business cycle. In good times, there is a compression in spreads that encourages an investment boom. However, during the recent crisis, the risk premium increased dramatically (but only in the periphery), exacerbating macroeconomic volatility. In our model the risk premium is endogenously determined as a function of the state of the economy, and is affected primarily by asset prices. We follow Gertler and Karadi (2011) and consider that during the crisis there is an increase in the volatility of capital quality shocks, which in turn affects asset prices, the balance sheet of financial intermediaries, aggregate demand, and a further decline in asset prices.

We have shown that the model overpredicts the volatility of some variables at the posterior mean. It is important that the calibration of the model reflects the volatility of main macro variables well, because this is the basis for the welfare exercise. Hence, we calibrate the parameters of the model at the posterior mean, except for the standard deviation of the intertemporal, permanent and transitory TFP, capital quality, and government spending shocks, which are calibrated at the lower bound of the 90 percent credible set. As we show in Table 6 below, this calibration allows the model to closely match the volatility of the main macroeconomic variables in the UK.

We adopt a conservative approach and assume that the transaction costs (or "iceberg costs" as defined in Section 2) drop by 5 percentage points. This value is at the lower end of estimated transaction costs reductions for joining the EMU (see Anderson and van Wincoop, 2004). We calibrate the change in the corporate risk premium according to the behavior of the corporate CDS spreads in the periphery of the euro area (Italy, Portugal, and Spain) under two scenarios: one of tranquil times and the other one during the

crisis.[21] Since there is high uncertainty about how transaction costs and the risk premium will behave for the UK once it enters the EMU, we conduct an extensive sensitivity analysis for alternative parameter values in Section 4.4.

We calculate the welfare gains of joining a monetary union following the same approach by Lucas (1987). Given a set of allocations $\left\{C_t^k, N_t^k\right\}_{t=0}^{\infty}$ for $k = I, MU$, where I is the allocation under the independent monetary policy and MU the allocation under the monetary union, the welfare gain γ is calculated as follows:[22]

$$E\left\{\sum_{t=0}^{\infty} \beta^t u\left[(1+\gamma)C_t^I, N_t^I\right]\right\} = E\left[\sum_{t=0}^{\infty} \beta^t u(C_t^{MU}, N_t^{MU})\right] \qquad (16)$$

If the resulting parameter γ is positive, then there are net gains from entering a monetary union. On the other hand, if $\gamma < 0$, then a country is better off following an independent monetary policy. We calculate the welfare gain γ for two cases. First, we calculate the welfare gain at the steady state to understand the long-run effects of joining a currency area. Second, we measure the combined effects of changes in the steady state and business cycle (i.e. volatility of main variables) on welfare.

4.1   Steady-State Effects

Table 5 shows the steady-state effects and associated welfare gains of joining a currency area under lower transaction costs. In the first column, we show the steady state values, which are normalized to a level of 100, under the current situation (independent monetary policy and flexible exchange rate). In the second column, we show the long-run effect of lower transaction costs. The overall effect is an increase in welfare of 1.2 percentage points of lifetime consumption. The reduction of transaction costs has several effects in the economy. First, it allows the UK economy to trade more: the reduction of transaction costs leads to an increase of 1.3 percent in both exports

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[21]During tranquil times we assume a reduction of 50 percent in the standard deviation of the risk premium, while during the crisis we consider an increase of 20 percent. This is achieved by changing the standard deviation of the capital quality shock. Both scenarios capture the changes in risk premium observed in recent years. Notice that in the tranquil scenario, the risk premium of the periphery mimics the dynamics in the core countries of the euro area.

[22]The welfare cost estimate comes from the unconditional expected lifetime utility, and is calculated up to a second order approximation following Schmitt-Grohé and Uribe (2007).

and imports. Second, households have more resources available due to lower transaction costs, and hence consumption will be higher. Third, lower distortions will lead to higher investment, capital stock and GDP. The increase in consumption implies an increase in welfare at the steady state. Note, however, that at the calibrated value of $\theta = 1$, reductions in τ have a steady-state effect on the level of main macroeconomic variables, but do not have a major impact in trade creation, and both exports and imports increase by about 1.3 percent in the steady state. In Section 4.4 below, we estimate the model with a high value of $\theta = 5$, which would have larger effects on exports and imports at the steady-state.

[Insert Table 5 here]

This experiment illustrates the long-run effects of the reduction in transaction costs after the adoption of a currency union. There are large positive effects coming from a reduction of transaction costs, that would imply that there are benefits of joining the currency area. However, these results abstract from the cyclical effects of joining a currency union. Under a common currency, there is a loss of monetary independence and exchange rate flexibility, which limits the ability of a country to stabilize the cycle and respond to shocks. If the cycle is not perfectly synchronized with the rest of the member countries of the currency union, and wages and prices are sticky, then the adjustment will involve higher macroeconomic volatility in real variables. This volatility effect can undermine the benefits derived from lower transaction costs.

4.2   Business Cycle Effects

Table 6 shows the business cycle effects and welfare gains of alternative monetary and exchange rate policy arrangements.[23] In the first column, we compute the volatility of the main UK variables under the baseline model with both the ECB and the BoE following independent monetary policy rules. Then, we compare this baseline scenario against four alternative policy scenarios.

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[23]The welfare gains measures the impact of both the steady state and business cycle effects of each monetary arrangement.

In the second column, we show the case of maximum benefit of pursuing Quantitative Easing (QE) policies by using a second policy instrument: public provision of credit. As shown in Gertler and Karadi (2011), the central bank can mitigate the effects of asset prices on credit by issuing bonds and lending to the private sector directly. In this case, we assume that the government is willing to fund a fraction ψ_t^{UMP} of intermediated assets using government bonds. Unlike bankers, the government does not have an incentive to divert assets. But government provision of intermediated assets has a cost of τ^{UMP} per unit supplied. Since privately intermediated funds are constrained by financial intermediaries net worth, we can rewrite equation (33) as

$$Q_t S_t = \frac{\phi_t}{1 - \psi_t^{UMP}} N_t^W$$

where the fraction of publicly intermediated assets follows the rule:

$$\psi_t^{UMP} = \kappa(E_t R_{t+1}^K - R_t - prem) \tag{17}$$

where $prem$ is the steady-state value for $E_t R_{t+1}^K - R_t$, the external finance premium between private investment and public bonds. Whenever the premium increases, the central bank provides credit to the private sector and aims at reducing the accelerator effects due to the financial friction. However, the public intervention has an efficiency cost. Once the budget constraint of all the sectors is aggregated, the cost appears in the market-clearing condition of the final good:

$$Y_t = C_t + I_t + G_t Y_t + \tau^{UMP} \psi_t^M Q_t S_t \tag{18}$$

We calibrate the coefficients $\kappa = 100$, and $\tau^{UMP} = 0.001$. Under the assumption that the BoE always uses QE, the welfare gains would be in the order of 0.06 percent of lifetime consumption, indicating that the benefits of adopting an independent monetary policy are enhanced under QE policies. This is not a large effect, but we leave the discussion to the following subsection when we discuss the effects of different policy regimes using impulse-response functions.

Next, we study what happens when the UK enters the EMU. In this scenario, the nominal exchange rate is fixed, and the expanded ECB follows a Taylor rule as in equation (15), where the UK would have a weight of $n = 0.2$ in the HICP and real GDP growth, and the rest of the euro area

would have a weight of $1 - n = 0.8$. We further assume that the volatility of UIP shocks in the risk sharing condition is zero, since this shock mostly explains the volatility of real and nominal exchange rates.

[Insert Table 6 here]

The third column shows the case when the UK joins the EMU and transaction costs remain at a value of $\tau = 0.1$. That is, we take the extreme assumption that fixing the exchange rate does not bring about any benefits in terms of trade creation. In this case, there is an increase in volatility for most macroeconomic variables due to the fact there is a fixed nominal exchange rate and there is no countercyclical domestic interest rate policy to absorb country-specific shocks in the UK. Only exports and real exchange rate volatility decline. In the model, the real exchange rate is less volatile because the external adjustment of the economy is done via prices, which adjust slowly overtime. A lower volatility of the exchange rate will also reduce the volatility of exports in the model. The welfare loss derived from entering the monetary union will be 1.7 percent of lifetime consumption, which is fully explained by higher macroeconomic volatility.

The fourth column of Table 6 shows the case when the UK joins the EMU, and there is a reduction of 5 percentage points in transaction costs, to $\tau = 0.05$. Consistent with the work of Ravn and Mazzenga (2004), the cyclical effects of a reduction in transaction costs are very small in the model. As a result of lower transaction costs, the welfare losses are now 0.5 percent of lifetime consumption. Interestingly, the gains from lower transaction costs do not fully offset the additional increase in volatility. For the UK to join the EMU, it would be necessary to have additional benefits associated with the currency area. One of these benefits is a reduction in the risk premium, that could occur for instance from an improvement in the macroeconomic fundamentals or a further deepening of financial markets.

The fifth column describes the situation in which the volatility of the risk premium is reduced by 50 percent once the UK joins the EMU (from a value of 2.8 to 1.4 percent). This scenario captures the episode of risk premium compression observed in the period 1999-2007 in several EMU country members, and would reflect that the UK corporate sector can further diversify risks in a monetary union. If that were the case, we assume that the

volatility of the risk premium is reduced by 50 percent by lowering the calibrated volatility of capital quality shocks.[24] In this scenario, there would be a dramatic reduction in the volatility of consumption, investment and employment that would provide substantial welfare gains: 2.4 percent of lifetime consumption, tilting the decision of the UK in favor of joining the EMU.

Finally, the sixth column shows the case when the UK enters the EMU in a situation of financial turbulence. We calibrated a situation of financial turbulence by increasing the standard deviation of the capital quality shocks such that the volatility of the risk premium increases by 20 percent (from a value of 2.8 to 3.3 percent). This scenario is consistent with what happened with the corporate risk premium in the periphery during the recent financial crisis. As a result, the volatility of domestic interest rates increases significantly, which transmits to all macroeconomic variables. This scenario leads to a welfare loss of 2.2 percent of lifetime consumption, rendering the monetary union as a very costly arrangement.[25]

4.3   Discussion of Impulse-Responses

We have just studied the impact of higher risk premium volatility, induced by changes in capital quality shocks, and their negative effect on welfare when the UK joins the euro. But what are the dynamics of a capital quality shock when the UK does not enter the euro area? In Figure 4 we present the impulse-responses to a 1 standard deviation in the capital quality shock, under three regimes: (i) an independent monetary policy following a Taylor-type rule, (ii) and independent monetary policy following the Taylor-type rule and QE policies; and (iii) a monetary union that follows a Taylor-type rule for all country members. The effects of the capital quality shock under

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[24]In the model, 73 percent of the volatility of the premium is explained by the capital quality shock.

[25]Our results are in the middle range of other studies that measures the costs and benefits of joining a monetary union. Auray et al. (2010) find that a trade expansion of 1 percent leads to a welfare gain of 0.6 percent of lifetime consumption, while in our model is higher (1 percent of lifetime consumption for 1 percent of trade expansion). Gradzewicz and Makarski find that the welfare loss associated with higher volatility in a monetary union is 0.1 percent of lifetime consumption and in our model is higher (our welfare loss derived from higher macroeconomic volatility is 1.7   percent of lifetime consumption). However, our welfare measures are lower than the estimates by Schmitt-Grohé and Uribe (2012). They find a welfare loss of 6 percent of lifetime consumption in a model with wage rigidities.

the three regimes are strikingly different.

