Persistent Global Growth Differences and Euro Area Adjustment: Real Activity, Trade and the Real Exchange Rate

Adrian Ifrim (European Commission, Joint Research Centre) (*)
Robert Kollmann (Université Libre de Bruxelles and CEPR)
Philipp Pfeiffer (European Commission, DG ECFIN)
Marco Ratto (European Commission, Joint Research Centre)
Werner Roeger (DIW-Berlin and VIVES–KU Leuven)

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Since the launch of the euro, the Euro Area has combined weak growth with persistent trade surpluses, a rising trade share, and the absence of a real exchange rate trend. In academic and policy debates, the Euro Area's trade surplus is often viewed as reflecting weak domestic aggregate demand. This paper argues that a purely demand-based view of the trade balance is incomplete. Using an estimated two-region framework, we find that slower productivity growth in the Euro Area has been a major driver of the trade surplus since 1999, while demand shocks play an important role in the rising trade balance following the global financial crisis. We further show that real exchange rate dynamics cannot be understood from productivity growth differentials and aggregate demand shocks alone, but also reflect longer-run shifts in trade patterns.

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(*) Corresponding author. Address: Adrian Ifrim, JRC, Via Enrico Fermi, 2749, 21027 Ispra (VA), Italy, adrian.ifrim@ec.europa.eu. The views expressed in this paper are those of the authors and should not be attributed to the European Commission. For helpful advice we especially thank Günter Coenen, Luca Fornaro and Lorenzo Forni, as well as two anonymous referees. Useful comments were also received from Björn Döhring, Oleg Itskhoki, Géraldine Mahieu, Lukas Vogel, and workshop participants at Durham, Lancaster, Strasbourg and Rotterdam Universities, at JRC (European Commission), the Franco-German Fiscal Policy Seminar, European Winter Meetings of the Econometric Society, American Economic Association Meetings, North American Winter Meetings of the Econometric Society, DG ECFIN-CEPR-JIE conference "Global Shocks, Macroeconomic Spillovers and Geopolitical Risks: Policy Challenges" and at the KMFA–Bank of Korea–CEPR 10th International Macroeconomics and Finance Conference.

1. Introduction

Over the last quarter-century, the Euro Area (EA) has exhibited persistently lower output and productivity growth than its global competitors, notably the United States and fast-growing East Asian economies. Since the launch of the euro in 1999, average annual real GDP growth was 1.26% in the EA compared to 3.28% in an aggregate of the rest of the world (RoW) (1999–2023). GDP per person in the labor force, a proxy for aggregate productivity, grew by 0.70% per year in the EA, compared to 1.95% in RoW. This growth gap is projected to persist over the medium term (IMF WEO, 2025). Over the same period, EA trade with RoW expanded steadily (with extra-EA exports and imports rising from about 15% to almost 30% of EA GDP), and the EA ran sizable trade surpluses, especially after the global financial crisis (average trade balance/GDP ratio 1999-2023: 2.6%). At the same time, the EA real exchange rate remained broadly trendless.

The EA vs. RoW growth gap and its implications have attracted wide attention in academic and policy debates. A prominent view (articulated, for example, by Darvas et al., 2026; Draghi, 2024a, 2024b) holds that the EA trade balance surplus reflects weak domestic demand—through, inter alia, fiscal consolidation and tighter financial conditions—while recognizing that supply-side factors also contribute to the trade surplus.[1] In this interpretation, the trade surplus is taken as evidence that weak domestic demand is an important source of the EA's broader growth malaise.

The present paper argues that a purely demand-driven interpretation of the EA trade surplus is incomplete. We highlight the role of aggregate supply factors for the EA trade surplus, and argue that the persistent EA vs. RoW productivity growth differential is a key driver of the EA external surplus. Simply put, slow EA productivity growth compresses domestic absorption relative to output, which may generate a sustained trade surplus.

Our paper's main contribution is to quantify the links between the EA-RoW growth differential and external adjustment. We develop a rich two-region New Keynesian dynamic stochastic general equilibrium (DSGE) model, and we estimate the model with Bayesian Maximum Likelihood methods, using 37 EA and RoW macroeconomic time series since the launch of the euro, so that the relative importance of competing mechanisms is determined by their *joint* ability to account for the data. To capture low-frequency swings in productivity and GDP growth, we model the growth rate of productivity in each region as the sum of two components: (i) an autoregressive process that we refer to as the trend growth rate; and (ii) a white noise disturbance capturing transitory deviations from the trend growth rate.[2] To account for the secular rise in the EA's foreign trade share, the model incorporates permanent shifts in the EA spending home bias (preference for imported goods). The framework also includes a broad set of stationary shocks to aggregate supply, demand, and financial risk premia. The estimation sample encompasses several major macroeconomic and financial disturbances, including the global financial crisis, and the Covid pandemic. A rich model structure, such as ours, is needed to adjudicate quantitatively between the role of aggregate supply, demand and trade shocks for EA real activity and external adjustment. A more restrictive model, with fewer alternative disturbances, could risk overstating the macroeconomic role of permanent productivity and trade shocks.

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[1] Related arguments were often made in discussions of Germany's trade surplus surge in the early 2000s; see, among others, Krugman (2013), Wolf (2013), and Kollmann et al. (2015).

[2] See Aguiar and Gopinath (2007) for evidence supporting this time series process for productivity.

