# Quantifying the Germany Shock:

*Structural Reforms and Spillovers in a Currency Union*

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**Abstract**

We examine the effects of unilateral structural reforms within a currency union. Focusing on the surge of German competitiveness following the introduction of the Euro, we first provide reduced-form causal evidence supporting the notion that German structural labor-market reforms in the early 2000s led to a crowding-out of manufacturing employment in other Eurozone economies. To assess the impact of this German competitiveness shock, we build a quantitative multi-sector trade model that features downward nominal wage rigidities, endogenous labor supply, unemployment-insurance benefits and international savings. The fixed nominal exchange rate can create binding nominal rigidities in response to a foreign real supply shock – like the one prompted by the German reforms – resulting in significant contraction of manufacturing sectors and increased involuntary unemployment across other Eurozone countries. We consider a number of counterfactual scenarios, such as the impact of German labor-market reforms in the absence of a fixed exchange-rate regime, the role of coordinated reforms within the Eurozone and a higher average inflation rate.

*Keywords:* Euro, monetary union, nominal rigidities, labor markets, structural reforms, import competition, spillovers, quantitative trade model
*JEL:* F16, F41, F45

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# 1 Introduction

The introduction of the Euro in 1999 sparked significant economic adjustments among the member economies of the currency union. An important one was the boom in manufacturing exports that Germany experienced in the aftermath of the structural labor-market reforms of the early 2000s. While German manufacturing thrived until the financial crisis of 2008, manufacturing sectors in other Eurozone (EZ) countries simultaneously experienced a significant downturn.[1]

In this paper, we study the real effects of unilateral structural reforms within a currency union. We focus on the effect German labor-market reforms on the other EZ economies. Starting in the 1990s, Germany experienced a substantial increase in wage flexibility. Additionally, a series of major labor-market and social-insurance reforms were implemented from 2003 to 2005 – known as the "Hartz reforms". These reforms (i) stimulated labor-market participation and (ii) reduced the generosity of unemployment insurance. We argue that these structural reforms substantially increased labor supply and reduced wages in Germany, and induced a significant gain in German competitiveness relative to the rest of the EZ. Simultaneously, the fixed nominal exchange rate prevented currency depreciation of the other EZ economies relative to Germany. To clear local labor markets, nominal wages in the rest of the EZ should have adjusted downward in response to increased German competition. However, as wages were strongly downward rigid in the rest of the EZ, the Germany shock instead led to a significant contraction in manufacturing employment and an increase in involuntary unemployment.

To motivate this narrative, we first present a number of stylized macroeconomic facts, focusing on the period from the mid-1990s up to the financial crisis of 2008. We document that, following the implementation of the Hartz reforms, labor-force participation strongly increased in Germany while real wages declined. These developments were reflected in a real depreciation of German goods relative to those of other EZ economies, implying a large gain in German manufacturing competitiveness within the EZ.[2] We also document that this competitiveness shock led to substantial crowding-out of other EZ countries' exports.[3]

We then proceed to analyze the causal effects of intensified competition from Germany on employment and wages in tradable sectors across EZ economies. Adopting a similar approach to that used by Autor et al. (2013) or Acemoglu et al. (2016), we calculate measures of exposure

[1] Another major one was the large capital flow from the EZ core to the peripheral countries, which resulted in a boom in the periphery – particularly in non-tradable service sectors (Baldwin and Giavazzi, 2015).

[2] The same period was also marked by a strong increase of the German current-account surplus.This increase was mostly due to trade imbalances and substantially driven by a rise in net exports into the EZ.

[3] In terms of its magnitude, the Germany shock was far more important than the China shock for EZ economies. While average German manufacturing import penetration into the EZ (measured as imports per domestic EZ absorption) increased from 7 to more than 16 percentage points between 1995 and 2008, average Chinese import penetration increased from less than 1 percentage point to 6 percentage points during the same period.

to German competition specific to each country-industry and employ Bartik shift-share instruments to tackle the endogeneity of these competition shocks. Our findings indicate that EZ country-industries more exposed to German competition suffered considerable reductions in employment relative to less exposed ones. Moreover, the employment reductions caused by these competition shocks are significant only after the introduction of the common currency. Concurrently, nominal wages failed to adjust downward in response to increased competition from Germany.

Motivated by these empirical facts, we then quantify the consequences of the Germany shock for the EZ in general equilibrium. For that purpose, we build a quantitative New-Keynesian multi-sector model of international trade that can account for the observed macroeconomic developments. Our model fits into the class of gravity models of international trade, featuring multiple sectors and an input-output structure akin to Caliendo and Parro (2015). The model also incorporates downward nominal wage rigidities (henceforth referred to as DNWR) à la Schmitt-Grohé and Uribe (2016). These rigidities lead to sluggish downward adjustment of wages over time, which can result in temporary involuntary unemployment. Our modelling approach builds on the work of Rodríguez-Clare et al. (2020) who introduce DNWR into a quantitative model of international trade. Workers choose between non-market activities and participation in the labor market, which leads to an upward sloping labor supply curve.[4] Our model differs from Rodríguez-Clare et al. (2020) in three aspects that are relevant to studying EZ adjustments to the Germany shock. First, since German structural reforms increased incentives to actively participate in the labor market, we explicitly allow for time variation in the utility value of staying out of the labor force. Second, we introduce unemployment benefits to take into account variation in unemployment replacement rates across countries and over time. Lastly, we introduce a saving decision and international trade in bonds to allow for an endogenous adjustment of countries' current accounts.

We assume that there are multiple countries within the EZ sharing a fixed nominal exchange rate which prevents reductions in real wages via nominal devaluations. Outside the EZ, nominal exchange rates can float freely such that nominal devaluations allow for flexible wage adjustments.

We back-out the nature of the Germany shock with the help of our structural model. First, we estimate nominal wage rigidities for EZ economies and find significantly smaller DNWR for Germany compared to all other EZ countries. Second, we back out shocks to the utility from non-market activities based on variation in labor-force participation and expected real wages. Lowering the attractiveness of non-market activities increases labor-force participation (labor

[4] In contrast to Caliendo et al. (2021), who study the integration effects of the 2004 EU Enlargement, our model abstracts from labor mobility across countries. While our sample ends with global financial crisis, most of the worker mobility from Eastern Europe to the rest of the European Union was restricted until at least 2007.

supply) for given real wages and creates downward pressure on nominal wages and prices. Following the Hartz reforms, German workers experienced a 25% reduction in the utility value of staying out of the labor force, while the rest of the EZ experienced no such shock. Third, we directly feed in data on replacement rates to assess the role of a less generous unemployment insurance for labor supply and international competitiveness.[5] Time series of replacement rates show a strong reduction in the replacement rate for Germany starting with the Hartz reforms in 2003. Additionally, we directly obtain sequences of country-sector-specific TFP shocks and shocks to bilateral trade costs using structural gravity in combination with data. We find that German productivity and trade costs evolved similarly to those of other EZ economies. Lastly, we assess the role of the German savings glut through the lens of our model. Investors can smooth consumption over time by saving and borrowing on the international bond market. We use time series on trade imbalances in combination with agents' Euler equation to back out changes in discount rates across countries and over time. We find that, around the Euro introduction, German investors put a larger weight on current consumption compared to consumption in future periods, which led to increases in saving over time. Together with investors' desire to smooth the temporary positive income shock caused by increased labor supply, this contributed to the large increase in the German current-account surplus.

Economies with a similar industrial structure and export-market composition to the German one are more susceptible to the German competitiveness shock as these economies tend to experience a greater contraction of their export demand. This negative manufacturing demand shock translates into decreased labor demand. Depending on whether the exchange rate regime is fixed or floating, this may have a differential impact on local employment and wages. Under flexible exchange rates, nominal rigidities are never binding, since the nominal exchange rate will depreciate in response to a negative demand shock and a nominal depreciation implies a reduction in the real wage. In this case the demand shock is cushioned by a reduction in the manufacturing real wage. The real wage in services increases due to cheaper imports and employment expands in this sector. By contrast, under a fixed exchange rate regime, the DNWR may become binding. In the short run, nominal wages cannot fully adjust downward to equalize labor supply and labor demand. This leads to excess supply of labor and a temporary increase in involuntary unemployment that only subsequently dies out over time. Additionally, binding DNWR can contribute to even larger decreases in employment because the prospect of involuntary unemployment reduces labor supply, as more workers prefer to engage in home production.

We then discuss alternative policies to deal with the German competitiveness shock. First, we

[5] As unemployment benefits are financed via a revenue-neutral income tax, we abstract here from demand-side effects and focus on the labor supply channel.

consider the impact of the Germany shock in the absence of a common currency. In this case, the spillover effects on other EZ countries are positive: the nominal wage in manufacturing may decline to equalize labor demand and labor supply, the real wage in the service sector increases due to cheaper imports and service employment surges. Second, we consider the impact of coordinated labor-market reforms. We assume that all EZ economies experience the same changes in the utility of non-market activities, reductions in DNWR and replacement rates as Germany. This counterfactual results in lower unemployment, a large increase in labor-force participation and manufacturing output in the EZ. This highlights the importance of coordinated labor-market policies within the currency area. The German competitiveness shock – triggered by unilateral reforms – in conjunction with the fixed-exchange-rate regime essentially allowed to shift unemployment from Germany to other EZ economies.[6] Lastly, we assess the role of monetary policy in cushioning the negative spillover effects of unilateral reforms. By computing a model-implied Phillips curve that maps the trade-off between inflation and involuntary unemployment, we illustrate that EZ countries could essentially have grown out of DNWR by allowing for a higher average inflation rate.

Our findings relate to the literature on nominal wage rigidities in international macroeconomics. Schmitt-Grohé and Uribe (2016) develop a small-open-economy model with DNWR that they apply to the boom-bust cycle in the EZ periphery countries which followed the introduction of the Euro. The Euro led to a reduction in real interest rates in the EZ periphery, which induced capital inflows from the core economies. This caused a boom in the non-tradable sector and an increase in nominal wages. When capital flows reversed in wake of the global financial crisis, wages could not adjust downward and unemployment surged. We focus instead on the period before the financial crisis and the impact of German labor-market reforms on the manufacturing sector of other EZ economies.

Our modeling approach borrows from Rodríguez-Clare et al. (2020) who apply a quantitative trade model with DNWR to study the impact of Chinese import competition on US local labor markets. Compared to their model, we add an endogenous savings decision and model labor-market institutions. Dix-Carneiro et al. (2023) instead study the impact of a China shock in a similar model but with matching frictions in the labor market. Moreover, they also allow for a savings decision and endogenize the current account.

Farhi et al. (2013) discuss various forms of tax changes (”fiscal devaluations”) that have the same real effects as nominal devaluations in the presence of nominal rigidities and fixed exchange rates. In our model, the German labor-market reforms effectively work like a fiscal devaluation because they worsen the terms of trade and generate an increase in employment at

[6] In the spirit of Farhi et al. (2013) this can be seen as a fiscal devaluation.

the expense of the other EZ economies.

Dustmann et al. (2014) provide a comprehensive review of the German labor-market reforms and Hünnekes et al. (2019) discuss the large magnitude of the German current-account surplus and show that returns on German foreign assets are very low compared to those of comparable economies. Caliendo et al. (2021) investigate the labor- and product-market impact of the EU Eastern enlargement and note that Germany opened its labor market to migrants from Eastern Europe as late as 2011 and thus only after the period we consider here.

The remainder of the paper is structured as follows. The following Section provides an overview of the institutional background around the Euro introduction and German labor-market reforms. Section 3 presents the stylized macroeconomic facts that motivate our narrative and the empirical estimates of the employment and wage effects of the German competition shock. Section 4 introduces the model. We then discuss its quantification in Section 5 and counterfactual scenarios in Section 6. Finally, Section 7 concludes.

## 2 Institutional Background

In this section, we first briefly explain the institutional setup of the Euro introduction and the scope of the German labor-market reforms of the late 1990s and early 2000s.

From 1979 to 1999, the future EZ economies were parties of the European Exchange Rate mechanism (EMS). Member countries' currencies were allowed to fluctuate within a band to the European Currency Unit (ECU), which was calculated as a weighted average of the member countries' currencies. Effectively, the German Mark formed the base currency and other central banks mostly (but not always) followed the monetary policy of the Bundesbank. Periodic realignments of the currencies' central parities were allowed and were also used regularly. Over time, such realignments became more and more coordinated between member countries. In 1992-1993, the EMS suffered a crisis as a consequence of a unilateral interest hike by the German Bundesbank. Several countries experienced speculative attacks and a number of them, including Italy and Spain, had to temporarily suspend their membership in the EMS. The UK even left the EMS permanently (Buiter et al., 1998). Thus, while the currencies of EU countries were not freely floating against each other before the introduction of the Euro, parities were regularly adjusted to fix misalignments between the real exchange rate and economic fundamentals. The EZ was officially created on January 1st 1999, locking in a hard currency peg between the initially 11 member countries Austria, Belgium, Finland, France, Germany, Italy, Ireland, Luxembourg, the Netherlands, Portugal, and Spain. National currencies were initially kept in circulation at fixed parities. Euro banknotes and currency were physically introduced in 2002. Greece joined the Euro in the same year.

The implementation of German structural labor-market reforms already started in the mid-1990s and ended around 2005. The reforms were a response to sluggish growth during the 1990s and a high unemployment rate close to 10%. German unification in 1990 had suddenly increased the labor force by roughly one third. It was a core political objective to adjust East German wages to the comparatively high West German levels as quickly as possible. As a result, the East German economy experienced high unemployment and continuing dependence on federal subsidies and transfer payments from West to East. From the mid 1990s, an increasing fraction of firms started to opt out of sectoral collective wage bargaining agreements and instead set firm-specific wages, which were often set below the collective bargaining wages.[7] These reforms strongly increased downward wage flexibility (Dustmann et al., 2014).

A second wave of structural reforms occurred in the period 2001-2005 (the "Hartz reforms" and reforms of the public pension and disability insurance systems). The Hartz reforms are frequently cited as an explanation for the "German job miracle" (Jacobi and Kluge, 2007). Before the Hartz reforms, German unemployment benefits were relatively generous. The replacement rate was 67% of the last net wage for up to 3 years and 57% thereafter for an unlimited period. In 2002, the Hartz Committee proposed directions for reform. Between 2003 and 2005, the reforms were set out in four laws aimed at strengthening job-search activities, providing incentives for the unemployed to accept a job, and deregulation of the labor market. Key measures accompanying the Hartz reforms included shortening the period of entitlement to wage-related unemployment benefits (Arbeitslosengeld I) to at most 12 months. After that period, the unemployed would receive lump-sum benefits close to the subsistence level (Arbeitslosengeld II). Complementary measures included ending options for early retirement and reducing other subsidies for non-market activities. Specifically, the reforms of 2001 implemented a sharp reduction in the access to public disability insurance, which accounted for around 20% of all pensions, and also made the system less generous (Seibold et al., 2022). Moreover, the 1999 pension reforms increased statutory retirement age from 60 to 65 in several steps between 2001 and 2005 (Boersch-Supan and Wilke, 2004). Effectively, the German structural reforms sharply

[7] In Germany, firms can opt in or out of a collective bargaining agreement at will by joining or leaving the German Employer Association. This association negotiates industry-region level agreements with unions, setting minimum standards for wages, working hours, and working conditions. All employees of member firms are covered by these agreements, regardless of their union status. For a detailed treatment of German industrial relations see Jäger et al. (2022). While in the mid 1990s, around 80 percent of German jobs were covered by collective bargaining agreements, this number had decreased by almost 20 percentage points until 2010 (see Figure A.4 in the Appendix). Moreover, coverage overstates the actual proportion of workers receiving collectively bargained wages: even for workers covered by collective bargaining agreements, opening clauses, which allowed downward-deviations of individual firms from collective bargaining conditions, were widely applied since the early 2000s.

reduced outside options to market work, thus increasing incentives for labor-force participation.