Under an independent monetary policy (blue line), the negative capital quality shock results in an increase in the risk premium of 3 percentage points. This leads to a decline in GDP and employment, that bring about a reduction in inflation. The BoE cuts interest rates (Panel F), which depreciates the pound sterling and cushions the negative effect of the shock by increasing net exports. Next, we study the case when the BoE additionally uses QE. We have used the calibration that Gertler and Karadi (2011, Figure 3) label as "aggressive policy" ($\kappa = 100$) to understand the largest possible benefits from using QE. The effects of this policy are that, whenever asset prices decline and the risk premium increases, the central bank lends large amounts to the private sector, thereby offsetting the tightening of the credit supply restriction in equation (5). As a result of this policy, the risk premium is basically fully stabilized.[26] As we can see from Figure 4, GDP still declines because the capital quality shock also affects the marginal productivity of capital. Yet, the QE policy contributes to cushion the decline in output. Notice that under the QE regime, monetary policy needs to be less accommodative, since most of the monetary stimulus is provided directly by the central bank through asset purchases. The effects of less agressive policies would fall in between the case we depict here (dashed red line), and not using QE at all (solid blue line).

Inside the monetary union, a negative capital quality shock translates into a much larger increase in the risk premium, of 9 percentage points (Panel G). The negative feedback loop between a decline in GDP and the increase in the premium becomes much worse, because the "expanded" ECB does not respond enough to a spike in risk premia, which lowers GDP, asset prices and tightens credit supply in the UK, thereby magnifying the effect on spreads, real variables, and inflation (Panels A, B, and E). The EMU-wide monetary policy does indeed respond to the output contraction with a reduction in the monetary policy rate. However, the reduction in the interest rate is not enough to offset the recession induced by a negative capital quality shock: the idiosyncractic disturbances in the UK bear a limited influence in the EMU monetary policy response. Notice that the resulting exchange rate

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[26]Ex-post, the central bank does not provide unlimited amounts of credit, but the promise of doing so is what stabilizes the risk premium (see Gertler and Karadi, 2009). One can also think of this intervention as countercyclical fiscal policy: the government uses its risk-free status to borrow and lend to the private sector with a subsidy, thereby addressing the tightening of credit supply.

depreciation (Panel C) is a result of the deflationary pressures (Panel E), a process that is typically described as an "internal devaluation" which is painful for the UK economy. Moreover, the increase in net exports is largely a result of an import compression induced by a decline in aggregate demand.

Figure 5 shows alternative impulse response functions, where the economy is affected by a 1 standard deviation in total factor productivity (TFP). Interestingly, the response of GDP, inflation and employment to a decline in TFP (Panels A and B) is very similar across regimes. This helps explain why the unconditional welfare benefits of QE policies (Table 5), taking into account all shocks and not only capital quality shocks, are smaller. The direct effect of a decline in TFP is a contraction of output and an increase in inflation (Panels A and E). In response to higher inflation, the BoE tightens policy in the case of independent monetary policy, which leads to a small increase in the external finance premium and a real exchange rate appreciation that hurts competitiveness. QE fully stabilizes the premium in this case, but the macroeconomic effect is negligible. On the contrary, when the UK is in the EMU, the expanded ECB does not tighten policy so aggressively, which leads a slightly smaller response of GDP. Moreover, there is a decline in the external premium on impact (Panel G), which gradually overshoots the long-run equilibrium.

4.4   Robustness

Given the uncertainty on how parameter values will behave before and after EMU membership, this subsection presents four experiments that illustrate how the basic trade-off for the UK of joining a currency area could be modified under alternative scenarios. In Table 7 we consider the impact on welfare of changing some key parameters of the model, including: (i) convergence in fiscal policy, (ii) a higher trade elasticity of substitution, (iii) a larger reduction in transaction costs, and (iv) a smaller reduction in the risk premium volatility.

Experiment 1 illustrates a possible scenario in which UK government spending shocks converge to the same process followed by the EMU. This entails a reduction of two thirds in government spending volatility. This convergence will increase the welfare of joining the monetary union, but the effect will be small and it would not change our basic result.

Experiment 2 considers the situation in which the trade elasticity is cal-

ibrated to $\theta = 5$, and the model is reestimated.[27] A larger trade elasticity has an impact both on the steady and business cycles. In the long-run, a large trade elasticity will result in a greater expansion in trade for a given reduction in transaction costs. This additional boost in international trade will provide larger welfare gains relative to the baseline scenario. However, at business cycles frequencies a large trade elasticity implies that there would be a larger substitution between home and foreign goods, resulting in an increase in macroeconomic volatility and hence larger welfare losses. The net effect of these two channels is a welfare loss of 0.3 percent, which is lower than in baseline scenario. This experiment underscores that the baseline results are robust to an alternative assumption on trade elasticity.

Experiment 3 considers the case when the reduction in transaction costs is 7 percentage points, to $\tau = 0.03$. In that case, the trade expansion would be larger and the welfare gain will be zero. This implies that the UK would be indifferent between the two monetary regimes. Finally experiment 4 evaluates the situation in which there is a modest reduction in the risk premium volatility of 7 percent (from 2.8 to 2.6 percent), induced by a corresponding moderation in the volatility of capital quality shocks. In that scenario, the volatility arising from joining a currency union would be contained and the welfare gain inside the monetary union would be zero.

[Insert Table 7]

To better illustrate alternative scenarios for experiments 3 and 4, Figure 6 shows the welfare impact of different magnitudes of trade cost and risk premium volatility. In panel A, experiment 3 corresponds to the situation in which $\tau = 0.03$, where the UK would be indifferent between an independent monetary policy regime and the currency union. In panel B, experiment 4 corresponds the situation in which the risk premium volatility is $\sigma_{rp} = 2.6$, and the UK would also remain indifferent between entering the EMU or not. The range of welfare gains associated with the risk premium is much larger than the correspondent range for transaction costs. This implies that

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[27]The parameter estimates are available upon request. The (log) Bayes factor in favor of the estimated model with $\theta = 1$ over $\theta = 5$ is 43.35, which is a large number. As it was the case with the baseline model, we calibrate the volatility of intertemporal, TFP, capital quality and government spending shocks to the lower bound of the confidence set, in order to have a baseline that better reflects the volatility of observable variables.

relatively small increases in the volatility of the risk premium need to be compensated by large reductions in the transaction costs in order for the UK to remain indifferent between entering the EMU or not. In fact, the key factor is changes in the volatility in the risk premium, that play the most important role in determining the decision of a country in joining the EMU.

5   Conclusions

This paper revisits the old issue of optimal currency areas. Since the seminal paper by Mundell (1961) on optimum currency areas, there has been an extensive research on benefits and costs of joining a monetary union. Even though a complete analysis of entering a currency union should include several dimensions in terms of the impact on growth and business cycles, we contributed to the discussion in two dimensions. First, we estimated a two-country DSGE model of the UK and the euro area in order to use it as a laboratory to evaluate the welfare impact on the UK of adopting the euro. Second, we evaluate the role of trade and financial channels in the decision of entering a monetary union.

On the one hand, joining a currency union could reduce the transaction costs of trade with other countries, providing efficiency gains to the new member country and the monetary union as a whole. On the other hand, adopting a common currency is costly for a country since it loses independent monetary and exchange rate policies as tools for macroeconomic stabilization. The paper shows that when comparing these two channels only, entering the euro area generates welfare losses of 0.5 percentage points of lifetime consumption.

However, the financial channel can radically change the welfare implications of entering a monetary union. In tranquil times the gains from joining the monetary union under low risk premium volatility is 2.4 percent of lifetime consumption, rendering the monetary union as the best policy regime. However, during crisis periods the welfare loss could increase up to 2.2 percent, eliminating the gains from entering into a currency area. The policy analysis underscores the fact that financial stability, measured as low and stable risk premium, is of key importance to sustain a monetary union over time. Changes in financial conditions might radically change the trade-offs inherent to the decision of joining a monetary union.

Throughout the analysis, we have modeled the change in corporate risk

premium by modifying the process of the capital quality shock. There are alternative ways to capture the change in market sentiment and their implications on asset prices such as news shocks, uncertainty shocks, or the introduction of different process of learning in the private sector. But we consider that the main implications of our results would not be changed, namely that the volatility of the corporate risk premium is on the main factors driving the decision to join a monetary union. The change in transaction costs, by itself, would be unlikely to induce a switch in policy regimes.

Finally, while we have not formally assessed the effects of the zero lower bound (ZLB) on nominal interest rates in the welfare calculation, we think that the benefits of QE policies are more important when the ZLB is in fact present. As a result, giving up using QE as a stabilization tool when joining a monetary union is likely to increase the welfare loss, which could be substantial in a financial crisis. Introducing the effects of the ZLB as an independent monetary policy, as well as in a monetary union, would be an interesting avenue for future research.

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A   Appendix: The Model

In this appendix we present the two country model that we use to analyze linkages between the UK and the euro area. We estimate a two-country version of a DSGE model similar to those by Christiano, Eichenbaum and Evans (2005) and Smets and Wouters (2003, 2007), where we include trade and financial linkages across countries. As in Rabanal and Tuesta (2010), our benchmark model assumes that there is local currency pricing for goods that are shipped internationally. The model also includes financial frictions with a banking sector as in Gertler and Karadi (2011). The presence of an agency cost for bankers leads to an inefficient spread between the return to capital and the real risk-free interest rate, that can be partially undone with the use of unconventional monetary policies. This allows us to assess the welfare implications of the loss of both conventional and unconventional monetary policies if the UK joined the euro area. In addition, we assume that there is an incomplete asset market structure at the international level: agents only have access to one non-contingent bond that is denominated in foreign-country currency. The model incorporates 16 shocks. In the econometric section we are interested in explaining 13 variables.[28]

We assume that there are two countries, home and foreign, of size n and $1 - n$, respectively. Each country produces a continuum of differentiated retail goods, indexed by $h \in [0, n]$ in the home country and $f \in [n, 1]$ in the foreign country, which are traded internationally. Differentiated goods are imperfect substitutes for each other, and are priced according to a Calvo-type restriction. They are used as in input in the production of a final good in each country that is used for domestic final consumption, investment, and government spending, and hence it is not traded across borders. The model also incorporates linear shipping costs of moving goods internationally. As it is typically done in the literature, we follow Samuelson (1954) and introduce "iceberg" shipping costs.

In what follows, we present the problem for households, domestic financial intermediaries, intermediate goods producers, capital goods producers, and final goods producers in the home country. The expression for the foreign country are analogous, and the convention we use is that variables and parameters with an asterisk denote the foreign country counterparts.

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[28] As discussed in Smets and Wouters (2003), including more shocks than observable variables helps in overcoming misspecification issues.