A negative shock to the EA productivity trend growth rate signals a steady future decrease in the *level* of EA productivity and GDP. In our model, this lowers EA consumption and investment demand, which triggers a sustained improvement of the EA trade balance. At the same time, the steady decline in relative EA productivity raises the relative price of EA output goods, relative to RoW goods, which triggers a trend appreciation of the EA real exchange rate. Qualitatively similar EA trade balance and EA real exchange rate responses are triggered by a *positive* shock to the RoW productivity trend growth rate.

When fed into our model, estimated RoW and EA productivity trend growth rate shocks induce an improvement in the EA trade balance, coupled with a trend appreciation of the EA real exchange rate. Their contribution varies over time, with trend growth rate shocks playing a central role both during the pre-crisis expansion and in sustaining the surplus after the global financial crisis. During the pre-crisis expansion, strong domestic demand would have implied a trade deficit absent offsetting productivity trend growth rate shocks, while following the crisis, the contraction in domestic demand widened the surplus.

Our results indicate that productivity trend growth rate shocks alone cannot account for the joint dynamics of relative output, the trade balance, and the real exchange rate. Instead, the observed broadly trendless behavior of the EA real exchange rate primarily reflects persistent shifts in EA trade patterns, namely a declining home bias in EA goods spending and a sustained decline in the relative price of EA imports (driven largely by rapid productivity growth in RoW export sectors). These trade shocks have increased EA demand for RoW goods, offsetting the long-run appreciation pressure on the EA real exchange rate stemming from the persistent positive RoW-EA productivity growth differential. These findings underscore the importance of incorporating trade trends into a model of EA macroeconomic adjustment.

The literature on trade balance and real exchange rate dynamics is too extensive to fully review here. It has established that a wide range of macroeconomic, financial, and trade shocks can influence both variables (see, e.g., Obstfeld, 2025, for a recent discussion of the US trade balance). Consistent with this literature, our estimated model incorporates a broad set of structural shocks. The distinguishing feature of our analysis lies in the explicit treatment of *non-stationary* shocks to productivity growth and foreign trade—features largely absent from open-economy DSGE models, which have focused on persistent but stationary disturbances (e.g., Backus, Kehoe, and Kydland, 1994; Obstfeld and Rogoff, 1995). Our empirical findings underscore the importance of non-stationary shocks in shaping external adjustment.

The theoretical prediction that persistent cross-country productivity growth differentials induce systematic trade balance adjustment is a standard implication of intertemporal models with optimizing forward-looking agents (see Obstfeld and Rogoff, 1996, for a textbook treatment). A small number of studies have offered quantitative empirical analyses of this mechanism using simpler models. For example, Kollmann (1998) showed that a widening productivity gap between the US and the rest of the G7 can explain the rising US trade deficit of the 1980s. Related explanations of the US trade balance deficit (in later sample periods) were provided by Engel and Rogers (2006), who used a model of endowment economies, and by Hoffmann et al. (2019), who estimated a two-country RBC model incorporating survey-based expectations of future growth.[3] In both models, a fully anticipated persistent rise in foreign growth induces a sharp but short-lived rise in the trade balance – a pattern driven by the immediate surge in foreign absorption. Both studies argue that this model-predicted front-loaded trade balance adjustment is at odds with the gradual trade balance dynamics observed in the data, and advocate models with imperfect information, in which agents gradually learn the persistence of productivity shocks—yielding a smoother trade balance response. By contrast, the present paper assumes full information regarding the persistence of growth shocks but introduces adjustment frictions in trade flows (following Auclert et al., 2024) and aggregate spending. We show that such real frictions generate gradual and persistent trade balance responses to productivity trend growth rate shocks, without the need to invoke imperfect information.

Our paper also relates to a growing literature on the macroeconomic effects of trade shocks. Clancy et al. (2024) present a calibrated DSGE model with reshoring shocks that reduce the import content of exports. Consistent with our findings, they show that a decline in home bias improves the trade balance and induces a persistent real exchange rate depreciation. Kollmann (2017) and Bodenstein et al. (2024) examine stylized calibrated models with *stationary* shocks to the import content of consumption, and find that such shocks account for a substantial share of real exchange rate fluctuations at business-cycle frequencies. In contrast, our estimated model incorporates *permanent* home bias shocks that simultaneously affect the import content of consumption, exports, and production. This richer propagation structure allows the model to capture long-run trade trends.

While the European trade balance surplus received attention in policy debates, it has received relatively little attention in the research literature. By contrast, a substantial body of work has analyzed *intra*-EA trade imbalances, particularly those associated with the boom-bust dynamics in Southern European economies around the global financial crisis (e.g., Kollmann et al., 2014; Martin and Philippon, 2017; Cardani et al., 2022b). These studies emphasize resource misallocation (e.g., Gopinath et al., 2017) and financial market imperfections (Kollmann et al., 2016; Ozhan 2019; Jaccard and Smets, 2020) as key drivers for trade balance dynamics. Given the sizable economic weight of Southern Europe, such mechanisms likely contributed also to the aggregate EA external position vis-à-vis RoW. Complementing this academic literature, policy reports, such as Draghi (2024a, 2024b), have argued that financial frictions have contributed to persistently weak investment in parts of the EA, thereby sustaining the region's trade surplus. In light of this literature, our estimated model incorporates financial frictions and a broad set of savings and investment shocks, enabling a comprehensive account of EA external adjustment.