By contrast, wage setting in other EZ economies continued to be highly centralized during the same period and no comparable reforms of labor market and social insurance institutions were implemented. Specifically, countries like Austria, Belgium, Finland, France, Greece, Italy, the Netherlands, Portugal and Spain were characterized by industry-level collective wage bargaining between worker unions and employers' representatives. Collective bargaining agreements set minimum wage levels and wage increases, which are typically extended by law to all firms in a given industry (Addison, 2016).

# 3 Empirical Analysis

We now present stylized facts to illustrate the adjustments around the German competitiveness shock and provide evidence on its impact on EZ employment.

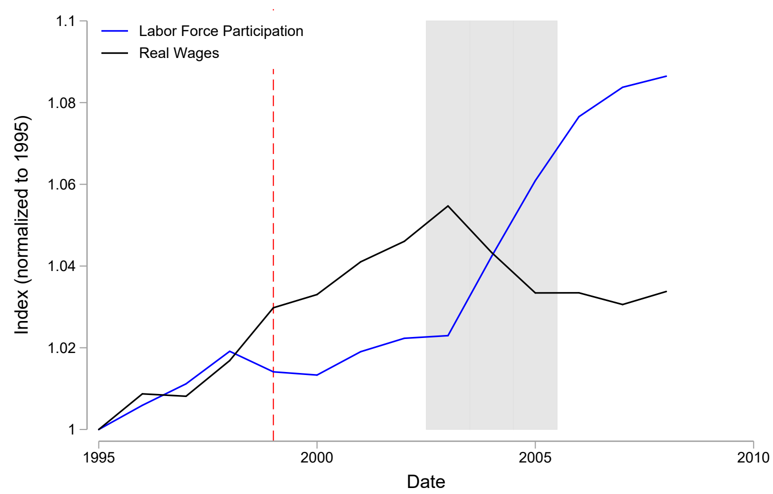
## 3.1 Stylized Facts on the Germany Shock

We start our presentation of the descriptive evidence on the Germany shock by looking at the evolution of labor-force participation and the real wage in Germany. Figure 1 plots the evolution of the labor-force participation rate and an index of real labor costs as a proxy for the real wage for the period 1995 to 2008. The participation rate captures the extensive margin of labor supply. Until the implementation of the labor-market reforms, the participation rate remained stable while the real wage grew. By contrast, from 2003 onwards the participation rate sharply increased by almost 10 percent, while the real wage simultaneously declined significantly. This pattern suggests that there were forces other than real-wage hikes behind the increase in labor supply, in particular increased incentives to participate in the labor market.[8]

To illustrate the implications of the increase in labor supply on manufacturing industries, in Figure 2 we plot the development of real manufacturing output in Germany and the rest of the EZ. It can be seen that until 2003, German manufacturing output grew at a similar rate as manufacturing output in the rest of the EZ. From 2003 onward, a wedge in manufacturing growth emerged and German manufacturing output grew much faster than manufacturing in the rest of the EZ.

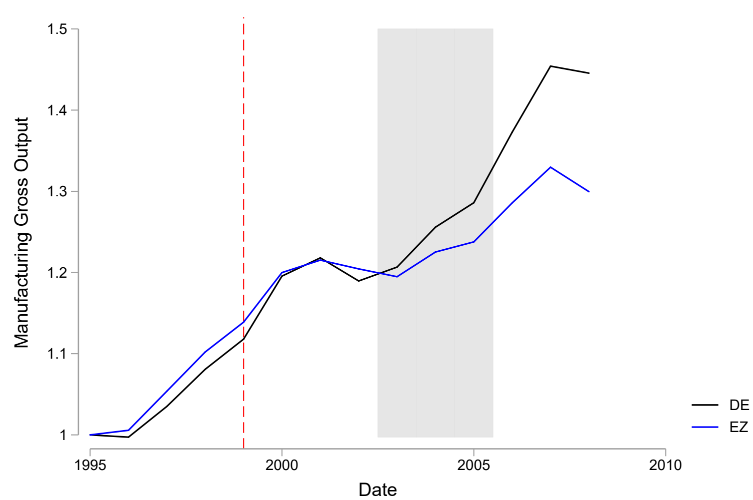
[8] In Appendix Figure A.2, we plot German labor force participation by age group and gender. It is apparent that the increase in the aggregate labor-force participation rate was mostly due to a 40% increase in the labor force participation rate of persons aged 55-64. Female labor force participation also increased slightly more than male labor force participation.

**Figure 1:** Labor Force Participation and Real Labor Costs in Germany




*Notes:* The Figure plots indices of labor-force participation and real labor costs in Germany. Index values are relative to the base year 1995. Labor-force participation is based on OECD data for working ages 20-64 years and real wages are deflated labor compensation per employment, using EU KLEMS data.

**Figure 2:** Manufacturing Output in the Eurozone




*Notes:* The Figure plots indices of real gross output in manufacturing in Germany and the rest of the EZ. Index values are relative to the base year 1995, using EU KLEMS data.

Accordingly, the German economy experienced a real depreciation vis-à-vis the rest of the EZ during that period. Figure 3 depicts this evolution of the German real exchange rate relative to that of other EZ countries from 1995 to 2008.[9] A decline in the relative real exchange rate represents a real appreciation relative to Germany, resulting in reduced trade competitiveness of the respective EZ economy. It is evident that all EZ countries appreciated against Germany during the sample period. The EZ periphery countries (Greece, Italy, Ireland, Portugal, Spain) started to appreciate relative to Germany already before the introduction of the Euro and continued to appreciate during the Euro period. These countries' real exchange rate appreciated by 20 to 30 percent during the sample period. By contrast, the core EZ economies (Austria, Belgium, Finland, France, the Netherlands) initially maintained their level of competitiveness relative to Germany and started their sharp appreciation around 2003. These countries' real appreciation amounted to around 10 percent during the sample period. While the real appreciation of the periphery countries may be partially explained by the boom which resulted from capital flows from the core to the periphery following the introduction of the single market in 1993 and the Euro in 1999 (Baldwin and Giavazzi, 2015), this is not the case for the core countries, which did not experience net capital inflows.[10]

These developments were accompanied by the buildup of a German current-account surplus, which started with the introduction of the Euro in 1999. Figure 4 illustrates two aspects of the increase in the German current-account surplus. First, the bulk of the German current-account imbalance was driven by trade imbalances instead of imbalances in factor income from abroad: the development of the goods trade balance in the left panel of Figure 4 largely follows the overall development of the current account. Second, the fraction of trade imbalances that is accounted for by intra-Eurozone imbalances increased steeply from 1997 on. As the right panel of Figure 4 shows, intra-Eurozone imbalances amounted to more than 40 percent of the German current-account surplus.

In Appendix A.1, we provide additional evidence indicating that exports of EZ countries to third markets were in part crowded out by exports from Germany after the introduction of the Euro.

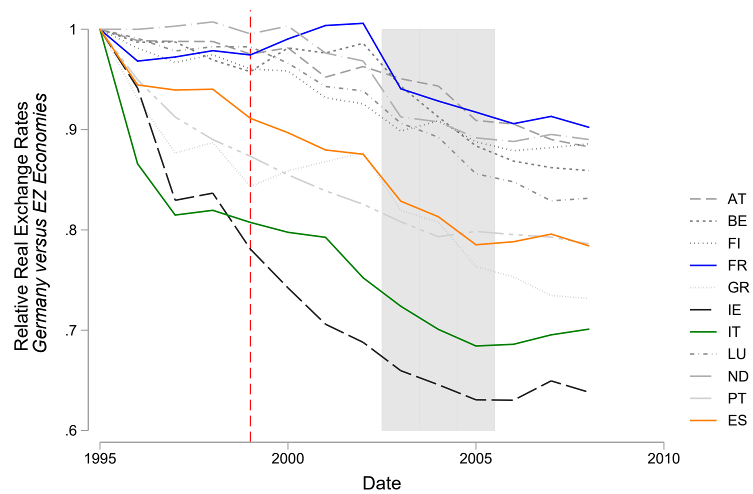
## 3.2 The Impact of the Germany Shock on Eurozone Employment

**Empirical Strategy:** We now study the impact of export competition from Germany on employment and wages in tradable sectors across EZ economies. Methodologically, our approach

[9] Relative real exchange rates are defined as the German expenditure-based price level of GDP in purchasing power parities relative to the price level of the respective EZ economy. We normalize relative real exchange rates to unity in the base year 1995.

[10] The real depreciation is also reflected in decreasing relative export prices as we show in Figure A.3 in the Appendix.

**Figure 3:** Real Exchange Rate Fluctuations in the Eurozone




*Notes:* The Figure plots indices of real exchange rates for EZ economies relative to the German real exchange rate. Relative real exchange rates are defined as the German expenditure-based price level of GDP in purchasing power parities relative to the price level of respective Eurozone economy using data from the Penn World Tables 8.0. Decreases in the relative real exchange rate imply a relative loss in trade competitiveness of the respective EZ economy.

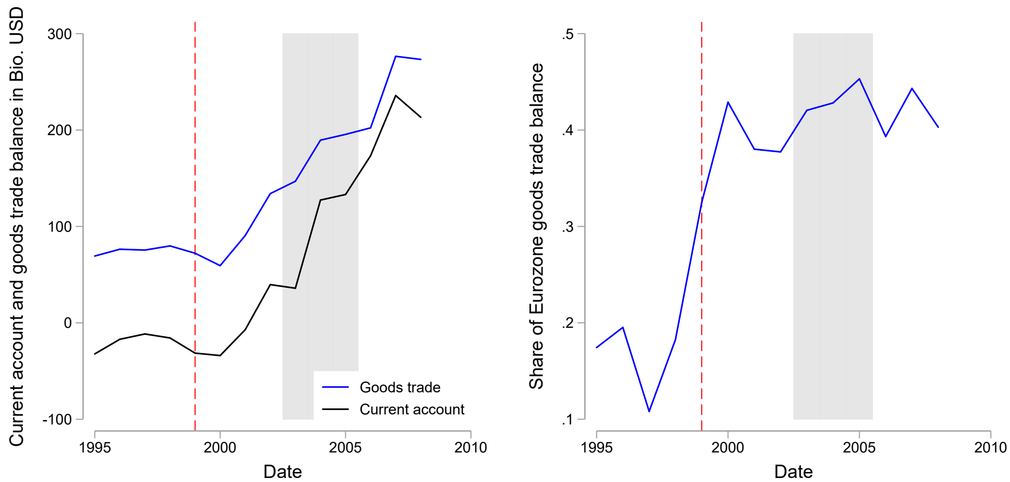
is similar to Autor et al. (2013) or Acemoglu et al. (2016). A key difference compared to their work is that we focus on German export-market competition in third markets rather than looking at import competition in the domestic market. Competition in third markets is important in the context of EZ economies, as for most European producers domestic markets are relatively small compared to the EZ market. Our baseline measure of export-market competition from Germany that an individual EZ country $c$ is exposed to is

$$EC_{cit}^{EZ} = \sum_{p \in EZ \setminus c} \phi_{ci}^{p} \frac{M_{DEit}^{p}}{Y_{i95}^{p} + M_{i95}^{p} - E_{i95}^{p}},$$

where $M_{DEit}^{p}$ are imports by EZ economy $p$ from Germany in industry $i$ during year $t$. In line with Acemoglu et al. (2016), we normalize imports by initial absorption of that industry in country $p$ in 1995. Initial absorption is defined as gross output produced $Y_{i95}^{p}$ plus imports $M_{i95}^{p}$ (excluding those from Germany) net of exports $E_{i95}^{p}$ (again excluding those to Germany).[11] To

[11] Data on gross output are obtained from EU KLEMS data. Trade data are obtained from Eurostat Comext. For total exports and imports, we consider OECD economies plus China as partner countries. The level of industry aggregation is based on EU KLEMS (corresponding roughly to 2 digit NACE Rev. 2 sectors). We omit Luxembourg from the set of EZ countries since Comext trade data for Luxembourg start only in 1999.

**Figure 4:** German Goods Trade Balance and the Current Account




*Notes:* The Figure plots the German current account and the goods trade balance in Bio. USD over time. The right plot depicts the fraction German goods trade surplus that accrues to trade within the EZ. Data are obtained from the World Bank World Development Indicators (WDI) and trade data from Eurostat Comext.

capture the exposure of country $c$ to German export competition in individual third markets, we weight each partner country with the respective initial market share $\phi_{ci}^{p}$ of country $c$ in partner country $p$ and industry $i$ in 1995.

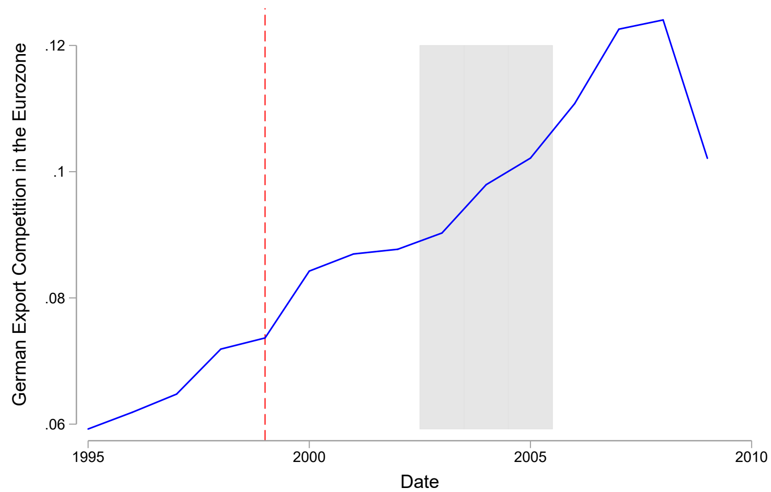
Figure 5 depicts the evolution of German export-market competition in the EZ. Between 1995 and 2008, it increased from around 6 to more than 12 percent. In terms of magnitudes, German export-market competition within the EZ exceeds Chinese export-market competition by far: during the same period, Chinese export-market competition increased from less than 1 percent to around 6 percent.

To evaluate the effect of German export-market competition on manufacturing employment and labor costs in the rest of the EZ, we run the following regression on the sample of EZ countries and industries, weighting each observation by start-of-sample initial employment:

$$L_{cit} = \beta_1 EC_{cit}^{EZ} + \beta_2 EC_{cit}^{EZ} \times PostEuro_t + \delta_{ci} + \epsilon_{cit}. \quad (1)$$

The outcome variable $L_{cit}$ is either employment or labor costs per employee (in logs) in EZ country $c$, 2-digit industry $i$ and year $t$. In some specifications, we interact $EC_{cit}^{EZ}$ with a Post-Euro dummy to see if German export-market competition affected other EZ countries differently after the introduction of the Euro peg. We include country by industry fixed effects $\delta_{ci}$, so that

**Figure 5:** Rising German Competition in the Eurozone




*Notes:* The Figure plots export-market competition from Germany in other EZ economies. Export market competition is weighted across countries and sectors according to initial gross output. Trade data are from Eurostat Comext and data on gross outputs from EU KLEMS.

we exploit variation within country-industry pairs and we include year fixed effects to control for business-cycle variation. Standard errors are clustered at the country-industry level.