A.1 Households

In each country, there is a continuum of infinitely lived households, that obtain utility from consuming the final good and disutility from supplying hours of labor. Within each household, there are two types of agents: bankers and workers. At any point in time, a fraction $(1 - f)$ of household members are bankers, and a fraction f are workers. Each banker manages a domestic financial intermediary that takes deposits from domestic households and finances domestic investment projects. Every period, a fraction θ_N of bankers stay in their position, while a fraction $(1 - \theta_N)$ become workers. In the same period, the same number $(1 - f)(1 - \theta_N)$ move from being workers to bankers. This assumption keeps the fractions of bankers and workers constant, and it is necessary to avoid bankers accumulating too many retained earnings and thus, making financial frictions irrelevant.

In the home country, households are indexed by $j \in [0, n]$ and their lifetime utility function is:

$$E_0 \sum_{t=0}^{\infty} \beta^t D_{c,t} \left[\log \left(C_t^j - bC_{t-1} \right) - D_{n,t} \frac{\left(N_t^j \right)^{1+\eta}}{1 + \eta} \right], \tag{19}$$

where E_0 denotes the rational expectations operator using information up to time $t = 0$. $\beta \in [0, 1]$ is the discount factor. Consumers obtain utility from consuming the final good, C_t^j, with external habit formation. $b \in [0, 1]$ denotes the importance of the habit stock, which is last period's aggregate consumption (C_{t-1}). $\eta > 0$ is the inverse elasticity of labor supply with respect to the real wage, and N_t^j is the labor supply of the household. $D_{c,t}$, and $D_{n,t}$ denote intertemporal and intratemporal preference shocks.[29] These shocks evolve as follows:

$$
\begin{aligned}
\log(D_{c,t}) &= \rho_c \log(D_{c,t-1}) + \varepsilon_t^{c,d}, \\
\log(D_{n,t}) &= \rho_n \log(D_{n,t-1}) + \varepsilon_t^{n,d}.
\end{aligned}
$$

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[29] See Primiceri et al. (2006).

A.1.1 International Asset Markets Structure and the Budget Constraint

Households can save domestically in government bonds and in bank deposits, which are perfect substitutes and pay the same riskless nominal interest rate. We introduce international incomplete markets in a simple and tractable way, following Benigno (2009). The budget constraint of home-country households is given by:

$$P_t C_t^j + B_t^j + NER_t D_t^j + T_t \tag{20}$$
$$= R_{t-1} B_{t-1}^j + R_{t-1}^* \Psi \left(\frac{NER_{t-1} D_{t-1}}{Y_{t-1} P_{t-1}} \right) U_{t-1} NER_t D_{t-1}^j + W_t^j N_t^j + \Pi_t^j,$$

where B_t^j denotes holdings of the domestic-currency debt (banks deposits and government debt), D_t^j denotes holdings of foreign currency denominated bonds, R_t is the home country gross nominal interest rate and R_t^* is the foreign country gross nominal interest rate. Home-country households also face a cost of undertaking positions in the foreign bonds market. The $\Psi(.)$ function captures this cost and depends on the aggregate real holdings of the foreign assets in the entire economy, and therefore is taken as given by individual households.[30] We also include an exogenous shock (U_t) which helps explains deviations from the uncovered interest rate parity condition. For this reason, we call this shock the "uncovered interest rate parity" shock, which also follows a zero mean, AR(1) process in logs. NER_t is the nominal exchange rate expressed in units of domestic currency needed to buy one unit of foreign currency and P_t is the price level of the final good (to be defined below). T_t are lump-sum taxes that are used to finance government spending.

Households obtain labor income from supplying labor to intermediate goods producers, for which they receive a nominal wage, W_t^j, and receive profits from financial and non-financial firms, Π_t^j. The model includes sticky wages, and hence the wage received by each household is specific and depends on the last time wages were reoptimized. We assume that households in each country can insure their labor income arising from staggered wage setting.

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[30] Hence households choose D_t^j but take the aggregate $D_t = \frac{1}{n} \int_0^n D_t^j dj$ as given. This cost induces stationarity in the net foreign asset position. See Schmitt-Grohé and Uribe (2003) for applications in small open economy models, and Benigno (2009) in two-country models.

This assumption allows us to separate the consumption/saving decisions from the labor supply decision (see Erceg, Henderson, and Levin, 2000; henceforth EHL).[31]

The first order conditions for holding domestic and foreign debt are:

$$1 = \beta R_t E_t \left(\Lambda_{t,t+1} \frac{P_t}{P_{t+1}} \right), \tag{21}$$

$$1 = \beta R_t^* \Psi \left(\frac{NER_t D_t}{P_t Y_t} \right) U_t E_t \left(\Lambda_{t,t+1} \frac{NER_{t+1} P_t}{NER_t P_{t+1}} \right), \tag{22}$$

where $\Lambda_{t,t+1} = \frac{C_t - b C_{t-1}}{C_{t+1} - b C_t} \frac{D_{c,t+1}}{D_{c,t}}$ is the ratio of marginal utilities of consumption between time t and $t+1$. Combining equation (22) with the analogous to (21) in the foreign country delivers the following risk-sharing condition, which forms the basis of the real exchange rate determination under incomplete markets:

$$E_t \left(\Lambda_{t,t+1}^* \frac{P_t^*}{P_{t+1}^*} \right) = E_t \left(\Lambda_{t,t+1} \frac{NER_{t+1} P_t}{NER_t P_{t+1}} \right) \Psi \left(\frac{NER_t D_t}{Y_t P_t} \right) U_t. \tag{23}$$

We define the real exchange rate as the ratio of final goods prices, expressed in common currency:

$$RER_t = \frac{NER_t P_t^*}{P_t}. \tag{24}$$

A.1.2 Staggered Wage Setting and The Wage Decision

As in EHL, we assume that each household is a monopoly supplier of differentiated labor service, N_t^j. The household sells differentiated labor to intermediate goods producers. Thus, one effective unit of labor that an intermediate good producer uses is given by

$$N_t = \left\{ \left(\frac{1}{n} \right)^{\varepsilon_w} \int_0^n \left(N_t^j \right)^{\frac{\varepsilon_w - 1}{\varepsilon_w}} dj \right\}^{\frac{\varepsilon_w}{\varepsilon_w - 1}}, \tag{25}$$

As shown by EHL, the demand curve for each type of labor is given by

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[31] In order to keep notation simple, we do not make the structure of the complete domestic asset markets explicit.

$$N_t^j = \left(\frac{W_t^j}{W_t}\right)^{-\varepsilon_w} N_t, \text{ for } j \in [0,1], \tag{26}$$

where W_t is the aggregate wage index as follows: $W_t = \left[\frac{1}{n}\int_0^n \left(W_t^j\right)^{1-\varepsilon_w} dj\right]^{\frac{1}{1-\varepsilon_w}}$.

Households set wages in a staggered way with a Calvo-type restriction. In each period, a fraction $1 - \theta_w$ of households can reoptimize their posted nominal wage. Consider a household resetting its wage in period t, and let W_t^* the newly set wage. The household will choose W_t^* in order to maximize

$$\underset{W_t^*}{Max} E_t \sum_{k=0}^{\infty} (\beta\theta_w)^k D_{c,t+k} \left[\log\left(C_{t+k} - bC_{t+k-1}\right) - D_{n,t+k}\frac{\left(N_{t+k|t}\right)^{1+\eta}}{1+\eta}\right], \tag{27}$$

where $N_{t+k|t}$ denotes labor supply in period $t+k$ of a household that last reset its wage in period t. Households maximize (27) subject to (20) and (26). The first order condition associated with the problem above can be expressed as follows:

$$E_t \sum_{k=0}^{\infty} (\beta\theta_w)^k \frac{D_{c,t+k}N_{t+k|t}}{(C_{t+k} - bC_{t+k-1})} \left\{\frac{W_t^*}{P_{t+k}} - \frac{\varepsilon_w}{\varepsilon_w - 1}D_{n,t+k}N_{t+k|t}^{\eta}\left(C_{t+k} - bC_{t+k-1}\right)\right\} = 0, \tag{28}$$

where $N_{t+k|t} = (\frac{W_t^*}{W_{t+k}})^{-\varepsilon_w}N_{t+k}$.

The evolution of the aggregate wage index is given by

$$W_t = \left[\theta_w W_{t-1}^{1-\varepsilon_w} + (1 - \theta_w)\left(W_t^*\right)^{1-\varepsilon_w}\right]^{\frac{1}{1-\varepsilon_w}}. \tag{29}$$

A.2 Domestic Financial Intermediaries

As in Gertler and Karadi (2011), we assume that bankers run a domestic financial intermediary that channels funds from depositors to intermediate goods producers. Bankers obtain funds from households, for which they pay an interest rate of R_t, and lend funds to intermediate goods producers to finance investment projects, for which they require a return on capital (R_t^K). We assume that bankers do not engage in cross-border deposit or investment activities, but only provide financial intermediation services to

domestic households and capital goods producers.[32] The intermediary balance sheet is given by

$$Q_t S_t = N_t^W + B_t, \tag{30}$$

where S_t is credit to firms, Q_t is the price of loans, B_t are deposits from households, and N_t^W is the financial intermediaries net worth, which evolves as:

$$
\begin{aligned}
N_t^W &= (R_t^K)Q_{t-1}S_{t-1} - R_{t-1}B_{t-1} \\
&= (R_t^K - R_{t-1})Q_{t-1}S_{t-1} + R_{t-1}N_{t-1}^W
\end{aligned} \tag{31}
$$

Absent financial frictions, the return to capital and to debt instruments would be the same and financial intermediaries would make zero profits. We introduce a financial friction as in Gertler and Karadi (2011), and assume that any given period bankers can divert a fraction λ of available funds for personal profit. Knowing this, depositors will only supply funds to the intermediary if the following incentive constraint is satisfied:

$$
\begin{aligned}
V_t &= \max E_t \sum_{i=0}^{\infty} (1-\theta_N)\theta_N^i \beta^{i+1}\Lambda_{t,t+1+i}\left[(R_{t+i+1}^K - R_{t+i})Q_{t+i}S_{t+i} + R_{t+i}N_{t+i}^W\right] \tag{32} \\
&\geq \lambda Q_t S_t.
\end{aligned}
$$

That is, the value of the financial intermediary is larger than the value of the funds that can be diverted. This friction will lead to a positive spread between the return to capital and the deposit rate $(R_t^K - R_{t-1})$. As shown by Gertler and Karadi (2011), when the constraint binds the following relationship holds:

$$Q_t S_t = \phi_t N_t^W, \tag{33}$$

where ϕ_t is the leverage ratio, which is common to all bankers and is given by

$$\phi_t = \frac{\eta_t}{\lambda - \nu_t}. \tag{34}$$

η_t is the marginal value of the bank's net worth, holding its portfolio (S_t) constant, and ν_t is the marginal value of expanding assets holding net worth (N_t^W) constant:

$$
\begin{aligned}
\eta_t &= E_t \left\{(1-\theta_N)\beta\Lambda_{t,t+1}R_t + \theta_N\beta\Lambda_{t,t+1}z_{t,t+1}\eta_{t+1}\right\} \tag{35} \\
\nu_t &= E_t \left\{(1-\theta_N)\beta\Lambda_{t,t+1}(R_{t+1}^K - R_t) + \theta_N\beta\Lambda_{t,t+1}\chi_{t,t+1}\nu_{t+1}\right\},
\end{aligned}
$$

---

[32]See Dedola, Karadi and Lombardo (2012) for a two-country DSGE model with financial intermediaries that can take deposits and make investments in both countries.