Few studies have *estimated* multi-country DSGE with the empirical scope and structural detail of the model developed in the present paper. This aspect is central to our contribution. Existing large-scale estimated models differ in both specification and focus. Coenen et al. (2018) examine EA productivity shocks but do not incorporate persistent trend growth and trade shocks in *both* the EA and the RoW. Other estimated EA models emphasize cyclical financial shocks (Kollmann et al.,

[3] See also Aguiar and Gopinath (2007) who show that a small-open economy RBC model with persistent shocks to the productivity growth rate captures the dynamics of the trade balance and consumption in emerging market economies.

2016), commodity price shocks (Giovannini et al., 2019), or post-pandemic adjustment (Cardani et al., 2022a, 2023). None jointly analyze the trade balance and the real exchange rate within a unified framework that incorporates both permanent and transitory productivity and trade shocks.[4]

2. EA and RoW growth trends and macroeconomic adjustment

This paper provides a quantitative framework to assess the role of EA and RoW growth trends in shaping the dynamics of GDP, trade, and the real exchange rate. Our model-based econometric analysis focuses on the period 1999-2023, i.e. it considers a sample that starts with the launch of the euro (1999). The theoretical model assumes that the EA region has a common monetary policy, and thus it is natural to focus the empirical analysis on the period since 1999. Nevertheless, it is instructive to place the post-1999 period in perspective by reviewing growth trends over a longer horizon, 1960-2023.[5]

2.1. Growth trends: 1960-2023

In 1960, the EA accounted for 24.2% of world real GDP and 8.9% of the world population.[6] By 2023, persistent GDP and demographic growth gaps vis-à-vis the RoW had reduced these shares to 14.2% and 4.3%, respectively.

This section documents large low-frequency changes in the year-on-year growth rates of aggregate and per capita GDP for EA and RoW. To account for these persistent shifts, the structural model introduced below incorporates fluctuations in the productivity trend growth rate.

Panel a of Figure 1 plots annual EA and RoW year-on-year growth rates of real GDP per capita, over the period 1960–2023 which serves as a crude proxy for aggregate productivity growth (see the solid blue and red lines, respectively).[7] The dashed lines in Fig. 1 are Hodrick–Prescott trends of the year-on-year growth rates (smoothing parameter $\lambda = 400$); we use these Hodrick–Prescott trends as simple, heuristic indicators of the low-frequency (trend) components of EA and RoW growth. The trend growth rate of EA per capita GDP too has been declining since the 1960s (from close to 5% p.a. to about 1% in the 2000s). Interestingly, EA per capita GDP trend growth exceeded

[4] Our framework builds on earlier work by authors of the present paper (see also the European Commission's Global-Multicountry Model; Albonico et al., 2019) but differs considerably in both specification and research focus. For example, our paper embeds persistent growth-rate processes in both regions (for productivity and home bias) and estimates the steady-state global growth rate. We also estimate time-varying input-demand elasticities. The RoW block and dataset here are enriched (relative to, e.g., Kollmann et al., 2016; Giovannini et al., 2019) by i.a. considering RoW investment and a financial wedge.

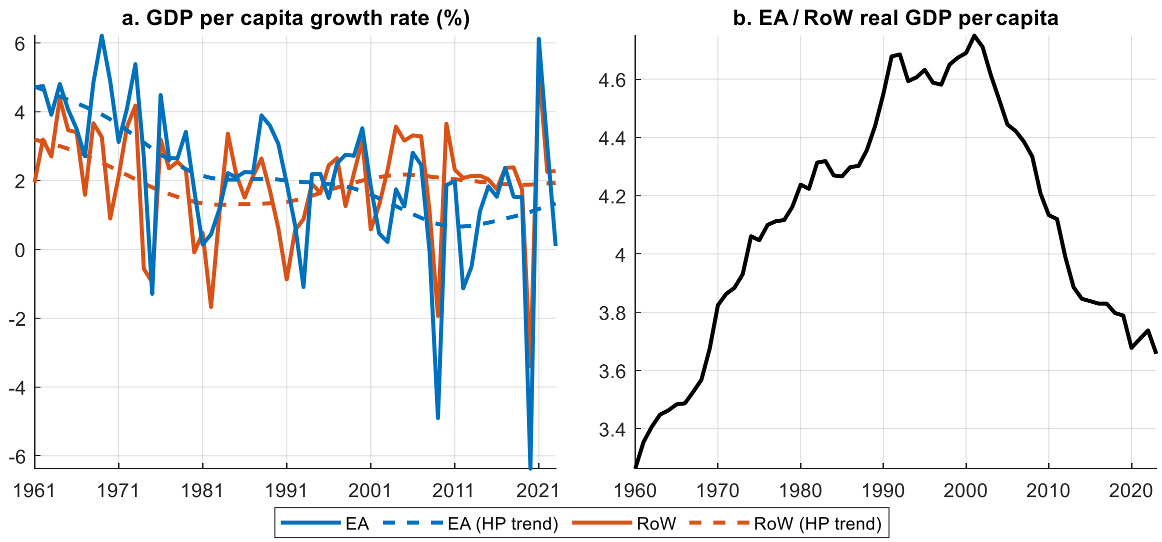
[5] Data source: World Bank Development Indicators (WDI). As of this writing, the WDI provides annual data for 1960-2023. The descriptive evidence in this section is annual and ends in 2023, whereas the model estimation in Section 4 uses quarterly data from 1999Q1 to 2024Q2.