**Shift-Share Design:** Exports from Germany to the EZ depend on EZ supply and demand conditions, which may have direct effects on EZ labor markets. Therefore, OLS estimates of (1) may suffer from an endogeneity bias. To estimate the causal effect of rising export competition from Germany on European labor markets, we follow a quasi-experimental shift-share instrumental variable approach. Like in Autor et al. (2013), our approach can be seen as the approximation of an idealized experiment that generates random variation in the growth of German exports across countries and industries. Specifically, we instrument $EC^{EZ}_{cit}$ using observed changes in trade patterns between Germany and the group of developed OECD countries outside the EZ:

$$EC^{OECD}_{cit} = \sum_{p,q} \phi^{p}_{ci} \psi^{q}_{DEi} \frac{M^{q}_{DEit}}{Y^{p}_{i95} + M^{p}_{i95} - E^{p}_{i95}}.$$

The shift-share instrument is based on a set of weighted shocks $\frac{M^{q}_{DEit}}{Y^{p}_{i95}+M^{p}_{i95}-E^{p}_{i95}}$. These shocks vary at the level of industry $i$ by OECD economy $q$ and EZ-partner $p$ since shocks are normalized by the EZ-partner's initial absorption. The quasi-experimental idea in that approach is that variation in the instrument shocks only reflects German supply shocks and the various supply and demand shocks in the non-EZ economies, in contrast to the endogenous German export shocks to the EZ. Under the assumption that shocks in non-EZ economies are uncorrelated with EZ-specific shocks, the only reason why the instrument is correlated with the endogenous variable $EC_{cit}^{EZ}$ are German supply shocks. Thus, our strategy can be understood as eliminating bias from shocks that are specific to the EZ, equivalently to Autor et al. (2013).

According to the shift-share taxonomy developed by Borusyak et al. (2021), the individual shocks can themselves be thought of as being instruments in a shock-level regression. To get to the country-by-industry level of variation in EZ employment, we weight these shocks by the product of the initial market share that country $c$ has in partner country $p$ and industry $i$ ($\phi_{ci}^{p}$) and the initial fraction of German exports in industry $i$ going to OECD economy $q$ ($\psi_{DEi}^{q}$ ).[12]

**Results:** The results for these regressions are reported in Table 1. Panel A presents results for employment and Panel B for labor costs. Columns (1)-(3) report OLS estimates, while columns (4) and (5) report shift-share IV estimates. Column (1) of Panel A shows that a one percentage-point increase in German EZ export-market competition is associated with approximately a 1 log-point reduction in manufacturing employment in other EZ economies. In column (2), we additionally include Chinese competition as a potential confounder. Chinese import competition also has a negative effect on employment and including Chinese competition slightly decreases the coefficient estimate on German EZ competition. Note that, even though the coefficient on Chinese competition is larger than the one on German competition, the Germany shock itself is much larger in magnitude than the China shock. In column (3), we split the effect of German EZ competition into a pre and post Euro period. Indeed, German export-market competition in the EZ has a statistically significant and large negative effect on competing EZ economies only after the Euro introduction, while the estimate is positive and marginally statistically significant before the Euro introduction. A one-percentage-point increase in German export-market competition reduces manufacturing employment in other EZ economies by around 0.3 log points. The positive coefficient before the Euro introduction may reflect that during this period the increase in German import penetration into the EZ is driven mostly by demand shocks or by input-output linkages. The stronger negative employment impact of export-market competition after the introduction of the currency peg is consistent with the idea that the Euro makes nominal wage rigidities binding. Columns (4) and (5) then use the shift-share instrument to address the potential endogeneity of German export competition. Our

[12] The quasi-experimental view of our shift-share research design puts particular emphasis on the variation in German exports and their average exposure across EZ countries and industries. We therefore document in Appendix A.2 the concentration of exposure shares as an inverse measure of effective shock-level sample size as well as the properties of the distribution of the shocks, following propositions by Borusyak et al. (2021).

estimates indicate that a one percentage-point increase in German EZ export-market competition decreases manufacturing employment in another EZ economy by 0.9 log-points. For the average EZ economy, this implies a manufacturing employment reduction between 1995 and 2008 of around 6 percent.[13] In line with the OLS result in column (3), also in the IV specification in column (5) we find evidence that the negative employment effect of German competition is present only in the period after the Euro was introduced.

In Panel B of Table 1, we repeat results for manufacturing wages, measured as log labor costs, as an alternative outcome to provide additional evidence for the significance of downward nominal rigidities. In contrast to employment, our results indicate that manufacturing wages did not fall in response to EZ export-market competition from Germany. The estimates instead suggest a statistically insignificant relation between German EZ export-market competition and nominal wages in the EZ. In fact, despite the substantial employment losses, workers in exposed industries received slightly higher wages.[14]

[13]The average weighted increase in export-market competition was around 6 percentage points. Hence, $6 \approx (exp(0.925 \times 0.06) - 1) \times 100$.

[14]One potential alternative explanation for this effect is worker selection: the employees who kept their jobs might have been more productive than workers who became unemployed.

**Table 1:** Eurozone Employment, Labor Costs and German Export Competition

| | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| | *OLS* | | | *2SLS* | |
| *Panel A:* | *Employment* | | | | |
| German EZ EC | -1.134*** | -0.778*** | 0.900** | -0.925** | 0.389 |
| | (0.347) | (0.288) | (0.453) | (0.369) | (0.487) |
| Chinese EZ EC | | -1.435*** | | | |
| | | (0.353) | | | |
| German EZ EC × Post Euro | | | -1.193*** | | -0.682** |
| | | | (0.307) | | (0.264) |
| F-statistic | | | | 237.0 | 76.04 |
| Observations | 2646 | 2646 | 2646 | 2646 | 2646 |
| Country-Ind. Clusters | 180 | 180 | 180 | 180 | 180 |
| *Panel B:* | *Labor Costs* | | | | |
| German EZ EC | 0.285* | 0.221 | -0.0284 | 0.237 | 0.0199 |
| | (0.156) | (0.137) | (0.126) | (0.166) | (0.130) |
| Chinese EZ EC | | 0.256** | | | |
| | | (0.0992) | | | |
| German EZ EC × Post Euro | | | 0.184 | | 0.113 |
| | | | (0.118) | | (0.105) |
| F-statistic | | | | 237.0 | 76.03 |
| Observations | 2634 | 2634 | 2634 | 2634 | 2634 |
| Country-Ind. Clusters | 179 | 179 | 179 | 179 | 179 |
| Country-Ind. F.E. | × | × | × | × | × |
| Year F.E. | × | × | × | × | × |

*Notes:* The Table presents estimates from regressing employment or labor costs (in logs) for EZ countries on EZ export competition from Germany. Regressions are weighted . Export competition (*Eurozone EC*) is defined according to $EC^{EZ}_{cit}$ in the main text. Data are obtained from the EU KLEMS database and Eurostat Comext. All estimations include a full set of country-industry and year fixed effects. state. Models are weighted by start of sample share of Eurozone employment. Standard errors are clustered at the country-industry level; $^{***}\ p < 0.01$, $^{**}\ p < 0.05$, $^{*}\ p < 0.1$.

# 4 Model

This Section presents our model. Our modeling approach builds on the Armington setup of Rodríguez-Clare et al. (2020) that we extend by including unemployment benefits, studying shocks to the utility of non-market activities and allowing for international saving. Unless noted otherwise, all monetary values are denoted in nominal Euros.

## 4.1 Basic Assumptions

**Setup** We assume that there is a set $I$ of geographic entities (indexed by $i$ or $j$): a subset of $M$ countries in the EZ (with a fixed nominal exchange rate) and $I - M$ countries outside the EZ (with a floating nominal exchange rate).

**Agents** There are two types of agents: workers and investors. Both types of agents are immobile across countries. There are $S$ narrow sectors (indexed by $s$ or $k$). We introduce the concept of "broad sectors", indexed with $b \in 1, ..., B$ and associate them with manufacturing, services and agriculture. Each narrow sector $s$ belongs to exactly one broad sector $b$. We assume that labor is mobile within any given broad sector such that each sector $s \in b$ shares the same wage rate. By contrast, workers face frictions of moving across broad sectors. Workers are hand to mouth and spend all their (labor) income in each period $t$. Investors instead own the capital stock of each country and have access to international financial markets, where they can trade one-period bonds. The stock of capital of each country is given and capital is immobile across countries. Investors have the same preferences as workers and thus split their consumption across sectors in the same way. Aggregate expenditure of each country is denoted by $P_{jt}C_{jt} = P_{jt}(C_{jt}^{w}+C_{jt}^{k})$, where $P_{jt}$ is the aggregate price index of country $j$ and $C_{jt}$ is the aggregate consumption basked. $C_{jt}^{w}$ denotes workers' aggregate consumption, while $C_{jt}^{k}$ is investors' aggregate consumption. Consumption is a Cobb-Douglas aggregate of sectoral bundles with expenditure shares $\alpha_{js}$. Within sectors, consumption is a CES Armington aggregate of goods produced by each country with elasticity of substitution $\sigma > 1$.

**Production** Within each country, each sector $k$ produces with a Cobb-Douglas production function. TFP, denoted by $A_{jkt}$, varies at the sector-country-time level. The sectoral labor share is denoted by $\phi_{jk}$, the sectoral capital share by $\psi_{jk}$ and the intermediate-input shares by $\phi_{j,sk}$ such that $\phi_{jk} + \psi_{jk} + \sum_{s} \phi_{j,sk} = 1$. Intermediates from different origins are aggregated in the same way as consumption goods (CES with elasticity $\sigma$). Product markets are perfectly competitive and there exist iceberg trade costs $d_{ijkt} > 1$ for good $k$ to flow from $i$ to $j$ in period $t$. Finally, we denote the nominal wage rate in country $i$, (broad) sector $b(k)$ during $t$ by $\mathcal{W}_{ibt}$ and the rental rate of physical capital by $\mathcal{R}_{it}$. The aggregate price index in country $j$ in period $t$ is given by

$$P_{jt} = \prod_{s} P_{jst}^{\alpha_{js}}, \tag{2}$$

where $P_{jkt}$ denotes the price index of sector $k$ in country $j$ in period $t$:

$$P_{jkt} = \left[ \sum_{i} \left( d_{ijkt} A_{ikt}^{-1} \mathcal{W}_{i,b(k),t}^{\phi_{ik}} \mathcal{R}_{it}^{\psi_{ik}} \prod_{s} P_{ist}^{\phi_{j,sk}} \right)^{1-\sigma_k} \right]^{\frac{1}{1-\sigma_k}}. \tag{3}$$

## 4.2 Labor Supply

We assume that the number of workers in each country $i$ is time-invariant and given by $\overline{L}_i$ and we treat treat labor supply as endogenous. Workers can engage in home production, in which case they receive flow utility $\mu_{it}$ or participate in the labor market to obtain *expected* real labor income in broad sector $b$ equal to $\omega_{ibt}$. The flow utility $\mu_{it}$ arises from non-market activities. Thus, an increase in incentives to participate in the labor market can be modeled as a reduction in $\mu_{it}$.

Let $\pi_{it} = \frac{\sum_b l_{ibt}}{\overline{L}_i}$ be the *labor-force participation rate*. Here, $l_{ibt}$ denotes the number of workers looking for work in broad sector $b$ and let $\pi_{ibt} = \frac{l_{ibt}}{\sum_{b'} l_{ib't}}$ be the *participation rate* in sector $b$. This implies that

$$l_{ibt} = \pi_{it} \pi_{ibt} \overline{L}_i \tag{4}$$

To obtain structure for $\pi_{it}$ and $\pi_{ibt}$, we follow Rodríguez-Clare et al. (2020) and assume that agents' per-period utility is given by $\ln \mu_{it} + z_0$ if choosing home production and $\ln \omega_{ibt} + z_b$ if choosing to supply labor in broad sector $b$. Moreover, each agent draws a set of utility parameters $z_b$ for each $b \in \{0, 1, ..., B\}$ from a nested Fréchet distribution involving parameters $\eta$ and $\kappa$ with $\eta \geq \kappa$ and with the following cumulative distribution function:

$$F(z) = \exp\left( -\exp(-\kappa z_0) - \left( \sum_{b \in B} \exp(-\eta z_b) \right)^{\frac{\kappa}{\eta}} \right).$$

With these assumptions, agents will choose to work in the sector $b$ that gives them the maximal utility. One can show that labor-force participation is given by

$$\pi_{it} = \frac{\omega_{it}^{\kappa}}{\mu_i^{\kappa} + \omega_{it}^{\kappa}}. \tag{5}$$

Thus, labor supply increases with the expected real wage $\omega_{it}$ and falls with the flow utility from non-market activities. Furthermore, the participation rate in sector $b$ increases when its expected real wage increases relative to the expected real wages in other sectors:

$$\pi_{ibt} = \frac{\omega_{ibt}^{\eta}}{\omega_{it}^{\eta}}, \text{ with } \omega_{it} = \left(\sum_b \omega_{ibt}^{\eta}\right)^{1/\eta}. \tag{6}$$

## 4.3 Downward Nominal Wage Rigidity

We introduce downward wage stickiness à la Schmitt-Grohé and Uribe (2016). This might lead to equilibria with involuntary unemployment such that employment levels are strictly smaller than labor supply, i.e. $L_{ibt} \leq l_{ibt}$. This may happen if nominal wages are too high to ensure full employment, so that DNWR is binding. So far, all wages and prices have been expressed in nominal Euros. However, a given country faces DNWR in terms of its local currency. DNWR takes the following form:

$$\mathcal{W}_{ibt}^{LCU} \geq \delta_{ib} \mathcal{W}_{ibt-1}^{LCU}, \text{ with } \delta_{ib} \geq 0.$$

Here, $\mathcal{W}_{ibt}^{LCU}$ denotes nominal wages measured in local currency units. The term $\delta_{ib}$ captures how rigid wages in sector $b$ are in country $i$. Nominal wages cannot fall below a fraction $\delta_{ib}$ of the previous period's wage rate. Thus, $\delta_{ib} = 1$ implies completely downward rigid wages, while $\delta_{ib} = 0$ implies completely flexible wages. Let $E_{it}$ denote the nominal exchange rate in Euros per LCU. Thus, an increase in $E_{it}$ implies an appreciation of the local currency. Hence, $\mathcal{W}_{ibt} = \mathcal{W}_{ibt}^{LCU} E_{it}$ is the nominal wage rate in Euros and we can rewrite DNWR measured in Euros as

$$\mathcal{W}_{ibt} \geq \frac{E_{it}}{E_{it-1}} \delta_b \mathcal{W}_{ibt-1}.$$

Note that under a flexible exchange-rate regime, the DNWR constraint can always be made non-binding by letting the domestic currency depreciate sufficiently, i.e. by setting $E_{it} < E_{it-1}$. However, within the EZ, the nominal exchange rate is fixed at $E_{it} = 1$ and $\mathcal{W}_{ibt}^{LCU} = \mathcal{W}_{ibt}$, $\forall i \in M$. DNWR in Euros can then be captured as

$$\mathcal{W}_{ibt} \geq \delta_{ib} \mathcal{W}_{ibt-1}. \tag{7}$$

We will assume that all countries outside the EZ and EZ countries before the introduction of the common currency have a flexible exchange rate regime. Hence, these countries can nominally devaluate their currencies such that DNWR never binds. This is captured by setting $0 < \delta_{ib} \leq 1$ for countries within the EZ ($\forall i \in M$) and $\delta_{ib} = 0$ for countries outside the EZ ($\forall i \notin M$).