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where $\chi_{t,t+1} = Q_{t+1}S_{t+1}/Q_tS_t$, is the growth rate of assets and $z_{t,t+1} = N_{t+1}^W/N_t^W$ is the growth rate of net worth.

Finally, the evolution of aggregate net worth can be decomposed between "surviving" bankers from last period, and "new" bankers entering the business at time t:

$$N_t^W = N_t^E + N_t^N. \tag{36}$$

Surviving bankers net worth is given by

$$N_t^E = \theta_N[(R_t^K - R_{t-1})\phi_{t-1} + R_{t-1}]N_{t-1}^W \exp(\varepsilon_t^{nw}), \tag{37}$$

where we include a "net worth" shock that can affect the bankers' balance sheet position, spreads and the macroeconomy. ε_t^{nw} is iid normally distributed shock. New bankers receive start-up funds which are a fraction $\omega/(1-\theta_N)$ of the exiting bankers' final period assets, which is $(1-\theta_N)Q_tS_{t-1}$. Hence, the start-up funds for new bankers are given by

$$N_t^N = \omega Q_tS_{t-1}. \tag{38}$$

This concludes the discussion of the financial sector in the model, that we will use for estimation. Below, we describe the role of unconventional monetary policies, and how some of the relationships in (33)-(38) change.

A.3 Non-Financial Firms

The model has final goods, differentiated home and foreign retail goods, intermediate goods, and capital goods. Final goods producers purchase a composite of differentiated retail home goods and foreign goods to produce a homogeneous final good product that is non-tradable across countries. Differentiated retail home and foreign goods producers operate under sticky prices and monopolistic competition. They buy homogeneous intermediate goods, differentiate them, and sell their products to final goods producers in both countries. Differentiated retail home and foreign goods are traded across countries. Capital goods producers increase the capital stock by purchasing the final good. Intermediate goods producers buy capital goods and hire labor to produce a homogeneous good that is sold to differentiated retail home and foreign goods producers.

A.3.1 Final good producers and "Iceberg" costs

A continuum of final goods producers firms purchase a composite of differentiated retail home goods, $Y_{H,t}$, and a composite of differentiated retail foreign-produced goods, $Y_{F,t}$, to produce a homogeneous final good product (Y_t). A fraction τ of the composite of imported goods is lost in transit between the two countries. This functional form for transportation costs was first proposed by Samuelson (1954), and is also known in the literature as "iceberg costs". Therefore, the production of the final good is given by:

$$Y_t = \left\{ \omega^{\frac{1}{\theta}} Y_{H,t}^{\frac{\theta-1}{\theta}} + (1-\omega)^{\frac{1}{\theta}} \left[(1-\tau) Y_{F,t} \right]^{\frac{\theta-1}{\theta}} \right\}^{\frac{\theta}{\theta-1}}, \tag{39}$$

where ω denotes the fraction of home-produced goods that are used for the production of the final good, and θ denotes the elasticity of substitution between domestically produced and imported composite goods in both countries. The domestic composite good includes the home differentiated retail goods as follows:

$$Y_{H,t} = \left[\left(\frac{1}{n} \right)^{\varepsilon_p} \int_0^n Y_{H,t}(h)^{\frac{\varepsilon_p-1}{\varepsilon_p}} dh \right]^{\frac{\varepsilon_p}{\varepsilon_p-1}},$$

where $\varepsilon_p > 1$ denotes is the elasticity of substitution between types of retail goods. Similarly, the composite of foreign differentiated retail goods is:

$$Y_{F,t} = \left[\left(\frac{1}{1-n} \right)^{\varepsilon_p} \int_n^1 Y_{F,t}(f)^{\frac{\varepsilon_p-1}{\varepsilon_p}} df \right]^{\frac{\varepsilon_p}{\varepsilon_p-1}},$$

The demand functions for both types of composite goods are:

$$Y_{H,t} = \omega \left(\frac{P_{H,t}}{P_t} \right)^{-\theta} Y_t, \quad Y_{F,t} = (1-\omega)(1-\tau)^{(\theta-1)} \left(\frac{P_{F,t}}{P_t} \right)^{-\theta} Y_t, \tag{40}$$

and the price level is given by:

$$P_t = \left[\omega \left(P_{H,t} \right)^{1-\theta} + (1-\omega) \left(\overline{P}_{F,t} \right)^{1-\theta} \right]^{\frac{1}{1-\theta}}.$$

where $\overline{P}_{F,t} = P_{F,t}/(1-\tau)$. That is, what matters for the definition of the price level is the after-iceberg cost price of imported goods. We can rewrite the weights as follows in the production function of the final good:

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$$Y_t = \left[\omega^{\frac{1}{\theta}} Y_{H,t}^{\frac{\theta-1}{\theta}} + (1 - \hat{\omega})^{\frac{1}{\theta}} (Y_{F,t})^{\frac{\theta-1}{\theta}} \right]^{\frac{\theta}{\theta-1}}, \tag{41}$$

where

$$(1 - \hat{\omega}) = (1 - \omega)(1 - \tau)^{\theta-1}.$$

Higher transportation costs τ, or an increase in the elasticity of substitution θ decreases the value of $(1 - \hat{\omega})$, and raises the home bias in the economy. The demand functions for individual retail goods are given by

$$Y_{H,t}(h) = \left[\frac{P_{H,t}(h)}{P_{H,t}} \right]^{-\varepsilon_p} Y_{H,t}, \text{ for all } h \in [0, 1], \tag{42}$$

and

$$Y_{F,t}(f) = \left[\frac{P_{F,t}(f)}{P_{F,t}} \right]^{-\varepsilon_p} Y_{F,t}, \text{ for all } f \in [n, 1],$$

where

$$P_{H,t}^{1-\varepsilon_p} = \frac{1}{n} \int_0^n P_{H,t}^{1-\varepsilon_p}(h) \, dh. \tag{43}$$

and

$$P_{F,t}^{1-\varepsilon_p} = \frac{1}{1-n} \int_n^1 P_{F,t}^{1-\varepsilon_p}(f) \, df. \tag{44}$$

A.3.2   Capital Producers

At the end of each period, capital producers buy capital from intermediate goods producers, and the final good in order to produce more capital. The value of a new unit of capital is Q_t, which as we show below equals the price of loans. Capital accumulation dynamics are given by the following expression:

$$K_t = (1 - \delta) V_t K_{t-1} + \left[1 - \Phi \left(\frac{I_t}{I_{t-1}} \right) \right] I_t. \tag{45}$$

where δ denotes the rate of depreciation and the adjustment cost function, $\Phi(.)$, is an increasing and convex function as in Smets and Wouters (2003). Furthermore, in the steady state, $\overline{\Phi} = \overline{\Phi}' = 0$ and $\overline{\Phi}'' > 0$. Specifically, we use the following function:

$$\Phi \left(\frac{I_t}{I_{t-1}} \right) = \frac{\psi}{2} \left(\frac{I_t}{I_{t-1}} \right)^2$$

The capital accumulation expression also includes a capital quality shock (V_t) that evolves as:

$$\log(V_t) = \rho_v \log(V_{t-1}) + \varepsilon_t^v.$$

Profit maximization delivers the following expression

$$
\begin{aligned}
& 1 - Q_t \left[1 - \Phi\left(\frac{I_t}{I_{t-1}}\right) - \frac{I_t}{I_{t-1}} \Phi'\left(\frac{I_t}{I_{t-1}}\right) \right] \\
& = \beta E_t \Lambda_{t,t+1} Q_{t+1} \left[\Phi'\left(\frac{I_{t+1}}{I_t}\right) \left(\frac{I_{t+1}}{I_t}\right)^2 \right].
\end{aligned}
\tag{46}
$$

A.3.3 Intermediate Goods Producers

In each country, there is a continuum of intermediate goods producers, each producing a homogeneous good that is sold to retailers for differentiation. Intermediate goods producers purchase capital from capital producers, and need to borrow an amount S_t to purchase an amount of capital K_t. There are no financial frictions in the relationship between retail firms and domestic financial intermediaries. Therefore:

$$Q_t K_t = Q_t S_t$$

The production function of intermediate goods in the home country is given by

$$Y_t^M = (A_t X_t N_t)^{1-\alpha} (V_t K_{t-1})^\alpha, \tag{47}$$

where α is the share of capital in the production function. The above production function has two technology shocks and the capital quality shock introduced above (V_t). The first technology shock, X_t, is a world technology shock, that affects the two countries the same way: it has a unit root in logs, as in Galí and Rabanal (2005), Lubik and Schorfheide (2006), and Rabanal and Tuesta (2010). In addition, there is a labor-augmenting country-specific technology shock, A_t, that evolves as an $AR(1)$ process. The evolution of the technology shocks is:

$$
\begin{aligned}
\log(X_t) &= \log(X_{t-1}) + \varepsilon_t^x, \\
\log(A_t) &= \rho_a \log(A_{t-1}) + \varepsilon_t^a.
\end{aligned}
$$

Let P_t^M denote the (real) price of the intermediate good (normalized by the final good price P_t). Then, the labor demand is given by:

$$P_t^M(1-\alpha)\frac{Y_t^M}{N_t} = \frac{W_t}{P_t}$$

The (real) return to capital is given by:

$$\frac{R_t^K}{P_t} = \frac{\alpha P_t^M Y_t^M / K_{t-1} + (1-\delta) V_t Q_t}{Q_{t-1}}$$

A.3.4 Retail firms, Nominal Price Rigidities and Local Currency Pricing

In the home country, a continuum of retail firms indexed by $h \in [0, n]$, purchase the intermediate good and differentiate it into a continuum of home and foreign differentiated retail goods. Each retail firm sells its product, $Y_{H,t}(h)$, to domestic and foreign final goods producers. Having paid a price P_t^M for each unit of intermediate good, retailers repackage it at a negligible cost, and choose the price that maximizes discounted profits subject to a Calvo-type restriction. We assume local currency pricing (LCP) for goods that are shipped internationally: a retail firm chooses a price for the domestic market and a price for the foreign market, each price quoted in the destination market currency. Hence, there is price stickiness in each country's imports prices in terms of local currency, and the law of one price does not hold in the short-run.