[6] The real GDP series used here (from WDI) are expressed in constant 2015 US dollars (using market exchange rates; not PPP-adjusted). The EA aggregate data pertain to the EA19, backcast prior to the euro's launch. In this Section, RoW is defined as the WDI 'world' minus EA. In the model estimation, we instead use the current EA composition (EA20), based on the most recent data releases. The differences between this and EA19 are quantitatively negligible for the results.

[7] The GDP-to-employment ratio would be a more accurate productivity measure. However, comprehensive employment data are not available for RoW. The ratio of growth of GDP to working-age population (ages 15–64) tracks per capita GDP growth very closely.

RoW trend growth until the late 1990s. RoW trend growth fell during 1960-90, but rose during the period 1990-2005, before gradually slowing thereafter; the post-1990 resurgence largely reflects the rapid transformation and expansion of China and other emerging economies, driven by pro-market reforms and deeper integration into the global trading system. Since 2010 there has been a modest convergence of per capita GDP trend growth across the two regions.

Fig 1: Global growth trends, EA and RoW



Notes: Panel a shows year-on-year per capita GDP growth rates (%); dashed lines trace Hodrick–Prescott trends. Solid blue and red lines pertain to the EA and RoW, respectively. Panel b presents the ratio of EA to RoW per capita real GDP measured in constant 2015 USD.

It is important to note that, despite the persistently low growth of the EA economy, the *level* of per capita GDP remains much larger in EA than in RoW (see Fig. 1b). Relative EA/RoW per capita real GDP showed a secular rise until about 2000, but has subsequently declined significantly, from a ratio of about 4.6 in 2000 to 3.6 in 2023.

The remainder of the paper focuses on the period 1999-2023. During that time, real GDP in the EA grew by 37% (from 9.7 trillion constant USD (2015) to 13.3 trillion USD) compared to 118% real GDP growth in RoW (from 36.7 trillion USD to 80.1 trillion USD).[8]

2.2. EA-RoW trade and real exchange rate: 1999-2023

While EA GDP growth decelerated after the 1990s, trade between the EA and RoW grew steadily and significantly between 1999 and 2023, with only temporary contractions during the global financial crisis (2008) and the COVID pandemic (2020).[9] Over this period, the ratio of EA nominal exports and imports to nominal GDP doubled, rising from approximately 15% to almost 30% (see Fig. 2a). Due to the strong growth of RoW GDP, the rise in EA-RoW trade relative to RoW GDP

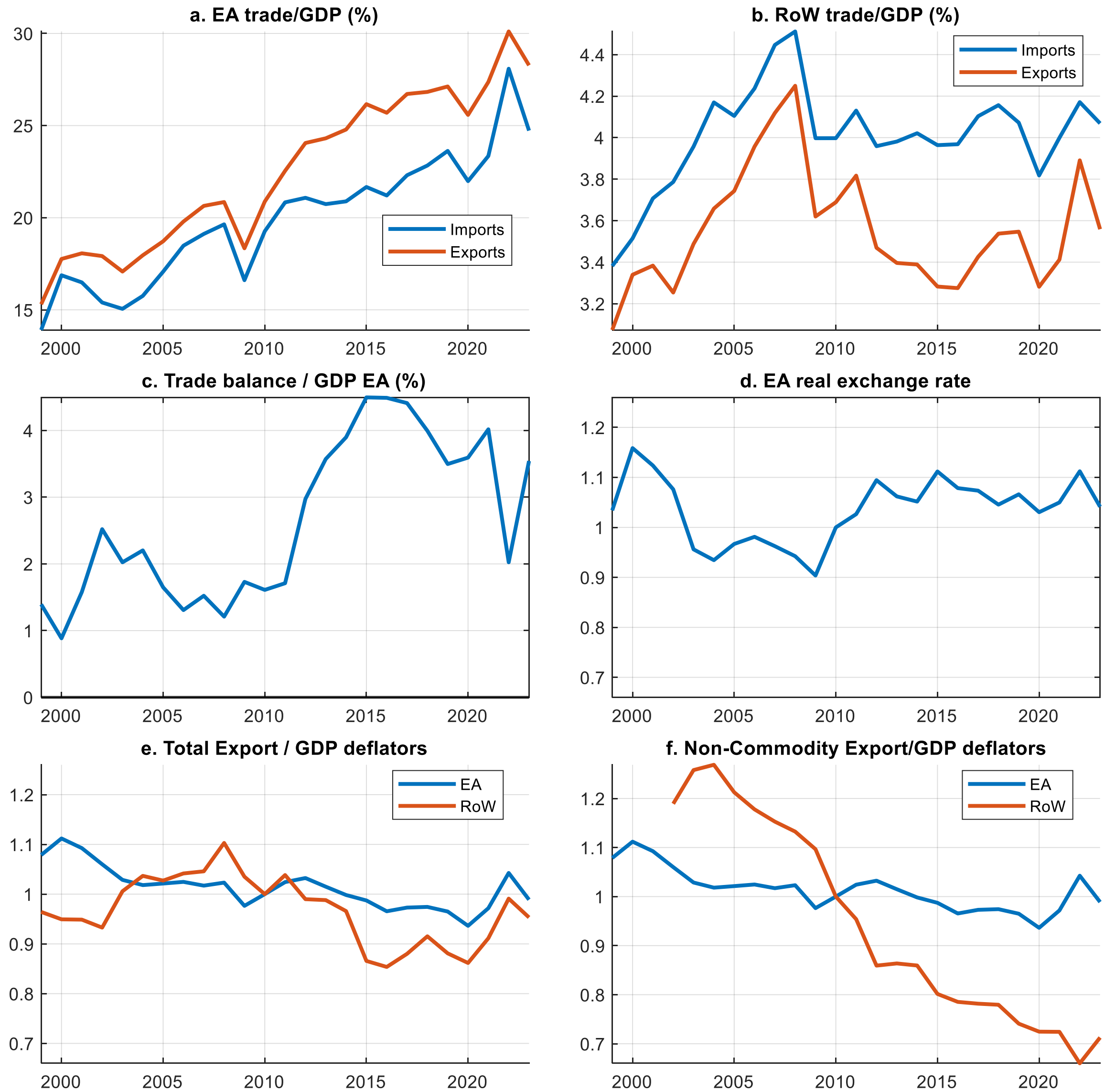
[8] Over the same period, the EA population increased by 8% (from 325 to 350 million), while the RoW population grew by 33% (from 5.7 to 7.6 billion).