Note that either DNWR is non-binding and then the labor markets clears, or DNWR is binding and then labor supply exceeds labor demand (i.e., there is involuntary unemployment). This can be expressed using the following complementary slackness condition:

$$(l_{ibt} - L_{ibt})\left(\mathcal{W}_{ibt} - \delta_{ib}\mathcal{W}_{ibt-1}\right) = 0. \tag{8}$$

## 4.4 Unemployment Benefits

We model unemployment benefits to broadly match three key characteristics of the German unemployment benefits scheme ("Arbeitslosengeld I"). First, eligibility for unemployment benefits requires workers to actively search for employment. Second, unemployment benefits are proportional to the individual's wage. Third, insurance fees are a fraction of labor income. Hence, we model unemployment benefits as a fraction $\tau_{it}$ of nominal wages that are received by those workers that are involuntarily unemployed, where $\tau_{it}$ denotes the *replacement rate*. Furthermore, unemployment benefits are financed via a revenue-neutral labor income taxes $\sum_b t_{it}\mathcal{W}_{ibt}L_{ibt}$.

As a consequence, the expected real wage in broad sector $b$ is

$$\omega_{ibt} = \frac{L_{ibt}}{l_{ibt}}\frac{(1-t_{it})\mathcal{W}_{ibt}}{P_{it}} + \left(1 - \frac{L_{ibt}}{l_{ibt}}\right)\frac{\tau_{it}\mathcal{W}_{ibt}}{P_{it}}. \tag{9}$$

In the absence of unemployment insurance, the expected real wage simplifies to the product of the realized real wage and the probability of employment:

$$\omega_{ibt} = \frac{\mathcal{W}_{ibt}L_{ibt}}{P_{it}l_{ibt}}.$$

Note that the unemployment rate is zero unless DNWR is binding. Thus, unemployment benefits only impact on labor supply in periods when DNWR binds. In this case, an increase in the replacement rate $\tau_{it}$ increases the expected real wage and thus encourages labor force participation $\sum_b l_{ibt}$. As long as DNWR is binding, this increases the unemployment rate because labor demand is determined by the wage constraint.

## 4.5 Investors and the Current Account

Investors are infinitely lived and maximize their live-time utility under perfect foresight. They receive income from renting out their capital and can trade a safe one-period bond in international financial markets. Their intertemporal utility function is given by:

$$U_j^k = \sum_{t=0}^{\infty} \varphi_{jt} \beta^t u_{jt}^k (C_{jt}^k).$$

Here, $\beta$ is the rate of time preference and $\varphi_{jt}$ is a country-period-specific patience shock. Let $u_{jt}^k = \log(C_{jt}^k)$. Investors in each country have access to one-period debt $D_{jt}$, denoted in Euros, with a net return $r_t$. Thus, their per-period budget constraint (in Euros) is given by

$$P_{jt} C_{jt}^k + (1 + r_{t-1}) D_{jt-1} = \mathcal{R}_{jt} K_{jt} + D_{jt}.$$

Investors are born with an initial level of debt $D_{j0}$, corresponding to the negative of a country's net foreign asset position. In each period $t$, they receive $D_{jt}$ Euros from borrowing and they need to repay the principal and the interest of the debt assumed in the previous period $(1+r_{t-1})D_{jt-1}$. The left-hand-side of the flow budget constraint thus equals investors' expenditure on consumption and debt while the right-hand side is their capital income and the resources received from their current debt. Investors are also subject to a no-Ponzi constraint: $\lim_{T\to\infty} \frac{d_{t+T}}{\prod_{s=0}^{T}(1+r_s)} \leq 0$.

The current account (in Euros) is defined as the change in the country's net foreign asset position (minus the change in debt stocks), which equals the difference between investors' income and their expenditure (note that workers always spend their income):

$$CA_{jt} = -(D_{jt} - D_{jt-1}) = \mathcal{R}_{jt} K_{jt} - P_{jt} C_{jt}^k - r_{t-1} D_{jt-1}. \tag{10}$$

The country's trade balance then equals the current account minus the interest payment on assets.

$$TB_{jt} = CA_{jt} + r_{jt-1} D_{jt-1} = \mathcal{R}_{jt} K_{jt} - P_{jt} C_{jt}^k \tag{11}$$

From the investors' intertemporal maximization problem, we can derive the following Euler equation:

$$\frac{P_{jt+1} C_{jt+1}^k}{P_{jt} C_{jt}^k} = \frac{\varphi_{jt+1}}{\varphi_{jt}} \beta (1 + r_t), \tag{12}$$

Intertemporal optimization equalizes the discounted marginal utility of consumption over time. Positive shocks to the time preference in current consumption $\varphi_t$ or increases in the inflation rate $(P_{jt+1}/P_{jt})$ raise the marginal utility of consuming today relative to the one of consuming in the future and thus reduce savings (worsen the current account). In contrast, a temporary increase in the nominal world interest rate or a positive patience shock $\varphi_{t+1}$ induce investors to shift consumption to the future and thus improve the current account.

### 4.6 Nominal Anchor

Finally, we need to introduce a nominal anchor that prevents nominal wages from rising so much in each period that DNWR is never binding.[15]

We model the nominal anchor in a way that world nominal GDP in Euros grows at a constant rate $\gamma$ across years:

$$\sum_i \left( \sum_b \mathcal{W}_{ibt} L_{ibt} + \mathcal{R}_{it} K_{it} \right) = \gamma \sum_i \left( \sum_b \mathcal{W}_{ibt-1} L_{ibt-1} + \mathcal{R}_{it-1} K_{it-1} \right). \tag{13}$$

### 4.7 Equilibrium

The following set of product-market-clearing and factor-market-clearing conditions are additionally required to characterize an equilibrium. Product markets clear if:

$$R_{ist} = \sum_{j=1}^{I} \lambda_{ijst} \left[ \alpha_{js} \left( \sum_b \mathcal{W}_{jbt} L_{jbt} + \mathcal{R}_{jt} K_{jt} - TB_{jt} \right) + \sum_k \phi_{jsk} R_{jkt} \right] \quad \forall i, s. \tag{14}$$

Here, $R_{ist}$ are the total revenues in sector $s$ of country $i$, $\phi_{jsk} R_{jkt}$ is the demand of country-industry $jk$ for intermediates from industry $s$. The terms $\lambda_{ijkt}$ are the "trade shares" (i.e. market share that country $i$ has in serving country $j$ in sector $k$) given by

$$\lambda_{ijkt} = \frac{(d_{ijk,t} A_{ikt}^{-1} \mathcal{W}_{i,b(k),t}^{\phi_{ik}} \mathcal{R}_{it}^{\psi_{ik}} \prod_s P_{ist}^{\phi_{j,sk}})^{1-\sigma_k}}{\sum_{r=1}^{I} (d_{rjkt} A_{rkt}^{-1} \mathcal{W}_{r,b(k),t}^{\phi_{rk}} \mathcal{R}_{rt}^{\psi_{rk}} \prod_s P_{rst}^{\phi_{r,sk}})^{1-\sigma_k}} \quad \forall i, s. \tag{15}$$

Labor market clearing requires

$$\mathcal{W}_{ibt} L_{ibt} = \sum_{s \in b} \phi_{is} R_{ist} \quad \forall i, b, \tag{16}$$

[15] Assume that in the background each country (or the EZ) has a central bank that tries to keep inflation low. The cost of inflation is not explicitly modeled but it could be endogenized by introducing a central bank that follows a Taylor rule where the nominal interest rate responds to inflation.

and capital market clearing requires

$$\mathcal{R}_{it}K_{it} = \sum_{s\in S} \psi_{is} R_{ist} \quad \forall i. \tag{17}$$

International bond-market clearing implies that current accounts balance at the world level:

$$\sum_{j} CA_{jt} = 0. \tag{18}$$

Given the vectors of initial wages $\mathcal{W}_{ib0}$, initial employment levels $L_{ib0}$ and initial debt levels $D_{i0}$, an equilibrium is a sequence of world interest rates $\{r_t\}$, wage vectors $\{\mathcal{W}_{ibt}\}$, rental rates $\{\mathcal{R}_{it}\}$, investors' consumption levels $\{C^k_{it}\}$, employment $\{L_{ibt}\}$, country and sector prices $\{P_{it}\}$ and $\{P_{ist}\}$, revenues $\{R_{ist}\}$, trade shares $\{\lambda_{ijst}\}$ and labor-market variables $\{l_{ibt}, \omega_{ibt}, \omega_{it}, \pi_{ibt}, \pi_{it}\}$ such that equations (2) to (18) hold.

## 4.8 Exact Hat Algebra

To solve the model, we follow the exact hat algebra methodology suggested by Dekle et al. (2007) and its dynamic extension proposed by Caliendo et al. (2019) and express the system of equations in relative changes $\hat{x}_t = x_t/x_{t-1}$. This allows to solve for the model responses to a sequence of shocks $\left\{\hat{\mu}_{it}, \hat{A}_{ist}, \hat{d}_{ijst}, \hat{\varphi}_{it}, \hat{\tau}_{it}, \hat{\delta}_{it}\right\}$ given an initial observed equilibrium.

Product-market clearing requires

$$\begin{aligned}\hat{R}_{ist}R_{ist-1} = \sum_{j=1}^{I} \hat{\lambda}_{ijst}\lambda_{ijst-1}\times \\ \left[\alpha_{js}\left(\sum_{b}\hat{\mathcal{W}}_{jbt}\hat{L}_{jbt}\mathcal{W}_{jbt-1}L_{jbt-1} + \hat{\mathcal{R}}_{jt}\hat{K}_{jt}\mathcal{R}_{jt-1}K_{jt-1} - \hat{TB}_{jt}TB_{jt-1}\right) + \sum_{k}\phi_{jsk}\hat{R}_{jkt}R_{jkt-1}\right] \\ \forall i, \forall s,\end{aligned} \tag{19}$$

where changes in trade shares and in prices are given by

$$\hat{\lambda}_{ijst} = \frac{\left(\hat{d}_{ijst}\hat{A}_{ist}^{-1}\hat{\mathcal{W}}_{i,b(s),t}^{\phi_{is}}\hat{\mathcal{R}}_{it}^{\psi_{is}}\prod_k \hat{P}_{ikt}^{\phi_{i,ks}}\right)^{1-\sigma_k}}{\sum_{r=1}^{I}\lambda_{rjst-1}\left(\hat{d}_{rjst}\hat{A}_{rst}^{-1}\hat{\mathcal{W}}_{r,b(s),t}^{\phi_{rs}}\hat{\mathcal{R}}_{rt}^{\psi_{rs}}\prod_k \hat{P}_{rkt}^{\phi_{r,ks}}\right)^{1-\sigma_k}} \qquad \forall i, \forall s \tag{20}$$

$$\hat{P}_{ist} = \left[\sum_j \lambda_{jist-1}\left(\hat{d}_{ijst}\hat{A}_{jst}^{-1}\hat{\mathcal{W}}_{j,b(s),t}^{\phi_{js}}\hat{\mathcal{R}}_{jt}^{\psi_{js}}\prod_k \hat{P}_{jkt}^{\phi_{j,ks}}\right)^{1-\sigma}\right]^{\frac{1}{1-\sigma}} \qquad \forall i, \forall s \tag{21}$$

$$\hat{P}_{it} = \prod_s \hat{P}_{ist}^{\alpha_{is}} \qquad \forall i. \tag{22}$$

Factor market clearing requires changes in factor incomes to correspond to changes in factor expenditures:

$$\hat{\mathcal{R}}_{it}\hat{K}_{it}\mathcal{R}_{it-1}K_{it-1} = \sum_{s\in S}\psi_{is}\hat{R}_{ist}R_{ist-1} \qquad \forall i \tag{23}$$

$$\hat{\mathcal{W}}_{ibt}\hat{L}_{ibt}\mathcal{W}_{ibt-1}L_{ibt-1} = \sum_{s\in b}\phi_{is}\hat{R}_{ist}R_{ist-1} \qquad \forall i, \forall b. \tag{24}$$

Nominal wages and employment need to satisfy the following inequality constraints:

$$\prod_{q=1}^{t}\hat{L}_{ibq} \le \prod_{q=1}^{t}\hat{l}_{ibq}, \hat{\mathcal{W}}_{ibt} \ge \hat{\delta}_{it}\delta_{it-1}, \quad \forall i, \forall s. \tag{25}$$

Furthermore, changes in labor supply and changes in expected real wages are given by:

$$\hat{l}_{ibt} = \frac{\hat{\omega}_{it}^{\kappa}}{\hat{\mu}_{it}^{\kappa}(1-\pi_{it-1}) + \hat{\omega}_{it}^{\kappa}\pi_{it-1}}\frac{\hat{\omega}_{ibt}^{\eta}}{\hat{\omega}_{it}^{\eta}} \qquad \forall i, \forall b \tag{26}$$

$$\hat{\omega}_{ibt} = \frac{\left(1-\hat{t}_{it}t_{it-1}-\hat{\tau}_{it}\tau_{it-1}+\frac{\hat{l}_{ibt}l_{ibt-1}}{\hat{L}_{ibt}L_{ibt-1}}\hat{\tau}_{it}\tau_{it-1}\right)}{\left(1-t_{it-1}-\tau_{it-1}+\frac{l_{ibt-1}}{L_{ibt-1}}\tau_{it-1}\right)}\frac{\hat{\mathcal{W}}_{ibt}\hat{L}_{ibt}}{\hat{P}_{it}\hat{l}_{ibt}} \qquad \forall i, \forall b \tag{27}$$

$$\hat{\omega}_{it} = \left[\sum_b \pi_{ibt-1}\hat{\omega}_{ibt}^{\eta}\right]^{1/\eta} \qquad \forall i, \tag{28}$$

Unemployment benefits are revenue neutral:

$$\sum_b \hat{t}_{it}t_{it-1}\hat{\mathcal{W}}_{ibt}\mathcal{W}_{ibt-1}\hat{L}_{ibt}L_{ibt-1} = \sum_b \hat{\tau}_{it}\tau_{it-1}\hat{\mathcal{W}}_{ibt}\mathcal{W}_{ibt-1}\left(\hat{l}_{ibt}l_{ibt-1}-\hat{L}_{ibt}L_{ibt-1}\right) \quad \forall i. \tag{29}$$