In each period, a fraction $1-\theta_H$ of retail firms in the home country change their prices, and set a price for the domestic market, $P_{H,t}(h)$, and a price for the foreign market, $P_{H,t}^*(h)$. Additionally, we assume that the prices of each firm that cannot reoptimize in a given period is indexed to sector-specific lagged inflation in the destination market:

$$\frac{P_{H,t}(h)}{P_{H,t-1}(h)} = (\Pi_{H,t-1})^{\lambda_H}, \text{ and } \frac{P_{H,t}^*(h)}{P_{H,t-1}^*(h)} = (\Pi_{H,t-1}^*)^{\lambda_H}, \quad (48)$$

where $0 < \lambda_H < 1$. Therefore, when allowed to reoptimize, firms maximize

the following stream of discounted profits:

$$
\underset{P_{H,t}(h),P^*_{H,t}(h)}{Max} E_t \left\{ \begin{array}{l} \sum_{k=0}^{\infty} (\beta\theta_H)^k \Lambda_{t,t+k} \left[\frac{P_{H,t}(h)}{P_{t+k}} \left(\frac{P_{H,t+k-1}}{P_{H,t-1}} \right)^{\lambda_H} - P^M_{t+k} \right] Y_{H,t+k|t}(h) + \\ \sum_{k=0}^{\infty} (\beta\theta_H)^k \Lambda_{t,t+k} \left[\frac{NER_t P^*_{H,t}(h)}{P_{t+k}} \left(\frac{P^*_{H,t+k-1}}{P^*_{H,t-1}} \right)^{\lambda_H} - P^M_{t+k} \right] Y^*_{H,t+k|t}(h) \end{array} \right\},
$$

$$(49)$$

where $P_{H,t}(h)$ and $P^*_{H,t}(h)$ are prices of retail good h in the home and foreign markets. $Y_{H,t+k|t}(h)$ and $Y^*_{H,t+k|t}(h)$ are the associated demands for retail good h in each country for those firms who last reoptimized at t:

$$
Y_{H,t+k|t}(h) = \left[\frac{P_{H,t}(h) \left(\frac{P_{H,t+k-1}}{P_{H,t-1}} \right)^{\lambda_H}}{P_{H,t+k}} \right]^{-\varepsilon_p} Y_{H,t+k},
$$

$$
Y^*_{H,t+k|t}(h) = \left[\frac{P^*_{H,t}(h) \left(\frac{P^*_{H,t+k-1}}{P^*_{H,t-1}} \right)^{\lambda_H}}{P^*_{H,t+k}} \right]^{-\varepsilon_p} Y^*_{H,t+k}.
$$

The first order conditions for the pricing decisions of retail firms in the home and foreign market are:

$$
\frac{\hat{P}_{H,t}(h)}{P_{H,t}} = \frac{\varepsilon_p}{\varepsilon_p - 1} \frac{E_t \sum_{k=0}^{\infty} (\beta\theta_H)^k \Lambda_{t,t+k} P^M_{t+k} Y_{H,t+k} \left[\frac{P_{H,t}}{P_{H,t+k}} \left(\frac{P_{H,t+k-1}}{P_{H,t-1}} \right)^{\lambda_H} \right]^{-\varepsilon_p}}{E_t \sum_{k=0}^{\infty} (\beta\theta_H)^k \Lambda_{t,t+k} Y_{H,t+k} \left(\frac{P_{H,t}}{P_{H,t+k}} \frac{P_{H,t+k}}{P_{t+k}} \right)^{1-\varepsilon_p} \left(\frac{P_{H,t+k-1}}{P_{H,t-1}} \right)^{\lambda_H(1-\varepsilon_p)}},
$$

$$(50)$$

$$
\frac{\hat{P}^*_{H,t}(h)}{P^*_{H,t}} = \frac{\varepsilon_p}{\varepsilon_p - 1} \frac{E_t \sum_{k=0}^{\infty} (\beta\theta_H)^k \Lambda_{t,t+k} \frac{P^M_{t+k}}{RER_{t+k}} Y^*_{H,t+k} \left[\frac{P^*_{H,t}}{P^*_{H,t+k}} \left(\frac{P^*_{H,t+k-1}}{P^*_{H,t-1}} \right)^{\lambda^*_H} \right]^{-\varepsilon_p}}{E_t \sum_{k=0}^{\infty} (\beta\theta_H)^k \Lambda_{t,t+k} Y^*_{H,t+k} \left(\frac{P^*_{H,t}}{P^*_{H,t+k}} \frac{P^*_{H,t+k}}{P^*_{t+k}} \right)^{1-\varepsilon_p} \left(\frac{P^*_{H,t+k-1}}{P^*_{H,t-1}} \right)^{\lambda^*_H(1-\varepsilon_p)}}.
$$

$$(51)$$

Equation (50) is the usual optimal price condition under a Calvo-type restriction with indexation, and includes the aggregate demand for domestic intermediate goods from final goods producers ($Y_{H,t}$). Equation (51) is the expression for the price of exports and transforms the relevant real marginal cost of production (P^M_t) to foreign currency by using the real exchange rate.

It includes exports of the composite good to the foreign country $(Y^*_{H,t})$. Note that the coefficients reflecting the degree of nominal rigidity (θ_H, λ_H) are the same for domestic inflation and for exports.

The evolution of the home-produced intermediate goods price indices in the home and foreign countries are, given indexation:

$$P_{H,t}^{1-\varepsilon_p} = (1-\theta_H)\left(\hat{P}_{H,t}\right)^{1-\varepsilon_p} + \theta_H\left[P_{H,t-1}\left(\frac{P_{H,t-1}}{P_{H,t-2}}\right)^{\lambda_H}\right]^{1-\varepsilon_p}, \tag{52}$$

$$P_{H,t}^{*1-\varepsilon_p} = (1-\theta_H)\left(\hat{P}_{H,t}^*\right)^{1-\varepsilon_p} + \theta_H\left[P_{H,t-1}^*\left(\frac{P_{H,t-1}^*}{P_{H,t-2}^*}\right)^{\lambda_H}\right]^{1-\varepsilon_p}. \tag{53}$$

A.4   Closing the Model

In order to close the model, we impose market-clearing conditions for all types of home and foreign intermediate and retail goods. For intermediate goods, we need to take into account the size of the countries and transportation costs. Hence, we multiply per capita quantities by the size of each sector.

$$nY_t^M = nY_{H,t} + (1-n)\tau Y^*_{H,t} + (1-n)(1-\tau)Y^*_{H,t}.$$

Notice that a fraction τ of the exports is assigned to transportation costs and the rest is demanded by the foreign country. For the final good, the market clearing condition in the home country is:

$$Y_t = C_t + I_t + G_t Y_t. \tag{54}$$

We introduce a government expenditure for each country (G_t, G_t^*) such that the ratios of government spending/final good production in each country evolve as $AR(1)$ processes in logs. We assume that both governments run a balanced budget every period (i.e. $G_t Y_t = T_t$ and $G_t^* Y_t^* = T_t^*$).

The law of motion of the internationally traded bonds is written in aggregate terms and is given by :

$$\frac{NER_t D_t}{P_t} = \frac{NER_t D_{t-1} R^*_{t-1} \Psi\left(\frac{NER_{t-1}D_{t-1}}{P_{t-1}Y_{t-1}}\right) U_{t-1} + NX_t}{P_t}, \tag{55}$$

where real net exports $\left(\frac{NX_t}{P_t}\right)$ are given by

$$\frac{NX_t}{P_t} = \frac{(1-n)NER_t P^*_{H,t} Y^*_{H,t} - nP_{F,t} Y_{F,t}}{P_t}. \qquad (56)$$

Finally, we assume that both countries follow a monetary policy rule that targets deviations of domestic CPI inflation and real GDP growth from their steady-state values, that we normalize to zero:

$$\frac{R_t}{R} = \left(\frac{R_{t-1}}{R}\right)^{\varphi_R} [(P_t/P_{t-1})^{\varphi_\pi} (GDP_t/GDP_{t-1})^{\varphi_y}]^{1-\varphi_R} \exp\left(\varepsilon^m_t\right). \qquad (57)$$

B The Model with Unconventional Monetary Policy

Here, we discuss the extension of the model where the central bank has a second instrument, direct credit provision to the corporate sector. Let S^g_t be the provision of public credit, where the government is willing to fund a fraction ψ^{UMP}_t of intermediated assets using government bonds:

$$S^g_t = \psi^{UMP}_t S_t.$$

Unlike bankers, the government does not have an incentive to divert assets. But government provision of intermediated assets has a cost of τ^{UMP} per unit supplied. Since privately intermediated funds are constrained by financial intermediaries net worth, we can rewrite equation (33) as

$$\begin{aligned} Q_t S_t &= \phi_t N^W_t + \psi^{UMP}_t Q_t S^g_t \qquad (58) \\ &= \frac{\phi_t}{1 - \psi^{UMP}_t} N^W_t, \end{aligned}$$

where the fraction of publicly intermediated assets follows the rule:

$$\psi^{UMP}_t = \kappa(E_t R^K_{t+1} - R_t - prem), \qquad (59)$$

and where *prem* is the steady-state external finance premium between private investment and public bonds. Whenever the premium increases, the central bank provides credit to the private sector and aims at reducing the accelerator

effects due to the financial friction. However, the public intervention has an efficiency cost. Once the budget constraint of all the sectors is aggregated, the cost appears in the market-clearing condition of the final good:

$$Y_t = C_t + I_t + G_t Y_t + \tau^{UMP} \psi_t^M Q_t S_t. \tag{60}$$

C Tables

Table 1: Calibrated Parameters

	Value	Parameter
β	0.99	Discount factor
δ	0.025	Depreciation rate
α	0.36	Capital share on the production of intermediate goods
ε_w	6	Elasticity of substitution across types of labor
ε_p	11	Elasticity of substitution across types of goods
$\overline{g}$	0.33	Fraction of government spending in GDP
ω	0.85	Degree of home bias in the UK
ω^*	0.9625	Degree of home bias in the EMU
θ	1.01	Elasticity of substitution between H and F goods
n	0.2	Size of the U.K.
R^K/R	0.01	Risk premium

Table 2: Prior and posterior distributions, model parameters

Parameters	Description	Prior			Posterior
		Type	Mean	Std. Dev.	
b	Habit persistence	Gamma	0.5	0.1	0.66 (0.56- 0.76)
b^*	Habit persistence	Gamma	0.5	0.1	0.41 (0.31- 0.52)
η	Labor disutility	Gamma	1.0	0.25	0.86 (0.63- 1.1)
η^*	Labor disutility	Gamma	1.0	0.25	0.80 (0.58- 1.03)
χ	Cost of foreign position	Gamma	0.01	0.005	0.01 (0.002 - 0.019)
τ	Iceberg costs	Gamma	0.10	0.02	0.1 (0.07 - 0.13)
θ_N	Banker survival probability	Beta	0.95	0.025	0.91 (0.87 - 0.95)
θ_N^*	Banker survival probability	Beta	0.95	0.025	0.86 (0.79 - 0.93)
$\bar{\phi}$	Steady-state leverage ratio	Normal	4	0.25	4.12 (3.73 - 4.52)
$\bar{\phi}^*$	Steady-state leverage ratio	Normal	4	0.25	3.99 (3.58 - 4.39)
$\psi = \psi^*$	Investment adjustment cost	Gamma	3	1	1.58 (0.94 - 2.22)
θ_H	Calvo lotteries in prices	Beta	0.75	0.10	0.71 (0.64 - 0.78)
θ_{F^*}	Calvo lotteries in prices	Beta	0.75	0.10	0.66 (0.60 - 0.73)
λ_H	Indexation	Beta	0.50	0.20	0.12 (0.02 - 0.22)
λ_{F^*}	Indexation	Beta	0.50	0.20	0.08 (0.01 - 0.16)
θ_w	Calvo lotteries in wages	Beta	0.75	0.10	0.78 (0.75 - 0.82)
θ_{w^*}	Calvo lotteries in wages	Beta	0.75	0.10	0.79 (0.75 - 0.83)
φ_π	Taylor rule inflation	Normal	1.5	0.125	1.63 (1.46 - 1.80)
φ_{π^*}	Taylor rule inflation	Normal	1.5	0.125	1.45 (1.27 - 1.63)
φ_y	Taylor rule output growth	Gamma	0.5	0.2	0.78 (0.61 - 0.96)
φ_{y^*}	Taylor rule output growth	Gamma	0.5	0.2	0.79 (0.57 - 1.02)
φ_R	Interest rate smoothing	Beta	0.5	0.2	0.82 (0.79 - 0.85)
φ_{R^*}	Interest rate smoothing	Beta	0.5	0.2	0.83 (0.79 - 0.87)

Notes: Parameters without an asterisk are for the UK, with an asterisk are for the EMU. The table presents the posterior mean and the 90 percent credible set.