[9] The international trade data presented in this paper encompass flows of both goods and services. EA (RoW) exports and imports refer exclusively to transactions between the EA and RoW, excluding intra-EA (intra-RoW) trade flows.

has been more modest; the ratio of RoW imports and exports (i.e., EA exports and imports) to RoW GDP rose before 2008, it then fell and stabilized at about 3% to 4%.

The EA has maintained a trade balance surplus every year since 1999, with an average surplus of 2.6% of EA GDP over 1999–2023. The trade balance/GDP ratio—defined throughout the paper as the ratio of nominal trade balance to nominal GDP—increased by nearly 2 percentage points during the European sovereign debt crisis and has remained elevated since, except in 2022 (Fig. 2c).

Fig. 2. EA-RoW trade and real exchange rate data



Notes: Panels a, b: Total imports and exports as a share of nominal GDP for EA (a) and RoW (b). Panel c: EA trade balance over GDP (%). Panel d: EA real exchange rate (based on GDP deflators). Panel e: Total export deflators (goods & services) relative to GDP deflators. Panel f: Non-commodity export deflators relative to GDP deflators. Series in Panels d-f are normalized to 1 in 2010.

Fig. 2d plots the EA–RoW real exchange rate. Throughout the paper (both in the empirical analysis and in the model simulations), the real exchange rate is constructed using GDP deflators (rather than consumer price indices, due to limited consumer price index coverage for RoW). An increase in the real exchange rate represents a depreciation of the EA. After the launch of the euro, the EA real exchange rate initially depreciated (for about one year) and then appreciated by about 20%–25% until the global financial crisis. Following the crisis, the real exchange rate depreciated by a similar magnitude and subsequently stabilized near the levels observed at the Euro's introduction. While the real exchange rate experienced substantial medium-term fluctuations, it thus displayed no clear trend over the full 1999–2023 period.

That absence of a long-term real exchange rate trend contrasts with the pronounced trends in relative EA/RoW output and productivity. This observation aligns with the findings of Krugman (1989) and Gagnon (2008), who documented, for a broader sample of countries, that secular real exchange rate trends are generally much more muted than those in relative (domestic/foreign) output.

Despite the absence of a pronounced long-term trend in the EA real exchange rate, the sample period has witnessed substantial shifts in relative export prices. Fig. 2e plots each region's export deflator divided by its GDP deflator (deflators are normalized at unity in 2010). Since the launch of the euro, the EA's exports/GDP deflator ratio has declined modestly but steadily. In contrast, the RoW ratio shows no clear trend but displays substantial medium-term fluctuations that are largely driven by the wide fluctuations in the prices of commodities exported by RoW to EA.[10] Fig. 2f plots non-commodity export deflators, again normalized by regional GDP deflators. Here, a distinct pattern emerges: RoW non-commodity export prices have declined persistently relative to the RoW GDP deflator—by more than 40% since the early 2000s. This is consistent with productivity growth in RoW's non-commodity export sector outpacing productivity growth in the rest of the RoW economy. The downward trend for RoW non-commodity relative export prices has been offset, however, by a rise in the relative price of RoW commodity exports (not shown in Figure), leading to the absence of a trend in the overall RoW export-to-GDP deflator ratio documented in Fig. 2e. RoW export prices, when expressed in Euros, correspond to EA import prices. The dynamics of the EA–RoW real exchange rate (based on GDP deflators) implies that the ratio of the deflator of EA non-commodity imports divided by the EA GDP deflator too has followed a similar downward trend (not displayed in Fig. 2).

3. Model description

To quantify the links between persistent EA–RoW growth differentials and external adjustment, we develop a rich two-region New Keynesian DSGE model.

3.1. The core idea in a stripped-down model

The basic supply-side mechanism at the core of our argument can be conveyed in a much simpler setting. In the Online Appendix, we consider a stripped-down two-country real business cycle model, namely the canonical Backus, Kehoe, and Kydland (1994) framework, in which each

[10] For example, the commodity price surges before the global financial crisis and after the Covid pandemic are reflected in pronounced increases in the RoW export deflator.

region produces a distinct tradable good and domestic and foreign goods are imperfect substitutes. In that framework, a persistent decline in home trend productivity growth compresses domestic absorption relative to output and generates a sustained trade surplus, while also appreciating the home real exchange rate. This simple model is useful because it makes transparent how persistent relative growth differentials can translate into persistent external imbalances.