The savings decision of investors is characterized by the Euler equation and world bond market clearing:

$$
\begin{aligned}
\hat{P}_{it}\hat{C}^k_{it} &= \hat{\varphi}_{it}\beta(1+r_{t-1}) && \forall i && (30)\\
\hat{TB}_{it}TB_{it-1} &= \hat{\mathcal{R}}_{it}\hat{K}_{it}\mathcal{R}_{it-1}K_{it-1} - \hat{P}_{it}\hat{C}^k_{it}P_{it-1}C^k_{it-1} && \forall i && (31)\\
\hat{CA}_{it}CA_{it-1} &= \hat{TB}_{it}TB_{it-1} - r_{t-1}D_{it-1} && \forall i && (32)\\
\sum_i \hat{CA}_{it}CA_{it-1} &= 0. && && (33)
\end{aligned}
$$

World nominal GDP growth is set equal to $\gamma$:

$$
\sum_i \left( \sum_b \hat{\mathcal{W}}_{ibt}\hat{L}_{ibt}\mathcal{W}_{ibt-1}L_{ibt-1} + \hat{\mathcal{R}}_i\hat{K}_{it}\mathcal{R}_{it-1}K_{it-1} \right) = \gamma \sum_i \left( \sum_b \mathcal{W}_{ibt-1}L_{ibt-1} + \mathcal{R}_{it-1}K_{it-1} \right). \quad (34)
$$

# 5 Quantitative Analysis

## 5.1 Data and Calibration of Model Parameters

We use trade and production data for 31 countries plus an aggregate rest of the world and we start with the base year 1995. We model in detail all European countries included in WIOD as well as China, India, Japan and the US.[16] We consider three broad sectors $b$: manufacturing, services and agriculture. For the narrow sectors $s$, we follow Rodríguez-Clare et al. (2020) and aggregate manufacturing industries from WIOD into 12 narrow manufacturing sectors. Furthermore, we aggregate agricultural and service industries in WIOD to one sector each, corresponding to the respective broad sectors. Thus, in total our model has 14 sectors.[17]

For each country $j$ and sector $s$, we need data to compute the shares of labor and capital in production $\phi_{js}$ and $\psi_{js}$, the share of intermediates from all other individual sectors $\phi_{j,ks}$, and the aggregate final consumption shares $\alpha_{js}$. We use data from the WIOD socio-economic accounts and EU KLEMS and take average values over the sample period to calculate the labor and capital shares in gross output ($\phi_{js}$ and $\psi_{js}$) and we compute $\phi_{j,ks}$ as the share of purchases of sector $s$ in country $j$ on goods coming from sector $k$ (the input-output coefficients).

In addition, our model requires data on bilateral trade flows for all sectors and all countries in our sample in order to compute trade deficits, sectoral revenues, and trade shares. We use the bilateral trade flows (combined with the input-output coefficients and deficits) to infer the average consumption shares $\alpha_{js}$. We take information on sector-level bilateral trade between countries directly from WIOD.

[16]See Table A.3 for the full list of countries.
[17]See Table A.4 for the list of sectors.

We obtain measures of countries' capital stocks measured in constant 1995 PPP Euros from the Penn World Tables version 8.0. Data on countries' net international investment position is taken from the IMF International Financial Statistics. We set the net international investment position of the rest of the world aggregate to balance out global imbalances (Zucman, 2013). For the Euro nominal interest rate, we take the EZ money market rate from the IMF.

To quantify the labor-market part of the model, we require data on the economy-wide labor-force participation rate as well as the distribution of the labor force across sectors in the initial period. We take the economy-wide labor-force participation rates for ages 15 to 64 from OECD data and add the values for China and Taiwan from the World Development Indicators.[18] For the distribution of workers across broad sectors, we turn to the WIOD socio-economic accounts.[19] Consistent with the approach in Rodríguez-Clare et al. (2020), we begin our counterfactual scenario under the assumption that the labor market is in the steady state in the initial period. This allows us to interpret the observed employment values as representing sectoral labor supply in that period. We use data on replacement rates from the OECD to construct time series of replacement rates for each country.

We model the nominal wages of all countries that joined the EZ in the first round plus Greece as being subject to DNWR due to the fixed nominal exchange rate starting with the introduction of the Euro in 1999. By contrast, all other countries are assumed to have floating nominal exchange rates relative to the Euro and thus DNWR is never binding for them. To estimate $\delta_{it}$, which governs the extent to which nominal wages can adjust downward for each EZ country, we follow Schmitt-Grohé and Uribe (2016). Specifically, we use the complementary slackness condition to infer $\delta_{it}$: whenever the unemployment rate is increasing in a given country, the growth rate of nominal wages must equal $\delta_{it}$, since the DNWR is binding in this case. For each EZ country, we take the average nominal wage growth over all periods where unemployment is increasing between 1999-2008 to pin down $\delta_{iPostEZ}$. To guarantee that, in the absence of shocks, the model converges back to a zero-unemployment steady state, we set the maximum of $\delta_{it}$ (Greece) to 0.999 and then normalize all values by that value. For years before 1999, we adjust $\delta_{it}$ for the width of the ERM exchange-rate band, corresponding to 2.25% per year, to obtain $\delta_{iPreEZ} = 0.975 \times \delta_{iPostEZ}$.

We set $\gamma$, the nominal growth rate of the economy, equal to 1.027, corresponding to the average annual inflation rate of the EZ between 1995 and 2008. In combination with the choice of $\delta_{it}$ for

[18] We divide the number of Chinese workers aged 15 to 64 by the population of China and adopt the same value for Taiwan. Some countries have missing values for some years. We impute those values by linear interpolation where only single years are missing. In cases of missing values over several years, we impute the values backwards from the most recent available year by applying the OECD-wide growth rate of labor force participation.

[19] Also here, data on Chinese sectoral employment are missing. Therefore, we take the values directly from the Chinese National Bureau of Statistics.

each country, this parameter determines the degree of DNWR. A higher level of $\gamma$ relaxes the DNWR-constraint because it induces positive growth in nominal wages.

We set $\kappa$, which determines the elasticity of labor force participation, equal to unity. Microeconomic estimates of the elasticity of labor force participation with respect to the real wage (the extensive-margin inter-temporal elasticity of labor supply) are in the range of 0.3 (Chetty et al., 2011). In the model, this elasticity is given as $\frac{d \ln \pi_{it}}{d \ln \omega} = \kappa(1 - \Pi_{it})$. Given that labor-force participation $\pi_{it}$ is around 0.7 for the typical country and setting the left-hand side equal to 0.3, this yields a value for $\kappa$ of around 1.[20] For simplicity, we set $\eta$ equal to $\kappa$, such that moving across broad sectors is equally difficult as moving between market and non-market activities.

We set the elasticity of substitution across varieties $\sigma$ equal to 4 for all sectors, implying a trade elasticity of three.[21] Finally, we set $\beta$ equal to 0.99.[22]

## 5.2 Calibration of Shocks

Our goal is to use a calibrated version of the model to characterize the nature of the Germany shock and to study policy counterfactuals.

We first discuss the calibration of the bilateral sector-specific shocks to trade costs $\hat{d}_{ijst}$, shocks to country-sector-specific productivities $\hat{A}_{ist}$, and country-specific shocks to the utility from home production $\hat{\mu}_{it}$. These shocks can be recovered from the structural equations of the model by replacing equilibrium objects with data.

Using data on gross-output prices from the WIOD socio-economic accounts and trade shares from WIOD, we follow Eaton et al. (2016) and Dix-Carneiro et al. (2023) and obtain an expres-

[20]We also confirm this parameter choice with an estimated elasticity $\frac{d \ln \pi_{it}}{d \ln \omega_{it}}$ of 0.3 in our dataset. While our choice implies a labor-supply elasticity that is consistent with the micro evidence, it is significantly smaller than in macro studies (where it is around 2). When we choose a level of $\kappa$ that implies a labor-supply elasticity which is consistent with the macro literature, we obtain unrealistically large employment fluctuations in the presence of binding DNWR.

[21]Our model focuses on the medium run and thus makes a compromise between short-run and long-run estimates for this parameter. Our choice is a bit lower than the standard value for long-run comparative statics in quantitative trade models (Costinot and Rodríguez-Clare, 2014) but higher than the values used in the international macro literature for business-cycle-frequency fluctuations. Recent econometric evidence suggests that the trade elasticity ranges between between 0.75 in the short run and 2.25 in the long run (Boehm et al., 2023).

[22]This is consistent with the steady-state relationship $\beta = \hat{P}/(1 + r)$ given an average nominal short-term EZ interest rate of 3.5% and an average inflation rate of around 2% during the sample period.

sion for the trade cost shocks from equations (20) and (21):[23]

$$\hat{d}_{ijst} = \left(\frac{\hat{\lambda}_{ijst}}{\hat{\lambda}_{iist}}\right)^{\frac{1}{1-\sigma}} \frac{\hat{P}_{jt}}{\hat{P}_{it}},$$

Using countries' own trade shares $\hat{\lambda}_{iist}$ and unit cost bundles $\hat{\mathcal{W}}_{i,b(s),t}^{\phi_{js}} \hat{\mathcal{R}}_{it}^{\psi_{js}} \prod_k \hat{P}_{ikt}^{\phi_{i,ks}}$, we can back out TFP shocks from equation (20):

$$\hat{A}_{ist} = \frac{1}{\hat{P}_{it}} \left(\hat{\lambda}_{iist}\right)^{\frac{1}{\sigma-1}} \left(\hat{\mathcal{W}}_{i,b(s),t}^{\phi_{js}} \hat{\mathcal{R}}_{it}^{\psi_{js}} \prod_k \hat{P}_{ikt}^{\phi_{i,ks}}\right).$$

Here, we use nominal wages from the WIOD socio-economic accounts and we calculate the rental rate of capital as the ratio of capital income from WIOD to each country's capital stock from PWT 8.0.

From equation (5) in changes, we back out the shocks to the utility of staying out of the labor force: $\hat{\mu}_{it}$:

$$\hat{\mu}_{it} = \left(\frac{\hat{\omega}_{it}^{\kappa}}{\hat{\pi}_{it}} - \hat{\omega}_{it}^{\kappa}\right)^{\frac{1}{\kappa}}. \tag{35}$$

We use data on labor-force participation rates $\pi_{it}$ from the OECD and we construct expected real wages $\omega_{it}$ from equations (9) and (6) using data on nominal wages and price indices from WIOD and data on replacement rates and unemployment rates from the OECD.

Finally, we can back-out country-specific patience shocks $\hat{\varphi}_{it}$ for each country using the Euler equation (30) and data on the money-market interest rate from the IMF. This requires solving the full structural model to determine the expenditure growth of investors $\hat{P}_{it}\hat{C}_{it}^{k}$. Specifically, we feed sequences of calibrated shocks equations $\left\{\hat{\mu}_{it}, \hat{\tau}_{it}, \hat{\delta}_{it}, \hat{A}_{ist}, \hat{d}_{ijst}, \hat{\varphi}_{it}\right\}$ into the model and we replace the trade balance change $\hat{TB}_{jt}$ for each country in equation (19) with data. We then use equations (19)-(29) and (34) to solve for the endogenous variables.

In Figure 6 below, we show plots of trade-cost shocks and TFP shocks for Germany, the rest of the EZ, and non-EZ countries. The upper panel shows the paths of TFP shocks, while the lower panel presents the trade-cost shocks. TFP shocks are weighted across countries and industries based on value added in 1995. Trade-cost shocks are first weighted across partner countries $j$ using $\lambda_{ijs'95}$ within source country $i$ and then also weighted across countries and industries based on value added in 1995. It is apparent that Germany's productivity and trade costs evolved very similarly to those of the rest of the EZ. Thus, they cannot explain Germany's strong export

[23] We winsorize shocks in trade shares at the 5th and 95th percentiles to prevent short-run fluctuations in trade costs coming from outliers. We then winsorize shocks in the backed out trade costs at the first and 99th percentile.

growth and import penetration into the EZ that started in 2003.

In the upper panel of Figure 7, we plot the calibrated paths of the cumulated shocks to utility of non-market activities for Germany, the rest of the EZ and other non-EZ countries. For the latter two, shocks are averaged using 1995 GDP weights. German utility evolves very differently from the one in the rest of the EZ: it strongly declines by around 20% between 2003 and 2005. This pattern is in line with German structural reforms sharply reducing the utility value of staying out of the labor market. In contrast, the rest of the rest of the EZ experienced only a small reduction in the this value.

We plot the paths of the cumulated patience shocks in the middle panel of Figure 7. The calibrated path of patience shocks indicates that German investors exhibited lower preferences for future consumption compared to investors in the rest of the EZ. Together with the transitory positive income shock driven by the increase in labor supply, this explains an increase of international saving over time and thus a growing current account surplus.

Finally, in the lower panel of Figure 7 we plot the levels of the replacement rate $\tau_{it}$ separately for Germany, the average of the other EZ economies, and the average of non-EZ economies using 1995 GDP weights. It is apparent that Germany reduced its replacement rate from 58 to 52 percent after 2005, while the rest of the EZ experienced no comparable reduction.

### 5.3 Simulating the Response to the German Competitiveness Shock

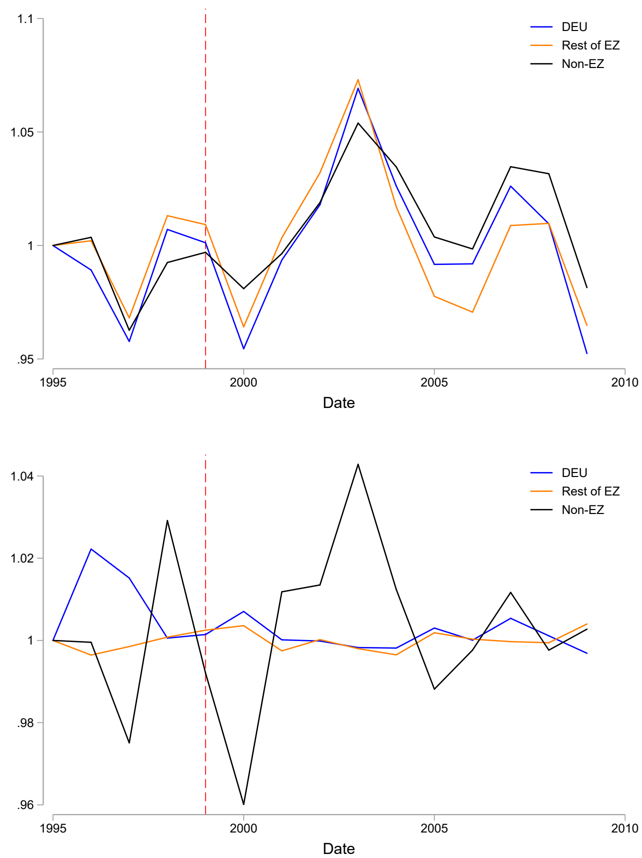
We now report the response of the endogenous variables to the sequences of factual shocks $\left\{\hat{\mu}_{it}, \hat{\tau}_{it}, \hat{\delta}_{it}, \hat{A}_{ist}, \hat{d}_{ijst}, \hat{\varphi}_{it}\right\}$ discussed above and compare the model performance with the data.