Table 3: Prior and posterior distributions, shocks processes

Parameters	Description	Type	Prior Mean	Std. Dev.	Posterior
ρ_c	AR(1) Intertemporal	$Beta$	0.5	0.2	0.87 (0.79 - 0.95)
ρ_c^*	AR(1) Intertemporal	$Beta$	0.5	0.2	0.97 (0.94 - 0.99)
ρ_a	AR(1) TFP	$Beta$	0.5	0.2	0.91 (0.84 - 0.97)
ρ_a^*	AR(1) TFP	$Beta$	0.5	0.2	0.27 (0.03 - 0.51)
ρ_η	AR(1) Intratemporal	$Beta$	0.5	0.2	0.18 (0.02 - 0.33)
ρ_η^*	AR(1) Intratemporal	$Beta$	0.5	0.2	0.05 (0.01 - 0.11)
ρ_g	AR(1) Govt. Spending	$Beta$	0.5	0.2	0.94 (0.91 - 0.97)
ρ_g^*	AR(1) Govt. Spending	$Beta$	0.5	0.2	0.97 (0.97 - 0.99)
ρ_v	AR(1) Capital Quality	$Beta$	0.5	0.2	0.98 (0.97 - 0.99)
ρ_v^*	AR(1) Capital Quality	$Beta$	0.5	0.2	0.98 (0.97 - 0.99)
ρ_{uip}	AR(1) UIP	$Beta$	0.5	0.2	0.90 (0.86 - 0.94)
$\sigma\left(\varepsilon_t^c\right)$	Std. Dev. Intertemporal	$Gamma$	2	1	2.56 (1.89 - 3.22)
$\sigma\left(\varepsilon_t^{c^*}\right)$	Std. Dev. Intertemporal	$Gamma$	2	1	1.39 (0.86 - 1.93)
$\sigma\left(\varepsilon_t^a\right)$	Std. Dev. TFP	$Gamma$	1	0.5	2.47 (1.65 - 3.28)
$\sigma\left(\varepsilon_t^{a^*}\right)$	Std. Dev. TFP	$Gamma$	1	0.5	2.39 (1.43 - 3.35)
$\sigma\left(\varepsilon_t^\eta\right)$	Std. Dev. Intratemporal	$Gamma$	30	10	42.7 (28.6 - 57.0)
$\sigma\left(\varepsilon_t^{\eta^*}\right)$	Std. Dev. Intratemporal	$Gamma$	30	10	38.6 (25.2 - 52.0)
$\sigma\left(\varepsilon_t^g\right)$	Std. Dev. Govt. Spending	$Gamma$	1	0.5	2.39 (2.14 - 2.65)
$\sigma\left(\varepsilon_t^{g^*}\right)$	Std. Dev. Govt. Spending	$Gamma$	1	0.5	0.82 (0.73 - 0.92)
$\sigma\left(\varepsilon_t^v\right)$	Std. Dev. Capital Quality	$Gamma$	1	0.5	0.36 (0.27 - 0.45)
$\sigma\left(\varepsilon_t^{v^*}\right)$	Std. Dev. Capital Quality	$Gamma$	1	0.5	0.14 (0.11 - 0.17)
$\sigma\left(\varepsilon_t^m\right)$	Std. Dev. Monetary Policy	$Gamma$	0.25	0.1	0.2 (0.17 - 0.23)
$\sigma\left(\varepsilon_t^{m^*}\right)$	Std. Dev. Monetary Policy	$Gamma$	0.25	0.1	0.18 (0.15 - 0.22)
$\sigma(\varepsilon_t^{uip})$	Std. Dev. UIP	$Gamma$	0.5	0.2	0.38 (0.26 - 0.52)
$\sigma\left(\varepsilon_t^x\right)$	Std. Dev. Permanent TFP	$Gamma$	1	0.5	0.99 (0.77 - 1.24)
$\sigma\left(\varepsilon_t^{nw}\right)$	Std. Dev.Net Worth	$Gamma$	1	0.5	1.16 (0.26 - 2.00)
$\sigma\left(\varepsilon_t^{nw^*}\right)$	Std. Dev.Net Worth	$Gamma$	1	0.5	0.84 (0.22 - 1.43)

Notes: Parameters without an asterisk are for the UK, with an asterisk are for the EMU.
The table presents the posterior mean and the 90 percent credible set.

Table 4. Second Moments

| | | | | | | Variance Decompositions | | | |
| | Standard Deviations (in %) | | | | | | | | |
	Data	Model	TFP	Cap. Q.	Pref.	Gov. Sp.	Mon.	UIP	N.W.
Δgdp	0.6	1.44	25.9	46.6	1.6	18.0	6.7	0.7	0.6
Δgdp^*	0.55	0.86	32.2	22.0	5.2	6.8	32.5	0.1	1.2
Δc	0.73	1.1	9.5	29.1	54.6	2.6	3.3	0.8	0.1
Δc^*	0.5	0.82	17.2	10.0	45.4	5.0	22.1	0.2	0.2
Δi	3.88	4.59	11.0	69.1	5.9	3.4	3.5	6.0	1.1
Δi^*	1.37	1.8	17.8	44.7	15.6	1.8	15.3	1.9	3.0
Δp	0.59	0.66	42.0	40.1	4.0	2.1	8.8	2.8	0.3
Δp^*	0.42	0.57	50.7	21.5	7.1	1.0	19.2	0.3	0.3
Δrw	0.55	0.73	40.5	31.8	23.3	0.6	0.8	3.0	0.0
Δrw^*	0.54	0.6	54.0	17.0	25.9	0.4	2.4	0.3	0.1
r	0.8	0.81	1.3	93.3	1.2	2.4	1.1	0.4	0.3
r^*	0.77	0.58	5.7	81.0	7.3	2.4	2.9	0.1	0.6
$\Delta(rer)$	3.07	3.47	3.4	7.0	1.0	0.6	8.2	79.9	0.0

Note: The table presents the standard deviation of the observable variables at
the model's posterior mean. The variance decomposition is performed at the
posterior mean of the model's parameters. "TFP" includes TFP and unit root
shocks, "Pref." includes intertemporal and intratemporal utility shocks, "N.W."
are net worth shocks.

Table 5. Steady State Effects and Welfare Gains

Variables in Levels	Ind. M.P.	M.U.
		$\tau = 0.05$
Output (gdp)	100	100.43
Consumption (c)	100	101.20
Investment (i)	100	101.21
Capital (k)	100	101.20
Employment (n)	100	100.00
Exports (x)	100	101.25
Imports (m)	100	101.25
$Welfare\ Gains\ (\lambda \times 100)$	$-$	1.20

Note: All the variables are reported in levels except the welfare gain, which is expressed as a percentage of steady state consumption. The macroeconomic variables with an independent monetary policy are normalized to 100. "Ind M.P." means Independent Monetary Policy. "M.U." means Monetary Union.

Table 6. Business Cycle Effects and Welfare Gains

Standard Deviations (in %)	Ind. M.P.	Ind. M.P. and Q.E.	M.U. $\tau = 0.1$	M.U. $\tau = 0.05$	M.U. $\tau = 0.05.$ Low R.P.	M.U. $\tau = 0.05$ High R.P.
Output (Δgdp)	1.33	1.11	2.94	2.94	1.76	3.44
Consumption (Δc)	0.92	0.91	1.11	1.11	0.85	1.23
Investment (Δi)	3.80	2.60	10.26	10.26	5.22	12.27
Employment (Δn)	2.22	2	4.72	4.72	3.00	5.47
Exports (Δx)	3.40	3.38	1.91	1.91	1.33	2.17
Imports (Δm)	1.62	1.32	3.83	3.83	2.23	4.50
Inflation (Δp)	0.58	0.79	0.97	0.97	0.32	1.11
RER (Δrer)	3.30	0.56	1.10	1.10	0.68	1.28
Welfare Gains ($\lambda \times 100$)	–	0.06	-1.71	-0.53	2.35	-2.19

See notes in Table 5. In addition, "Q.E." means Quantitative Easing. The welfare gains measures the impact of both the steady state and business cycle effects of each monetary arrangement.

Table 7. Experiments

	Standard Deviation				Steady State		Welfare
	GDP	C	K	L	GDP	(EX+IM)	(λ)
1. Fiscal Policy Convergence							
Ind. M. P.	1.33	0.92	1.19	2.22	100.00	100.00	
M.U. and $\tau = 0.05$	2.87	1.30	1.81	4.54	100.43	101.25	-0.47
2. High Elasticity $\theta = 5$							
Ind. M. P.	1.81	1.22	1.38	3.22	100.00	100.00	
M.U. and $\tau = 0.05$	3.05	0.97	1.31	4.81	100.02	103.21	-0.32
3. Larger trade gains							
Ind. M. P.	1.33	0.92	1.19	2.22	100.00	100.00	
M.U. and $\tau = 0.03$	2.94	1.11	1.64	4.72	100.63	101.82	0.00
4. Smaller R.P.($\sigma_{rp} = 2.6$)							
Ind. M. P.	1.33	0.92	1.19	2.22	100.00	100.00	
M.U. and $\tau = 0.05$	2.76	1.07	1.52	4.45	100.43	101.25	0.00

See notes in Table 5. In addition, "EX" denotes real exports and "IM" denotes
real imports.