At the same time, the simple model does not allow to assess whether this mechanism is quantitatively more important than domestic-demand and other explanations, since it abstracts from the main channels through which fiscal policy or financial shocks affect the economy. We therefore turn to a richer quantitative framework of the kind that has become standard in international macroeconomics, namely a model incorporating nominal rigidities, fiscal and financial demand disturbances, and household heterogeneity. We estimate such a model on EA–RoW data using Bayesian Maximum Likelihood methods, so that supply- and demand-based explanations of the EA trade surplus can be evaluated jointly and their relative importance disciplined by the data.

3.2. Overview of the estimated model

We now present our structural model. We focus here on the essential elements.[11] A full model description is provided in the Online Appendix. The model's detailed structure matters for quantitatively disentangling the drivers and interactions across the two regions. It is also necessary to match the large set of observable time series used in our estimation. Our main methodological contribution lies in the joint estimation of trend and cyclical factors within a unified framework.

The model comprises two regions: EA and RoW. In each region, the engine of long-term GDP growth is technical progress in the intermediate goods sector, where monopolistically competitive firms employ domestic labor and capital. Perfectly competitive firms combine domestically produced intermediates with imported inputs to generate final output.[12] Bonds denominated in RoW currency serve as the vehicle for cross-region financial flows.

Each region includes two representative household types: (i) 'Ricardian' households, who own local firms and have access to financial markets; (ii) 'Hand-to-mouth' households, who consume their disposable wage and transfer income each period. Wage setting is governed by monopolistic trade unions. Wages and intermediate-goods prices exhibit nominal stickiness.

The following subsections outline the main features of the EA block. The RoW block shares the same general structure (parameter values are allowed to differ across regions), with two exceptions: (i) RoW produces and exports commodities, whereas the EA does not; and (ii) owing to limited fiscal data for RoW, we do not model a RoW government, while the EA block includes fiscal variables.

[11] For example, here we do not explicitly describe public investment and capital, overhead labor, fixed costs, and include only the main exogenous shocks as identified in our estimation (see Section 5).

[12] The model does not feature a separate tradable and non-tradable production sector with distinct technologies and factor allocation; accordingly, it abstracts from Balassa–Samuelson-type mechanisms.

3.3. Multi-stage production

Production follows a multi-stage process (the Online Appendix presents a schematic overview). Final goods are produced by perfectly competitive firms combining domestic and imported intermediate goods and, in the EA, imported commodities. Intermediate goods are produced by monopolistically competitive firms using domestic capital and labor.

3.3.1. Final goods (aggregate demand components)

Final goods, used for domestic private consumption (C), public consumption (G), domestic physical investment (I) and exports (X), are produced by perfectly competitive firms. (C, G and I are non-traded.) The model captures the EA's role in global value chains by assuming that imported intermediates are used in the production of EA final export goods.[13] Final good production functions for final good $D \in \{C, G, I, X\}$ are of the following CES (constant elasticity of substitution) form:

$$D_t = A_t^D \left(\left(1 - s_t^{M,D}\right)^{\frac{1}{\sigma_Z}} O_t^{D^{\frac{\sigma_Z - 1}{\sigma_Z}}} + \left(s_t^{M,D}\right)^{\frac{1}{\sigma_Z}} M_t^{D^{\frac{\sigma_Z - 1}{\sigma_Z}}} \right)^{\frac{\sigma_Z}{\sigma_Z - 1}} \quad (1)$$

where O_t^D is an aggregate of domestically-produced intermediates, while M_t^D denotes imports. σ_Z is the elasticity of substitution between domestic output and imports. $s_t^{M,D}$ is a time-varying exogenous parameter that governs the foreign content of final good D (and thus its home bias $(1 - s_t^{M,D})$). A_t^D is an exogenous productivity shock that is specific to the production of final good D.[14] Home bias shocks are common across sectors while steady-state home bias, $s^{M,D}$, differs across sectors: $s_t^{M,D} = s^{M,D} \, exp(h_t^M)$, where h_t^M is a non-stationary exogenous random variable.

The final good deflator corresponding to (1) is

$$P_t^D = \left[\left(1 - s_t^{M,D}\right)(P_t^O)^{1-\sigma^z} + s_t^{M,D} (P_t^M)^{1-\sigma^z}\right]^{\frac{1}{1-\sigma^z}} / A_t^D,$$

where P_t^O and P_t^M are price indices of domestic and imported intermediate inputs, respectively.

Time-varying intermediate input elasticities. The estimated model enriches the final good technology (1) by assuming delayed adjustment of the mix of domestic and imported intermediate inputs, following Auclert et al. (2024); see the Online Appendix for details.

3.3.2. Intermediate goods

In the EA, the domestic intermediate aggregate O_t is itself a CES aggregate of EA domestic value added, Y_t, and industrial supplies IS_t (a bundle of energy and non-energy commodities imported from RoW):

$$O_t = ((1 - s_t^{is})^{1/\sigma_O} (Y_t)^{(\sigma_O - 1)/\sigma_O} + (s_t^{is})^{1/\sigma_O} (IS_t)^{(\sigma_O - 1)/\sigma_O})^{\sigma_O/(\sigma_O - 1)},$$

[13] Gross exports therefore exceed the value of domestic value added embodied in exports.