First, we report how our model performs in terms of replicating non-targeted moments of the data and then we discuss the time paths of endogenous variables for individual countries. To assess model fit, in Table 2 we regress data on labor-force participation rates, the real exchange rates, the cumulative gross-output growth in manufacturing and services, the cumulative wage growth in manufacturing and services and the cumulative employment growth in manufacturing and services on their model counterparts.[24] We report regressions both without (capturing pooled variation) and with (capturing within variation) country fixed effects. Perfect fit implies a regression coefficient of unity and an explained variation of 100%.

It is evident that the model performs extremely well in terms of replicating labor-force participation rates, real exchange rates and cumulative gross-output growth in manufacturing and services. It also does a good job in replicating wages.

[24]We do not try to replicate unemployment data, since our model does not generate any unemployment unless DNWR is binding. Therefore, model-implied unemployment rates are not comparable to the data.

**Figure 6:** Productivity and Trade-Cost Shocks




*Notes:* The Figure plots calibrated average TFP shocks $\hat{A}_{ist}$ (upper panel) and trade-cost shocks $\hat{d}_{ijst}$ (lower panel) for Germany, the rest of the EZ and non-EZ economies. TFP shocks are weighted across countries $i$ and industries $s$ based on value added in 1995. Trade-cost shocks are first weighted across partner countries $j$ using $\lambda_{ijs'95}$ within source country $i$ and then also weighted across countries and industries $s$ based on value added in 1995.

**Figure 7:** Non-market Utility Shocks, Patience Shocks and Replacement Rates


*Notes:* The Figure plots calibrated average cumulated shocks to the utility of non-market activities $\hat{\mu}_{ist}$ (upper panel) and cumulated patience shocks $\hat{\varphi}_{it}$ (middle panel) and replacement rates in levels $\tau_{it}$ (lower panel) for Germany, the rest of the EZ and non-EZ economies. Variables are weighted across countries $i$ based on GDP in 1995.

**Table 2:** Untargeted Moments: Baseline Calibration Outcomes versus Data

| Variable | Regression Coefficient | Explained Variation |
|---|---|---|
| *Labor-Force Participation* | | |
| no fixed effects | 0.70 | 67% |
| country fixed effects | 0.59 | 58% |
| *Real Exchange Rates* | | |
| no fixed effects | 0.85 | 87% |
| country fixed effects | 0.89 | 87% |
| *Cumulative Gross-Output Growth* | | |
| no fixed effects | 1.09 | 69% |
| country fixed effects | 1.19 | 63% |
| *Cumulative Wage Growth* | | |
| no fixed effects | 0.36 | 48% |
| country fixed effects | 0.51 | 66% |

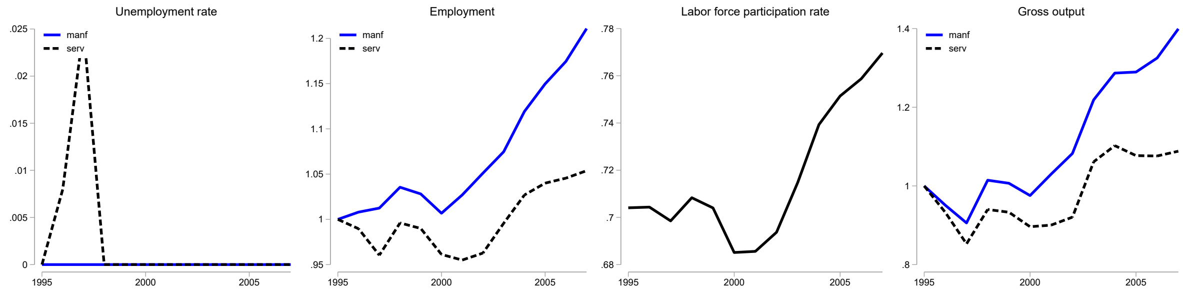
*Notes:* The Table compares outcomes of the calibrated model with data by regressing data objects on model outcomes, either with or without fixed effects for countries. Labor-force participation and real exchange rates are measured at the country and year level. Cumulative growth of gross output and nominal wages measured separately for the broad sectors manufacturing and services.

Figure 9 shows time paths for the simulated unemployment rate, employment in the broad sectors manufacturing and services, the labor force participation rate and the expected sectoral real wage for four key European economies: Germany, France, Italy, and the UK. Each row plots these variables for a given country. Figures for the remaining EZ economies can be found in Appendix B.1.

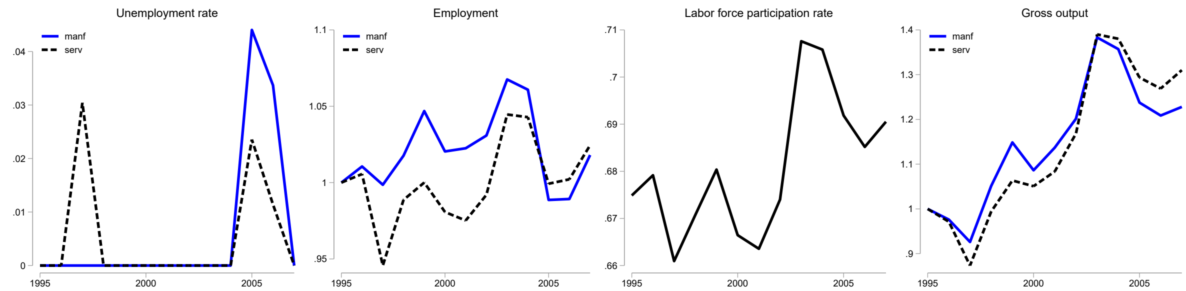
In Germany, the decline in the utility of non-market activities between 2003 and 2005 strongly increased labor supply. In line with the data, the labor-force participation rate increased by around 8 p.p. There was also a strong increase in employment and a boom of gross output, which was particularly pronounced in manufacturing. Due to the the relatively low DNWR in Germany, the labor-supply shock did not create any involuntary unemployment. However, it created additional competitive pressure on French workers. In France, DNWR became binding after 2003. This led to a strong contraction of manufacturing output and an employment reduction in manufacturing by 5 percent, accompanied by an increase in the involuntary unemployment rate of up to 4 p.p. in manufacturing and 2 p.p in the service sector. The expected real wage also declined significantly and the labor-force participation rate dropped slightly after 2003. The adjustments of the Italian economy were similar to those of the French one. DNWR became binding after 2003, the involuntary unemployment rate increased by 4 p.p. and employment dropped significantly. By contrast, the UK was completely insulated from the German supply shock due to its flexible exchange rate. While manufacturing employment fell in response to the shock, the service sector boomed and gross output surged. Intuitively, the German supply shock implied a terms-of-trade improvement which translated into higher real income under flexible exchange rates. This increased labor-force participation in the UK.

**Figure 8:** The Germany Shock: Factual Equilibrium

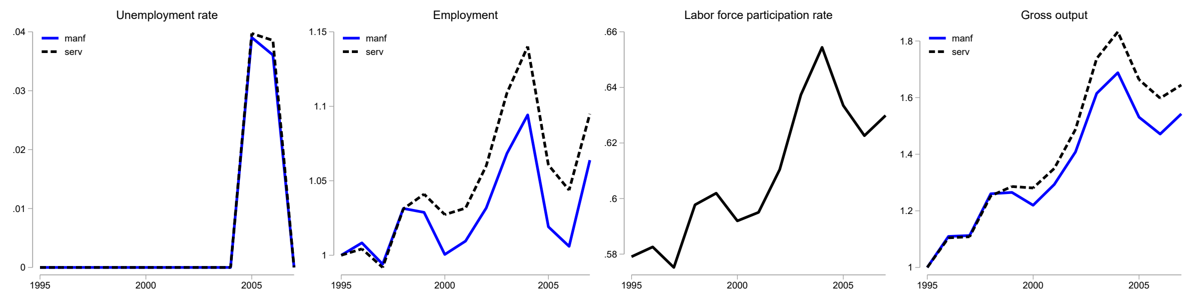
(**a**) Germany



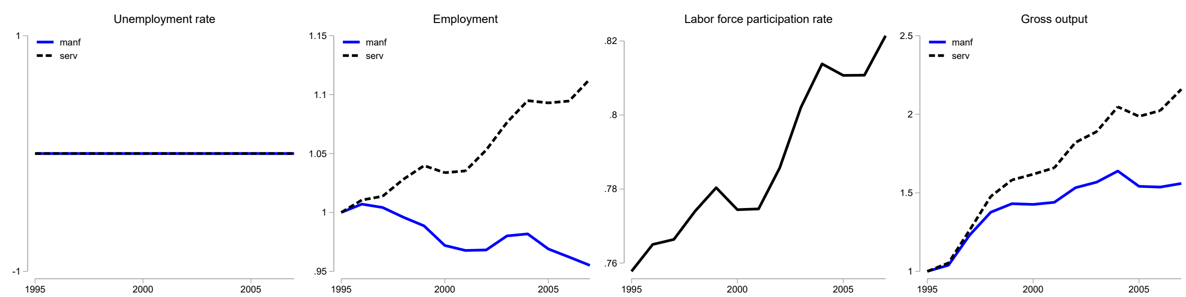

(**b**) France




(**c**) Italy




(**d**) United Kingdom




*Notes:* The Figure plots equilibrium levels of the sectoral unemployment rate, sectoral employment, the labor force participation rate $\pi_{it}$ and sectoral gross output in the factual equilibrium for Germany, France, Italy and the UK.

# 6 Counterfactuals

We now discuss three alternative policies to address the impact of the German competitiveness shock on the rest of the EZ. We do this through the lens of our model using counterfactual scenarios.

**No Currency Union:** First, we consider the impact of the Germany shock in the absence of a common currency. Under this scenario, DNWR are absent and $\delta_{it}$ equals zero for all countries. Table 3 lists the factual outcomes for each country in the baseline scenario and the counterfactual outcomes as percentage-point differences relative to the factual equilibrium of the model. As nominal wages may flexibly adjust to equalize labor demand and labor supply in the absence of the currency peg, involuntary unemployment vanishes entirely. The spillover effects of Germany's reform on other EZ countries are positive. This reflects real-wage gains through cheaper imports, which trigger an increase in labor supply and in employment (mostly in services). In particular, Spain, Greece and Ireland experience also higher manufacturing employment growth. All countries benefit from the absence of rigidities in terms of a higher growth in expected real wages.

**Coordinated Reforms:** Second, we consider the impact of coordinated labor market reforms. We assume that all EZ economies experience the same changes in the utility of non-market activities, reductions in DNWR and replacement rates as Germany. Results for this scenario are also reported in Table 3. This counterfactual results in lower unemployment and large increases in labor-force participation and manufacturing output in the EZ. Expected real wages instead drop in most countries to absorb the increased labor supply. The positive employment effects under this scenario compared to the baseline scenario highlight the importance of coordinated labor-market policies within the currency area. The German competitiveness shock – triggered by unilateral reforms – essentially allowed shifting unemployment from Germany to other EZ economies.

**Monetary Policy** Lastly, we assess the role of monetary policy in dealing with binding DNWR as a consequence of the Germany shock. We compute counterfactual unemployment rates for a range of nominal anchor growth rates $\gamma$. The higher the average nominal growth rates of the nominal anchor (corresponding to a higher average inflation rate), the less likely DNWR is to become binding. To show this visually, we plot the model-implied Phillips curve in Figure 9, which shows a clear relationship between a higher average inflation rate and lower involuntary

**Table 3:** Counterfactual Scenarios: No Rigidities and Coordinated Reforms

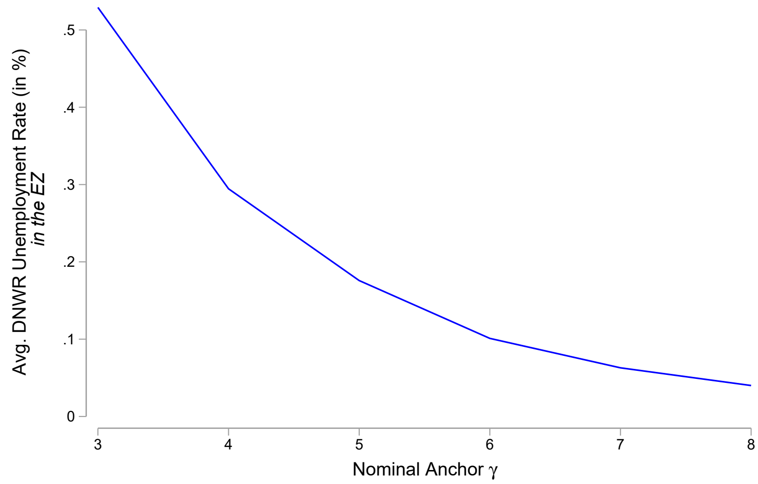
| | Baseline | | | Flex. Exch. Rate | | | Coord. Reforms | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | *ppt. difference to baseline* | | | *ppt. difference to baseline* | | |
| EZ country | *manf.* $\hat{L}_{ibt}$ *avg. growth* | $\hat{\omega}_{it}$ *avg. growth* | *unempl. avg. rate* | *manf.* $\hat{L}_{ibt}$ *avg. growth* | $\hat{\omega}_{it}$ *avg. growth* | *unempl. avg. rate* | *manf.* $\hat{L}_{ibt}$ *avg. growth* | $\hat{\omega}_{it}$ *avg. growth* | *unempl. avg. rate* |
| AUT | 1.26 | 2.24 | 0.00 | 0.00 | 0.00 | 0.00 | 0.36 | -0.12 | 0.00 |
| BEL | 0.33 | 0.59 | 0.89 | 0.00 | 0.01 | -0.89 | 0.36 | -0.12 | -0.30 |
| DEU | 1.61 | 0.52 | 0.08 | 0.00 | 0.01 | -0.08 | 0.03 | 0.00 | 0.02 |
| ESP | -1.35 | -1.06 | 3.51 | 1.20 | 0.46 | -3.51 | 1.38 | 0.36 | -2.66 |
| FIN | 0.21 | 3.04 | 0.03 | 0.00 | 0.00 | -0.03 | 0.72 | -0.27 | -0.02 |
| FRA | 0.15 | 1.01 | 0.67 | 0.00 | 0.00 | -0.67 | 0.71 | -0.24 | -0.14 |
| GRC | -1.09 | 2.14 | 1.13 | 0.46 | 0.05 | -1.13 | 1.46 | -0.32 | -0.82 |
| IRL | -3.55 | 2.55 | 6.83 | 4.18 | 1.47 | -6.83 | 1.95 | 0.39 | -2.39 |
| ITA | 0.52 | 0.75 | 1.35 | 0.00 | 0.01 | -1.35 | 0.43 | -0.15 | 0.07 |
| LUX | 0.95 | 3.42 | 2.50 | 0.00 | 0.03 | -2.50 | 0.12 | -0.02 | -1.32 |
| NLD | 0.65 | 0.73 | 0.04 | 0.00 | 0.00 | -0.04 | 0.18 | -0.09 | -0.03 |
| PRT | -0.06 | 0.05 | 0.56 | 0.01 | 0.02 | -0.56 | 0.51 | -0.21 | -0.30 |

*Notes:* The Table compares growth in manufacturing employment (annualized, in %), growth in expected real wages (annualized, in %) and average unemployment rates (in %) between the counterfactual to the baseline calibration of the model for each country within the EZ.

unemployment in the EZ in the model. For a nominal growth rate of more than 8 percent, DNWR is always slack and unemployment disappears in all EZ countries.[25]

[25] Admittedly, this view is over-simplistic, as a higher average inflation rate would likely also result in higher values for $\delta_{it}$, thereby undoing the benefits of higher inflation.