Figure 1
Monetary Policy in the United Kingdom and the Euro Area
**1999 - 2013**
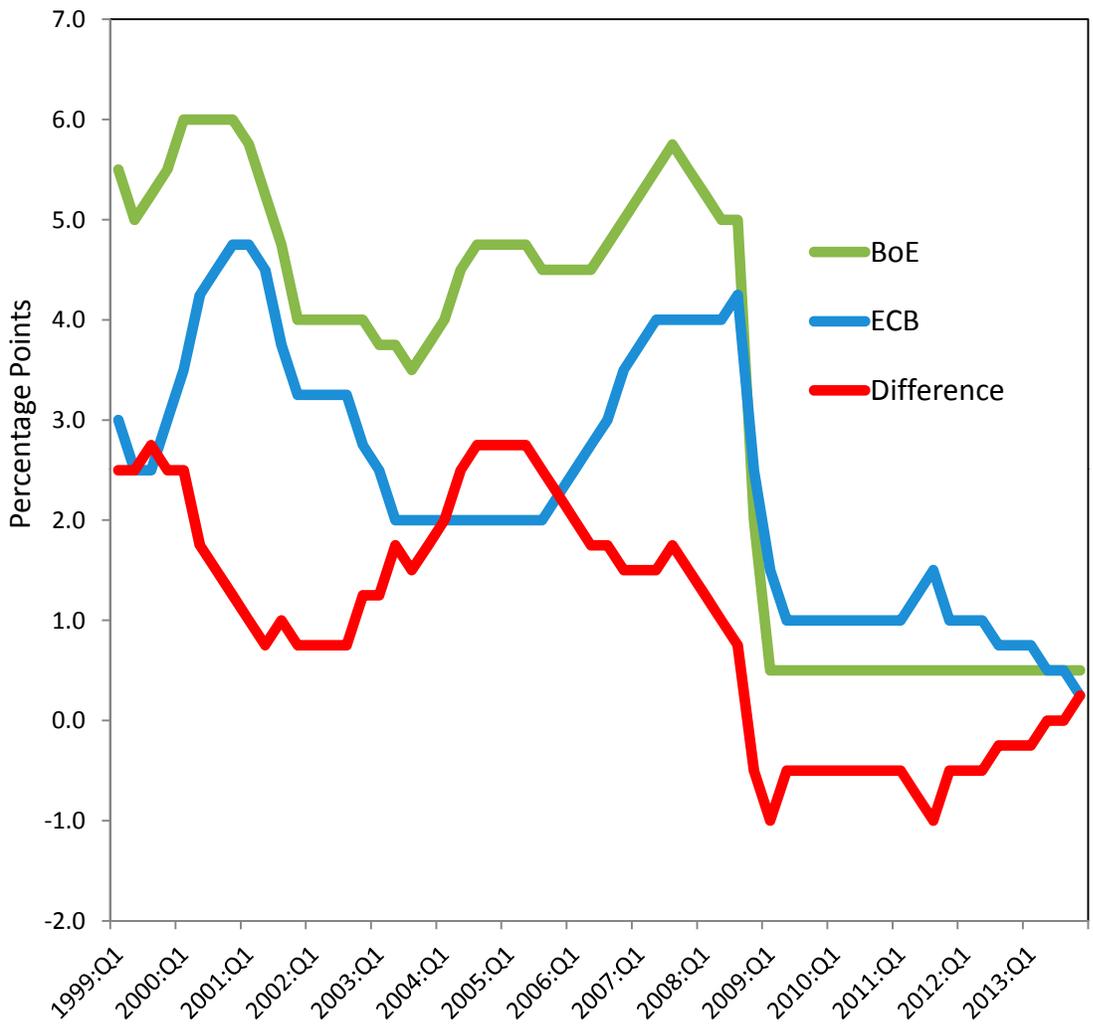
Source: Haver Analytics.

Figure2
Trade with Euro Area in France, Germany, Italy, Spain and the United Kingdom. 1990 -2012
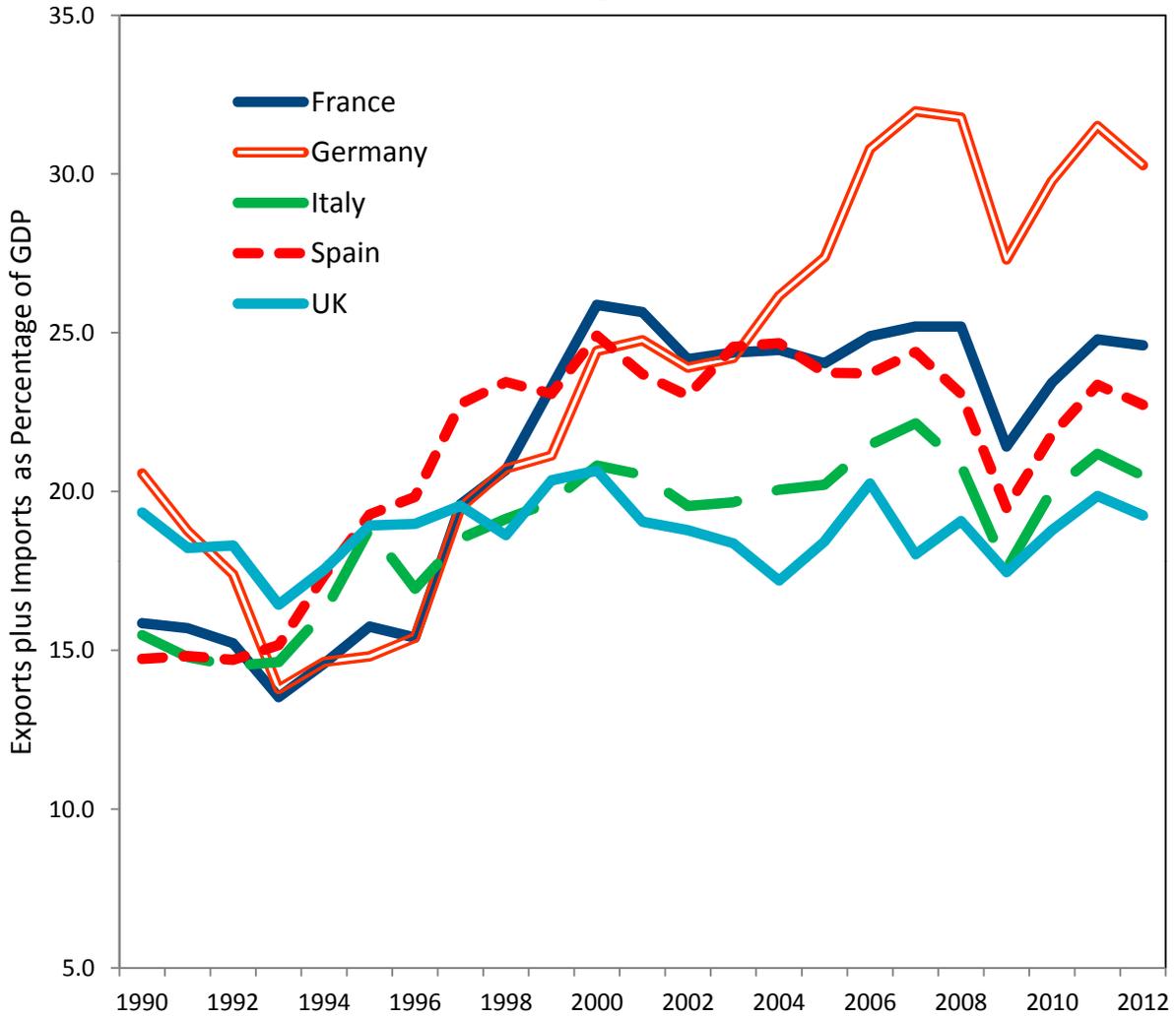
Source: Direction of Trade Statistics, WEO.