[14] The model assumes good-specific A_t^D shocks to capture empirical fluctuations in ratios of C, G, I, X deflators divided by the GDP deflator, which are included in the set of observables used for model estimation (see Online Appendix).

with $\sigma_o > 0$. Perfectly competitive "packers" aggregate a continuum of differentiated local intermediates using a CES technology with substitution elasticity σ_y: $Y_t = \left[\int_0^1 Y_{i,t}^{\frac{\sigma_y - 1}{\sigma_y}} di\right]^{\frac{\sigma_y}{\sigma_y - 1}}$. [15]

The production function for intermediate good i is

$$Y_{i,t} = \left(A_t^Y N_{i,t}\right)^{\alpha} \left(cu_{i,t} K_{i,t-1}\right)^{1-\alpha}, \quad (2)$$

where A_t^Y is an exogenous productivity parameter that is common across firms; $N_{i,t}$, $K_{i,t-1}$ denote labor and capital in period t; $cu_{i,t}$ is an endogenous rate of capacity utilization.[16] The capital stock accumulates according to $K_{i,t} = K_{i,t-1}(1-\delta) + I_{i,t}$, with $0 < \delta < 1$, where $I_{i.t}$ is gross investment.

The firm's dividend in period t is: $div_{i,t} = P_{i,t}Y_{i,t} - W_t N_{i,t} - P_t^I I_{i,t} - P_t \Gamma_{i,t}$, where $P_{i,t}$ is the firm's output price, P_t^I is the investment price, and $\Gamma_{i,t}$ summarizes nominal and real adjustment costs.[17] Price adjustment costs follow $\Gamma_{i,t}^P \equiv \frac{1}{2}\gamma(P_{i,t} - (1+\pi)P_{i,t-1})^2 / P_{i,t}$ where π is the steady-state inflation rate. Up to a linear approximation, this gives rise to a standard New-Keynesian Phillips curve, $\pi_t - \pi = \beta E_t(\pi_{t+1} - \pi) + \vartheta^j \left(P_{i,t}/MC_{i.t} - \frac{\sigma_y}{\sigma_y - 1}\right)$, where π_t is intermediate good inflation, $MC_{i,t}$ is the marginal cost of intermediate good firms and $\sigma_y/(\sigma_y - 1)$ is the steady-state mark up. β is the Ricardian households' steady-state subjective discount factor. The slope coefficient $\vartheta^j > 0$ depends on the degree of price rigidity.

3.4. Households

Household welfare depends on consumption and hours worked. Each household $j = r, h$ (r: Ricardian, h: hand-to-mouth) has period utility function

$$U_{j,t} \equiv \frac{(C_{j,t} - hC_{j,t-1})^{1-\theta}}{1-\theta} - s_t^N \cdot (C_t)^{1-\theta} \frac{(N_{j,t})^{1+\theta^N}}{1+\theta^N} \quad \text{with } 0 < \theta, \theta^N, s_t^N \text{ and } h \in (0,1)$$

where $C_{j,t}$ and $N_{j,t}$ denote consumption and labor hours, respectively. The parameters $\theta, \theta^N,$ and h govern risk aversion, labor disutility, and external consumption habit formation, respectively. s_t^N captures an exogenous shock to labor disutility. [18]

Households maximize expected life-time utility $V_{j,t} = U_{j,t} + E_t \beta_{t,t+1} V_{j,t+1}$, where $0 < \beta_{t,t+1} < 1$ is a subjective discount factor that fluctuates exogenously.

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[15] In the RoW, we set $O_{RoW,t} = Y_{RoW,t}$.

[16] The model assumes a time-varying rate of capacity utilization to better capture the cyclicality of the empirical aggregate Solow residual (e.g., King and Rebelo (1999)).

[17] Real adjustment costs for investment, labor inputs, and capacity utilization follow standard quadratic forms, as described in the Online Appendix.

[18] To allow for balanced growth, the disutility of labor features the multiplicative term $(C_t)^{1-\theta}$ that depends on aggregate consumption (treated as exogenous by an individual household).

3.4.1. Ricardian households

Ricardian households own domestic firms, hold domestic government bonds (denominated in local currency and not traded internationally) and internationally traded bonds. Their period t budget constraint is:

$$(1+\tau^C)P_t^C C_t^r + B_{t+1}^r = (1-\tau^N)W_t N_t^r + B_t^r(1+i_t^r) + div_t + T_t^r,$$

where P_t^C, W_t, div_t and T_t^r are the consumption (final good) price, the nominal wage rate, dividends generated by domestic firms, and government transfers received by Ricardian households. B_{t+1}^r denotes the Ricardian households' total asset (bonds and stocks) holdings at the end of period t, and i_t^r is the nominal return on the households' portfolio between periods $t-1$ and t (net of tax). τ^C and τ^N are (constant) consumption and labor tax rates, respectively.

Bonds and stocks are subject to exogenous stochastic convenience yields that affect the households' perceived returns on these assets.[19] Ricardian households' Euler equations imply that the expected return on stocks is equated (up to a linear approximation) to bond returns adjusted for an investment risk premium ε_t^S that is assumed to follow an AR(1) process:

$$E_t\left(\frac{P_{t+1}^s + div_{t+1}}{P_t^s}\right) = 1 + r_t + \varepsilon_t^S, \tag{3}$$

where P_t^s is the stock price and r_t is risk-free bond interest rate.[20]

3.4.2. Hand-to-mouth households

Hand-to-mouth households are introduced to capture empirically relevant limits to consumption smoothing and magnify the short-run transmission of income and fiscal shocks to aggregate demand. These households do not participate in asset markets. Their consumption equals disposable income each period: $(1+\tau^C)P_t C_t^h = (1-\tau^N)W_t N_t^h + T_t^h$.