**Figure 9:** Model-Implied Phillips Curve




*Notes:* The Figure plots average unemployment rates created by binding DNWR in the EZ for different levels of the nominal anchor $\gamma$. Unemployment rates across countries are weighted by 1995 value added.

# 7 Conclusion

In this paper, we have studied the impact of the German manufacturing export boom that followed the introduction of the Euro on the other EZ economies. We have presented both reduced-form evidence and results based on a quantitative trade model with nominal wage frictions. We have shown that, in the early to mid 2000s, Germany experienced a positive labor-supply shock induced by structural labor-market reforms. This shock implied a gain in competitiveness of Germany relative to other EZ economies. Due to the peg in the nominal exchange rate and downward nominal wage rigidity, nominal wages could not adjust sufficiently in response to the shock. This led to a temporary increase in involuntary unemployment in the rest of the EZ. We also show that the German labor-market reforms would have been beneficial for the rest of the EZ in the absence of the Euro. Alternatively, coordinated labor-market reforms would also have increased employment across the EZ. Finally, a higher average inflation rate would have better cushioned the impact of the Germany shock.

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# Internet Appendix

# Contents



# A Empirical Appendix

## A.1 Crowding-out of Exports

In this section we document that the increased German trade competitiveness resulted in a crowding-out of exports of other EZ economies, as the growth of intra-Eurozone trade imbalances in Figure 4 already suggests. We run the following regression at the sector-destination-year level:

$$\hat{X}^p_{cit} = \beta_1 \hat{X}^p_{DEit} + \beta_2 \hat{X}^p_{DEit} \times \mathit{PostEuro}_t + \delta_{cip} + \delta_t + \epsilon_{cipt}.$$

The dependent variable, $\hat{X}^p_{cit} = \frac{X^p_{cit}}{X^p_{cit-1}}$, is the annual growth rate of export value or export quantity of EZ country $c$ to partner country $p$ in a 4-digit NACE industry $i$ during year $t$. We regress this growth rate on $\hat{X}^p_{DEit} = \frac{X^p_{DEit}}{X^p_{DEit-1}}$, the annual growth rate of German exports to the same partner country in the same industry and year and its interaction with $\mathit{PostEuro}_t$, a dummy equal to unity for all years from 1999 onward, the introduction year of the EZ currency peg. Partner countries are all OECD economies plus China. The regression includes year, and reporter by industry and partner fixed effects. We use industry-level trade data from Comext.

The coefficient $\beta_1$ is proportional to the within-correlation between the export growth rates of country $c$ and Germany to a given partner. A positive coefficient implies that the bulk of export growth is determined by demand shocks originating in the partner country or shared EZ supply shocks, so that all exporters increase their sales to the partner economy. The coefficient $\beta_2$ on the interaction term differentiates if the correlation between the two countries' exports to the partner economy was different after the introduction of the Euro and the subsequent implementation of reforms in Germany. In particular, an increase in German competitiveness relative to another exporting country (a positive supply shock in Germany) would result in substitution away from the other country's exports towards German exports, implying a negative coefficient on the interaction term. Moreover, this substitution effect would be more pronounced once the nominal exchange rate among EZ members is fixed.

Table A.1 presents the result for these regressions. In panel A, we show results for export values and in panel B those for export quantities. Columns (1)-(2) present results for individual EZ countries $c$ and columns (3)-(4) treat the pooled EZ excluding Germany as an individual country. The odd columns (1) and (3) consider the full set of partner economies including OECD and China and the even columns (2) and (4) only consider partner economies in the EZ. Throughout all specifications, the conditional correlation between countries' export growth and German export growth was positive before 1999 ($\beta_1 > 0$) and became smaller afterwards ($\beta_2 < 0$). For example, before 1999 a one-percentage-point increase in German exports was associated with an increase in exports of about 0.4 percentage points by another EZ country to the same destination. This number fell to about 0.2 percentage points after 1999. Thus, from 1999 on, German exports crowded out other EZ countries' exports.

## A.2 Properties the Shift-Share Instrument

Borusyak et al. (2021) show that a shift-share design leads to consistent estimates when the assignment of shocks is quasi-random and there are many uncorrelated shocks. Since the instrument shocks that we use to construct our shift-share instrument are not truly randomized across countries and industries, one may still worry that shocks are confounded by other endogenous unobserved characteristics. We therefore report on the properties of our instrument shifts and shares here, following the suggestions by Borusyak et al. (2021).

First, note that in contrast to Autor et al. (2013), our instrument has complete shares in the sense that weights $\sum_{p,q} \phi_{ci}^{p} \psi_{DEi}^{q}$ add up to 1 for each observation and are constant across time periods. With complete shares, we do not need to control for any time-varying differences in the sum of exposure shares. Further, the inverse Herfindahl-Hirschman concentration index of the shock-level shares is relatively high and equals 5,576 and 372 on average within each period between 1995 and 2009, suggesting a sufficiently large effective sample size.

The distribution of shocks – computed with importance weights – is not too granular as it has a standard deviation of 0.461 with a mean of 0.136 and an interquartile range of 0.101. The 99th percentile of weighted shocks is 1.74. This suggests a sizable degree of variation at the EZ-

**Table A.1:** Crowding-Out of Eurozone Exports

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| | Individual EZ Econ. | | Aggregate EZ | |
| *Partner:* | *OECD* | *Intra-EZ* | *OECD* | *Intra-EZ* |
| *Panel A:* | *Growth in Export Value* | | | |
| Export Growth DE | 0.388*** | 0.402*** | 0.180*** | 0.177*** |
| | (0.0322) | (0.0688) | (0.0147) | (0.0282) |
| × Post Euro | -0.198*** | -0.218*** | -0.127*** | -0.126*** |
| | (0.0374) | (0.0778) | (0.0161) | (0.0310) |
| Observations | 879,864 | 283,862 | 121,319 | 37,877 |
| Clusters | 76,924 | 24,232 | 9,066 | 2,849 |
| *Panel B:* | *Growth in Export Quantities* | | | |
| Export Growth DE | 0.232*** | 0.237*** | 0.159*** | 0.166*** |
| | (0.0174) | (0.0354) | (0.0153) | (0.0316) |
| × Post Euro | -0.114*** | -0.150*** | -0.114*** | -0.136*** |
| | (0.0202) | (0.0406) | (0.0171) | (0.0339) |
| Observations | 825,097 | 266,546 | 119,641 | 37,570 |
| Clusters | 73,657 | 23,354 | 9,016 | 2,843 |
| Exporter × Partner × Ind F.E. | × | × | × | × |
| Year F.E. | × | × | × | × |

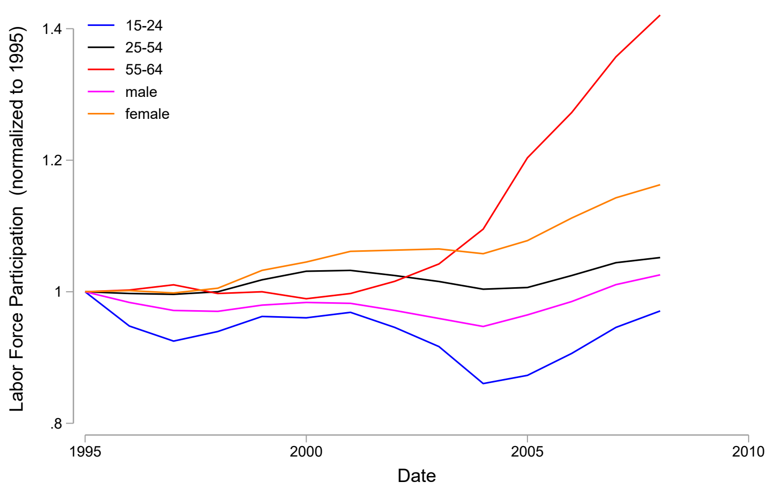
*Notes:* The Table presents estimates from regressing export growth rates for Eurozone countries on German export growth rates and its interaction with a dummy *Post Euro* which equals 1 from 1999 onwards. The unit of observation is a NACE Rev. 2 4-digit industry and export data are obtained from the Eurostat Comext database. Export growth rates are defined relative to the previous year and measured at the annual level and for each OECD partner country individually (plus China). All estimations include a full set of exporter by partner by industry fixed effects and year fixed effects. The upper panel considers growth rates in export values and the lower panel considers growth rates in export quantities. Standard errors are clustered at the exporter-partner-industry level; $^{***}$ $p < 0.01$, $^{**}$ $p < 0.05$, $^{*}$ $p < 0.1$.

partner by industry and year level. To assess the plausibility of the assumption that shocks are sufficiently mutually uncorrelated, we then compute the intra-class correlation (ICC) of shocks across EZ partner countries by industries from a random-effects model that includes period fixed effects. The estimated share of the overall shock residual variance due to the random effect EZ partner by industry combinations is equal to 0.26. The ICC results thus reveal moderate clustering of shock residuals.

**Figure A.1:** Coverage on the "Germany Shock" by the *Economist*

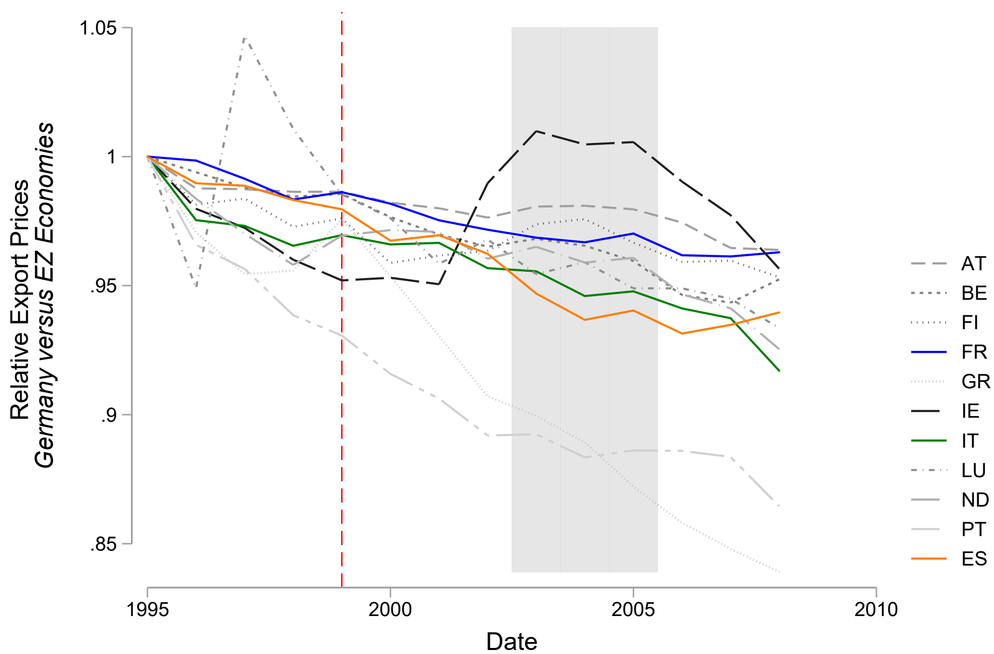

*Notes:* Headlines and caricatures from the Economist: 5-Jun-1999, 24-Aug-2002, 22-Mar-2003, 20-Dec-2003.

**Figure A.2:** Labor Force Participation by Age and Gender in Germany



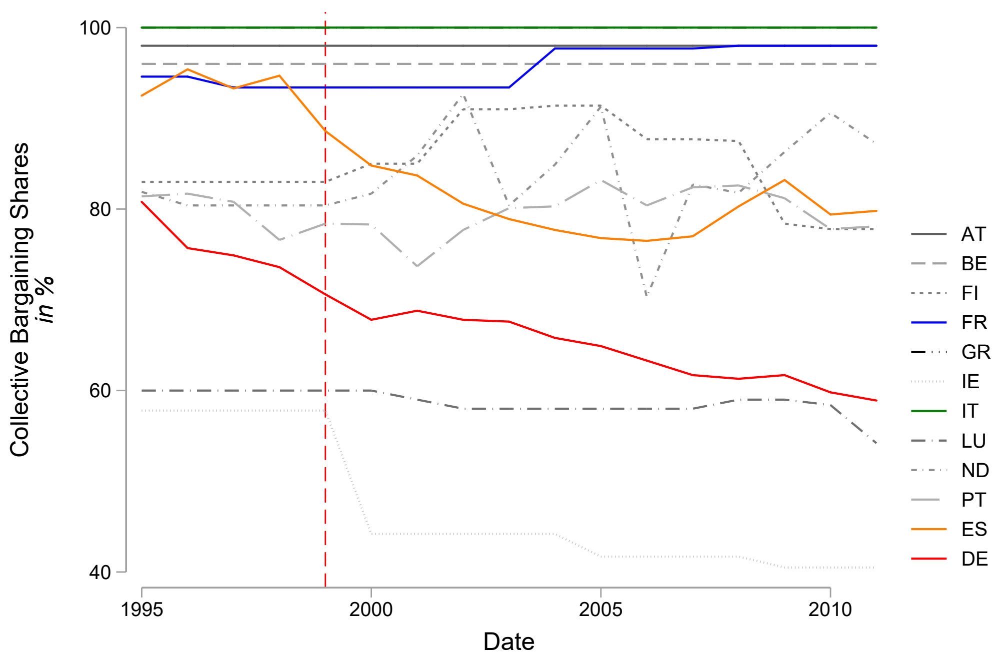

*Notes:* The Figure plots indices of labor force participation in Germany. Index values are relative to the base year 1995. Labor force participation is based on Eurostat data for age cohorts 15-24, 25-54, 55-64 years and males and females (ages 15-64).

**Figure A.3:** Export Price Fluctuations in the Eurozone




*Notes:* The Figure plots indices of export price levels for Eurozone economies relative to the German export price level. Relative export prices are the German price level of exports relative to the according price level from the respective Eurozone economy using data from the Penn World Tables 8.0. Decreases in the relative export prices denote a relative loss in trade competitiveness of the respective Eurozone economy.

**Figure A.4:** Collective Wage Bargaining in the Eurozone




*Notes:* The Figure plots the share of workers with jobs covered by collective wage bargaining in percent for Eurozone economies using data from the OECD.