Figure 3
CDS Spreads of Non-financial corporations in the United Kingdom and the Euro Area. 2008 -2013
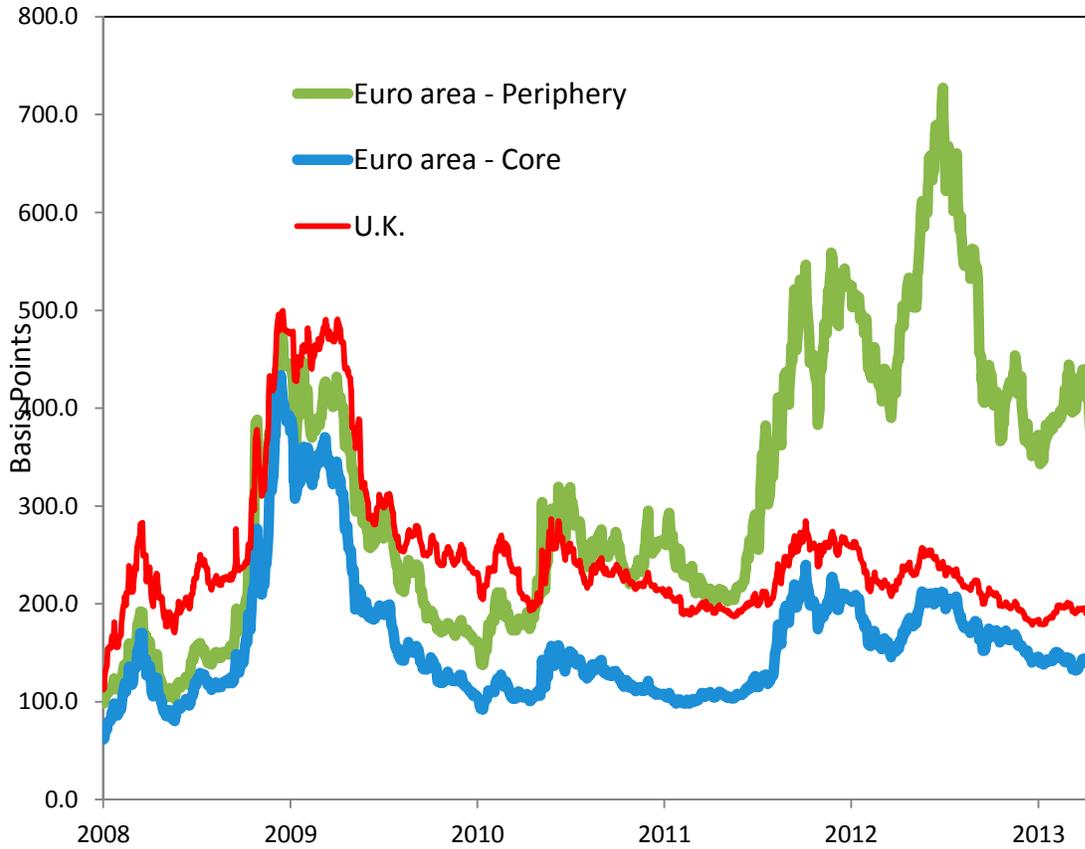
Notes: 5-year non-financial corporate CDS spreads in the U.K., core and periphery euro area countries. Core euro area includes Austria (number of firms in our sample:1), Finland (4), France (29), Germany (21), and Netherlands (8). Periphery euro area includes Italy (4), Portugal (2), and Spain (6). UK CDS spreads are calculated for 26 firms.
Data source: Bloomberg. Corsetti et al. (2013).
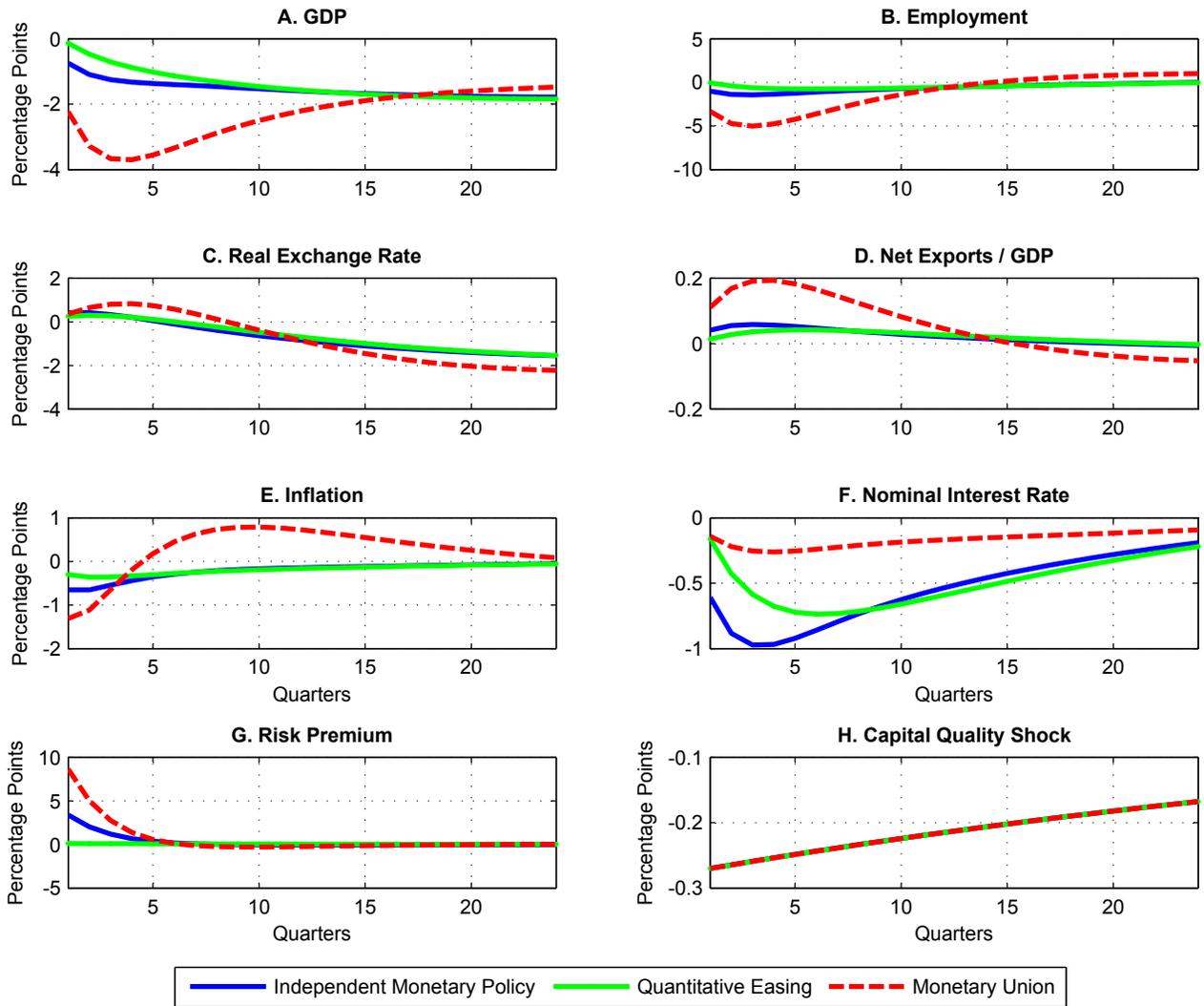
Figure 4. Impulse Response Functions to 1 Standard Deviation Increase in Capital Quality Shock.
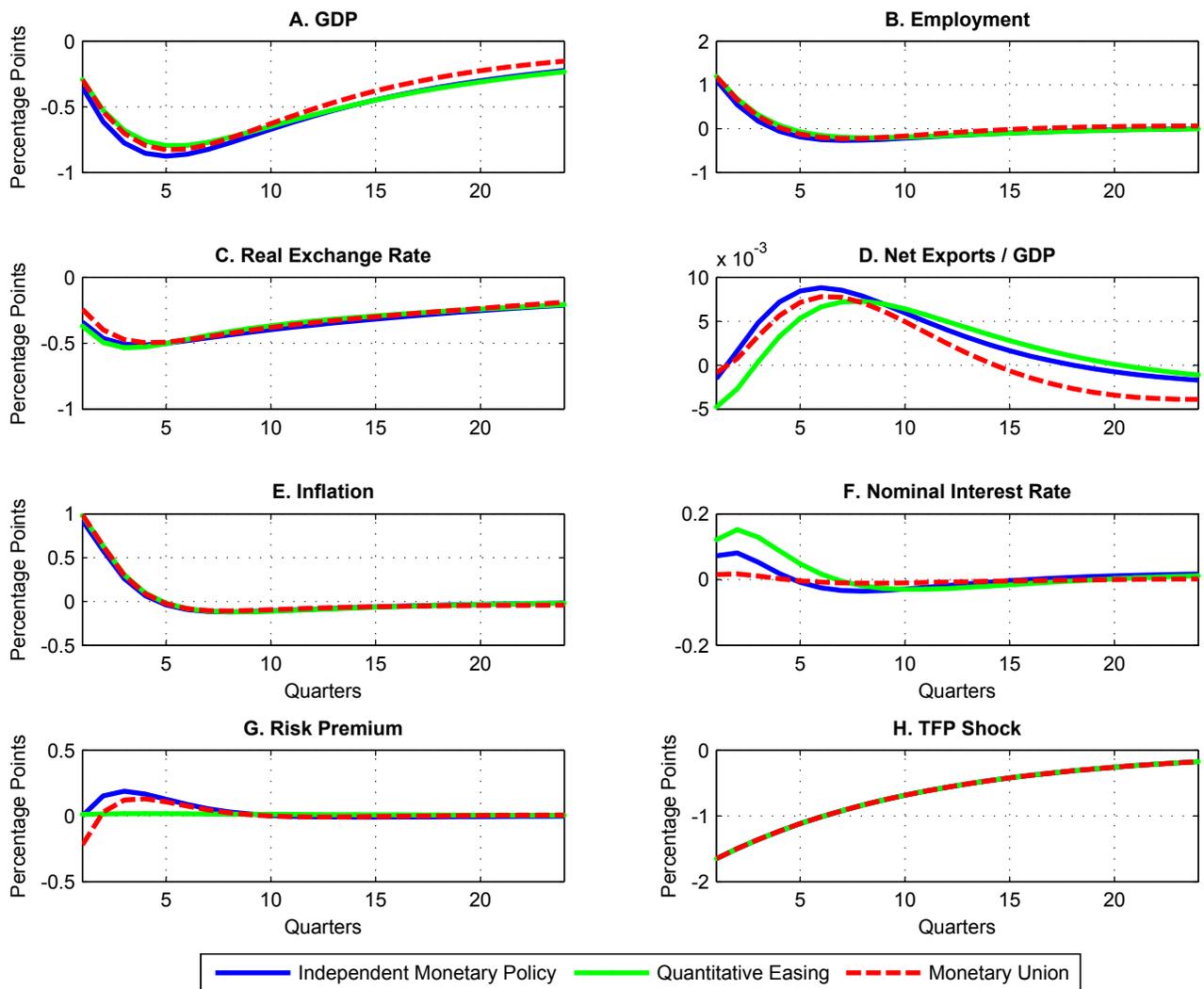
Figure 5. Impulse Response Functions to 1 Standard Deviation Increase in TFP Shock.
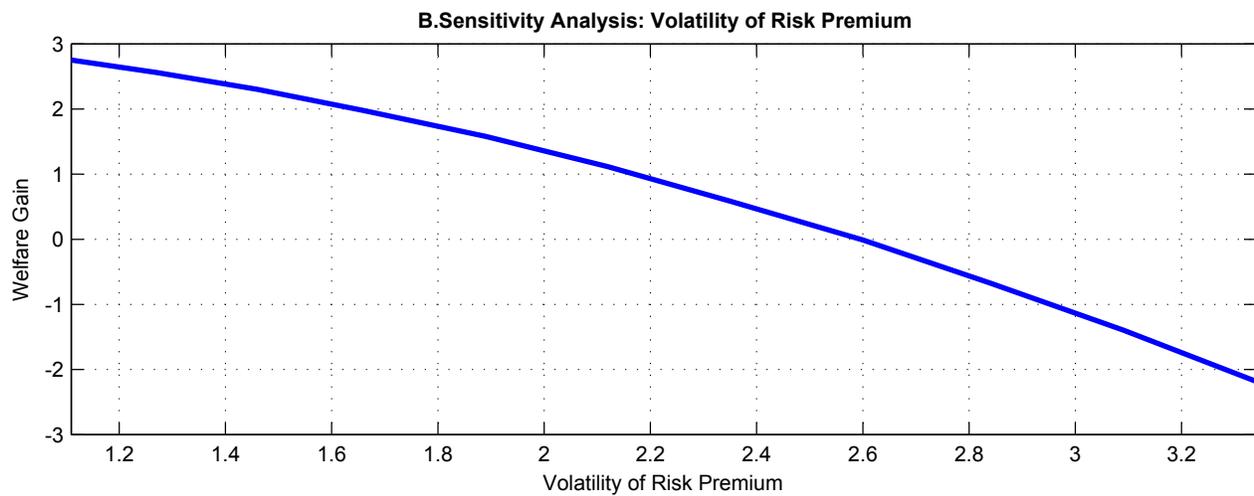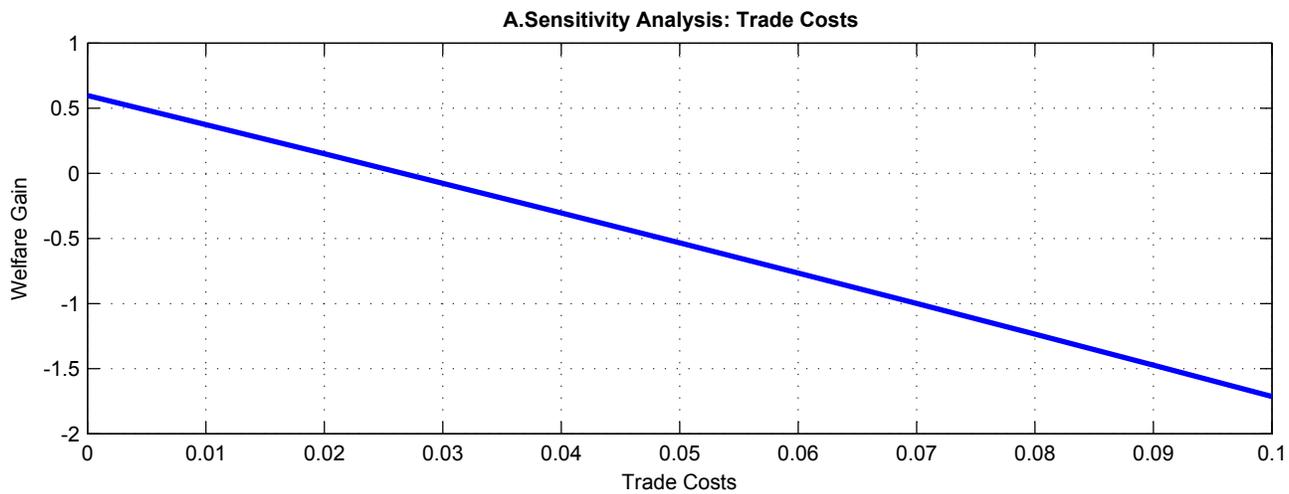
Figure 6. Sensitivity Analysis of Welfare.