**Table A.2:** Robustness: Eurozone Employment, Labor Costs and Aggregate German Competition

| | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| *Panel A:* | | | *Employment* | | |
| Eurozone EC | -1.030*** | -0.938*** | -0.368 | -0.288 | -0.0229 |
| | (0.299) | (0.286) | (0.465) | (0.461) | (0.394) |
| $\times$ Post Euro | | | -0.415* | -0.408* | -0.325* |
| | | | (0.223) | (0.212) | (0.178) |
| Observations | 4,020 | 4,020 | 4,020 | 4,020 | 2,856 |
| Country-Ind. Clusters | 194 | 194 | 194 | 194 | 194 |
| *Panel B:* | | | *Labor Costs* | | |
| Eurozone EC | 0.377** | 0.374** | 0.690** | 0.700*** | 0.413* |
| | (0.189) | (0.179) | (0.289) | (0.248) | (0.248) |
| $\times$ Post Euro | | | -0.196 | -0.204 | -0.0998 |
| | | | (0.145) | (0.133) | (0.126) |
| Observations | 4,002 | 4,002 | 4,002 | 4,002 | 2,844 |
| Country-Ind. Clusters | 193 | 193 | 193 | 193 | 193 |
| Sample Frame | 1995 - 2015 | 1995 - 2015 | 1995 - 2015 | 1995 - 2015 | 1995 - 2009 |
| Country-Ind. F.E. | $\times$ | $\times$ | $\times$ | $\times$ | $\times$ |
| Year F.E. | $\times$ | | $\times$ | | $\times$ |
| Country-Year F.E. | | $\times$ | | $\times$ | |

*Notes:* The Table presents estimates from regressing employment or labor costs (in logs) for Eurozone countries on Eurozone export competition from Germany and its interaction with a dummy *Post Euro* which equals 1 from the introduction of the Euro in 1999 onwards. Data are obtained from the EU KLEMS database and Eurostat Comext. Import competition (*Eurozone IP*) is defined according to $\tilde{EC}_{it}^{EZ}$ in the main text. All estimations include a full set of country-industry fixed effects and either year or country-year fixed effects. Standard errors are clustered at the country-industry level; $^{***}$ $p < 0.01$, $^{**}$ $p < 0.05$, $^{*}$ $p < 0.1$.

# B Quantitative Appendix

## B.1 Details on the Quantification

**Table A.3:** List of countries

| | | | |
|---|---|---|---|
| AUT | ESP | IRL | POL |
| BEL | EST | ITA | PRT |
| BGR | FIN | JPN | ROU |
| CHN | FRA | LUX | SVK |
| CYP | GBR | LTU | SVN |
| CZE | GRC | LVA | SWE |
| DEU | HUN | MLT | USA |
| DNK | IND | NLD | RoW |

*Notes:* List of countries included in the structural model. Countries in blue mark the EZ.

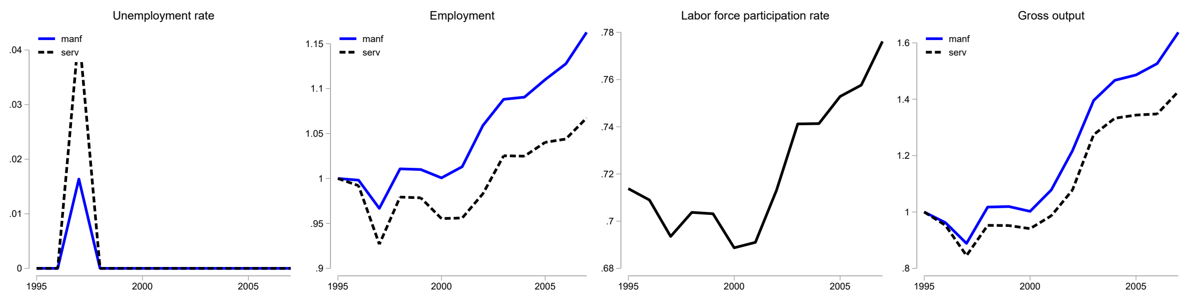
**Table A.4:** List of sectors

| | |
|---|---|
| 1 | Agriculture |
| 2 | Mining, petroleum and coal products |
| 3 | Food, Beverages, and Tobacco |
| 4 | Textiles and textile products |
| 5 | Wood and paper products |
| 6 | Chemicals and chemical products |
| 7 | Rubber and plastics |
| 8 | Other non-metallic mineral products |
| 9 | Basic metals and fabricated metal |
| 10 | Machinery |
| 11 | Computer and electronic products |
| 12 | Transport equipment |
| 13 | Furniture and misc. manufacturing |
| 14 | Services |

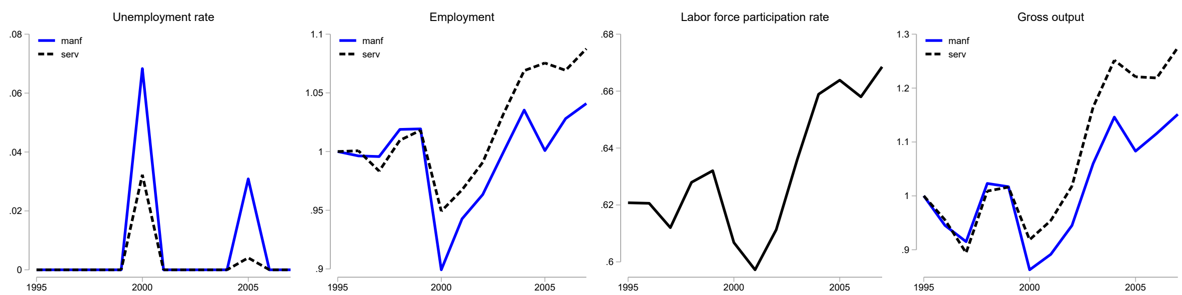
*Notes:* List of sectors included in the structural model.

**Figure A.5:** The Germany Shock: Factual Equilibrium - Other EZ Economies

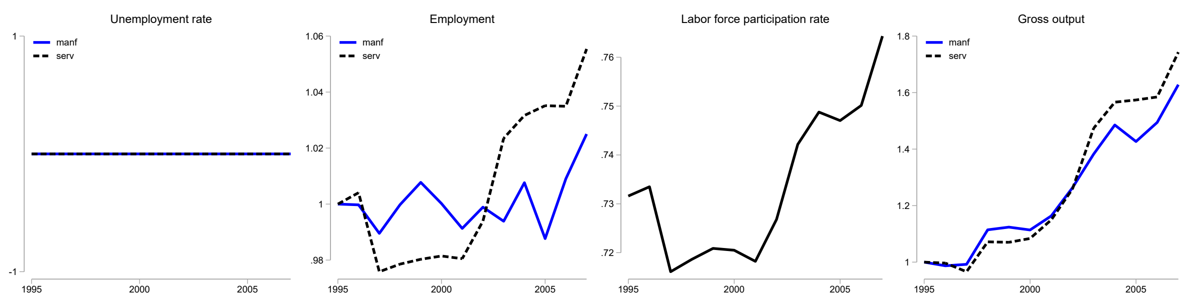
(**a**) Austria



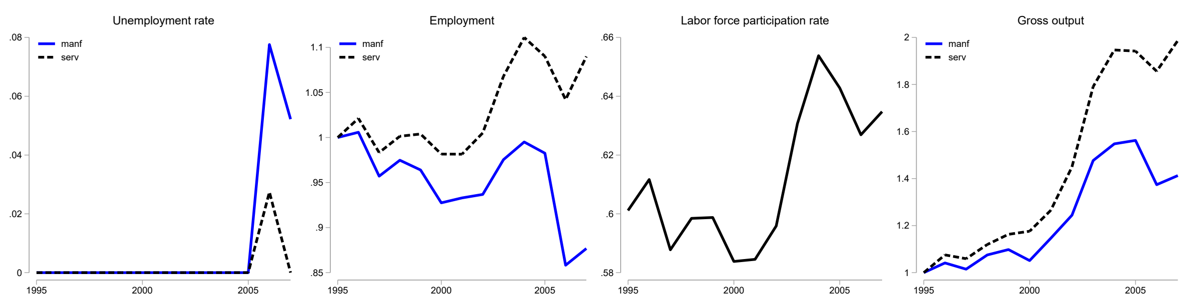

(**b**) Belgium



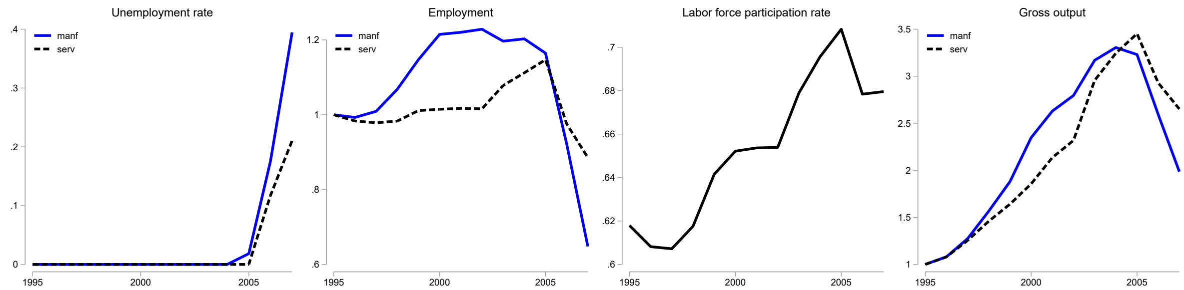

(**c**) Finland



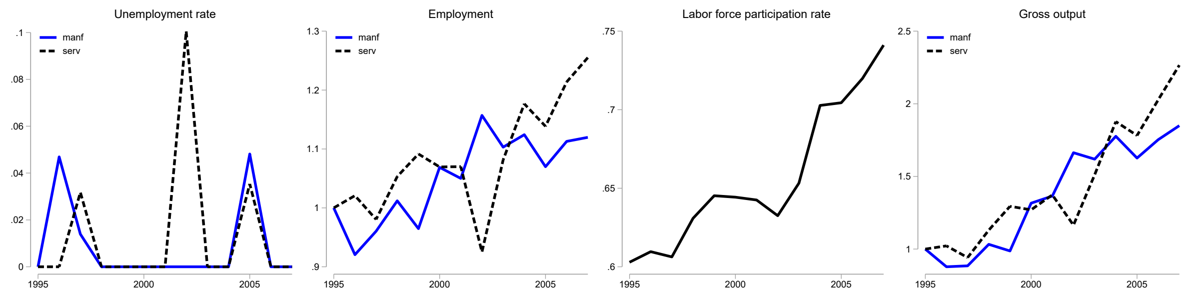

(**d**) Greece



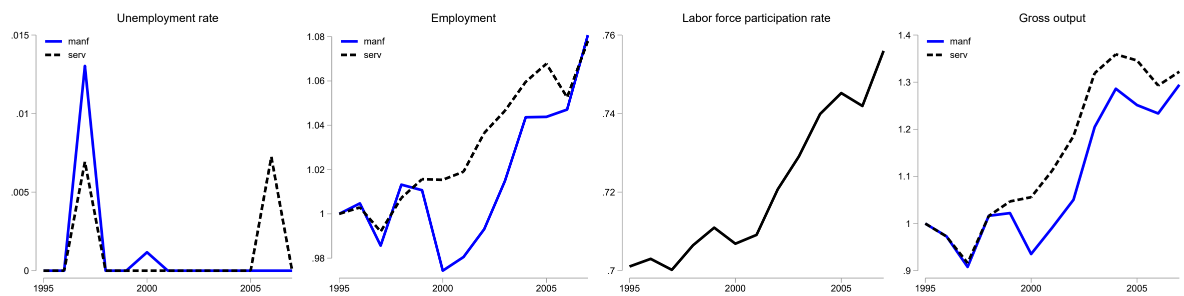
(**e**) Ireland



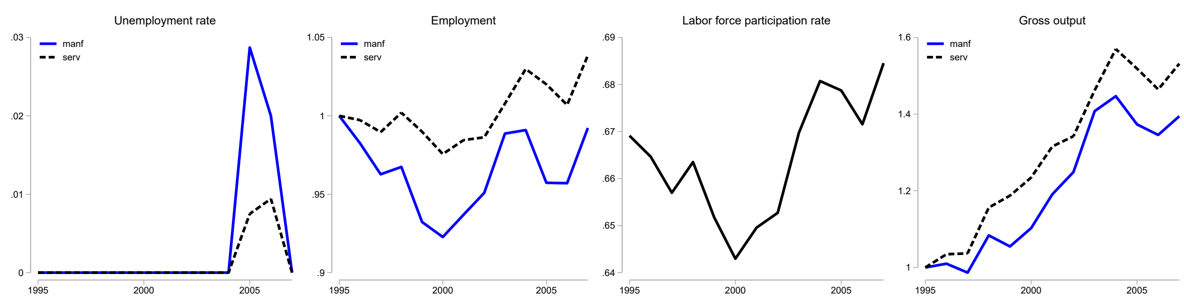

(**f**) Luxemburg




(**g**) Netherlands




(**h**) Portugal



(i) Spain

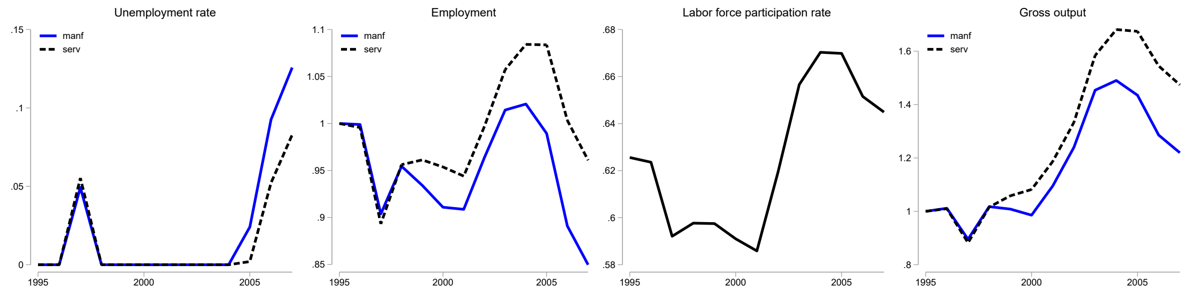
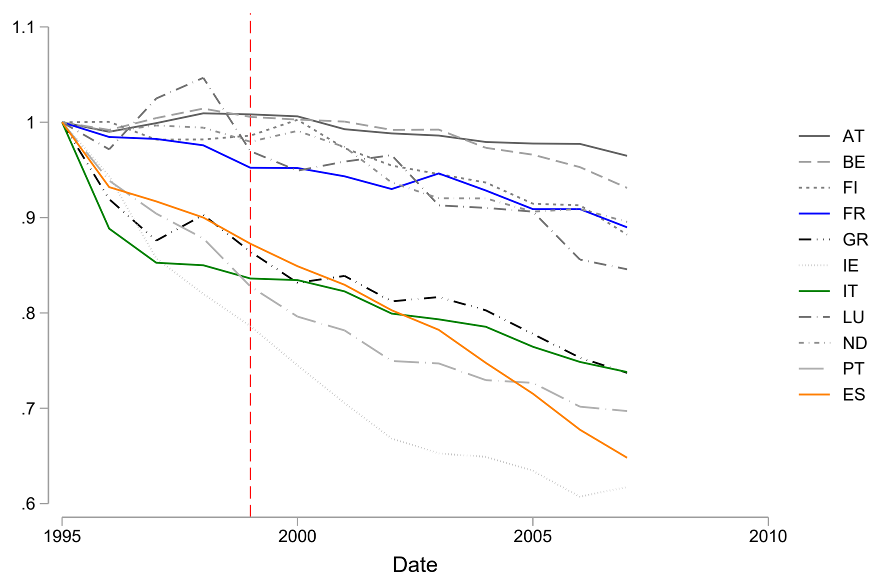



**Figure A.4:** Model-Implied Real Exchange Rate Fluctuations




*Notes:* The Figure plots model-implied real exchange rates for Eurozone economies relative to the German real exchange rate (analogously to Figure 3). Relative real exchange rates are defined as the German price index relative to the price index of respective Eurozone economy.