3.5. International financial markets

The only internationally traded asset is a one-period bond denominated in RoW currency. The Ricardian household's first-order conditions for domestic and foreign bonds yield (up to a linear approximation) the following uncovered interest parity condition:

$$1 + i_{EA,t} = \left(1 + i_{RoW,t}\right)\frac{E_t(\mathcal{E}_{t+1})}{\mathcal{E}_t} + \varepsilon_t^{BW},$$

where, $i_{EA,t}$ and $i_{RoW,t}$ are EA and RoW nominal interest rates, respectively. $\mathcal{E}_t$ is the nominal exchange rate expressed as Euros per unit of RoW currency. ε_t^{BW} is a serially correlated shock that represents an exogenous shift in the (relative) convenience yield of domestic vs. foreign bonds.

Total net foreign assets evolve as:

$$NFA_{EA,t} = \left(1 + i_{RoW,t}\right)NFA_{EA,t-1} + TB_{EA,t} + \varepsilon_{EA,t}^{NFA}$$

where $\varepsilon_{EA,t}^{NFA}$ represents international remittances and other cross-country income transfers; we assume that this variable is exogenous. It is needed to reconcile the observed net foreign asset position and trade balance series in model estimation.

[19] For a micro foundation, see Fisher (2015). See also the Online Appendix.
[20] We also allow for exogenous fluctuations in government bond premia.

3.6. Economic policy and commodity supply

We incorporate policy elements commonly used in quantitative macro models. Monetary policy follows an interest rate feedback (Taylor-type) rule, under which the central bank adjusts the nominal policy rate gradually in response to deviations of inflation from its steady state and to GDP growth. Fiscal policy is modeled using simple, rule-based government behavior. Government consumption, investment, and transfers follow exogenous processes (around steady-state shares of potential output), public investment accumulates into a productive public capital stock, and lump-sum taxes adjust systematically in response to budget deficits and public debt.

In RoW, a competitive sector supplies commodities (energy and non-energy materials), to EA and RoW firms. Commodity prices are flexible.

3.7. Exogenous variables

The model incorporates both stationary and *non-stationary exogenous processes* to capture dynamics at both trend and business-cycle frequencies. The non-stationary variables are (both for EA and RoW): intermediate sector productivity, A_t^Y; export sector productivity, A_t^X; and the final good home bias parameter of the final good aggregate, $s_t^{M,D}$ (see (1)). Non-stationary export-sector productivity is intended to capture the trend in the relative price of export goods, measured relative to the GDP deflator, while non-stationary home bias help capture the secular rise in trade shares (see Sect. 2). All other exogenous variables are stationary.

The logarithm of non-stationary variables is modeled as the sum of two components: (i) a trend component, T_t^q, with stochastic growth rate g_t^q and (ii) a stationary component S_t^q following an AR(1) process. For sector q, this implies:

$$ln(A_t^q) = T_t^q + S_t^q \ , \tag{6}$$

$$T_t^q - T_{t-1}^q \equiv g_t^q = \rho^{g,q} g_{t-1}^q + (1-\rho^{g,q}) g^q + u_t^{g,q} \quad with\ 0 \leq \ \rho^{g,q} < 1$$

$$S_t^q = \rho^q S_{t-1}^q + u_t^q, \qquad with\ \ 0 \leq \ \rho^q < 1.$$

An analogous decomposition applies to the home bias shock process $s_t^{M,D}$. In eq. (6), $u_t^{g,q}$ and u_t^q are orthogonal *i.i.d.* white noise innovations with standard deviation $\sigma^{g,q}$ and σ^q, respectively. *We refer to g_t^q as the "trend growth rate" of A_t^q and to $u_t^{g,q}$ as a "trend growth rate shock"*. The innovation u_t^q represents a "transitory growth shock". The parameter g^q denotes the growth "drift", i.e. the unconditional mean of the trend growth rate. [21]

For intermediate sector productivity, A_t^Y, we set the persistence of the second component of intermediate goods productivity shocks to unity, $\rho^Y = 1$ based on estimates which point to a near-unit root in the "stationary" component (model estimation results are robust to instead using estimates of ρ^Y very close to unity). Thus, the (log) growth rate of intermediate goods productivity is the sum of a serially correlated trend growth rate, g_t^Y, and a white noise disturbance, u_t^Y:

$$ln(\ A_t^Y / A_{t-1}^Y) = \ g_t^Y + u_t^Y. \ ^{22}$$

[21] We allow for non-zero drift in productivity but assume that final good home bias has zero drift.

[22] Empirical support for this time series process for productivity can be found, among others, in Aguiar and Gopinath (2007).

The stationary exogenous variables assumed in the model are AR(1) processes in levels, corresponding to a special case of eq. (6) with $T_t = 0 \; \forall \; t$.

3.8. Balanced growth path and model solution

We assume that steady-state growth rate (growth rate drift *g*) of intermediate goods productivity is common across the two regions. This assumption ensures the existence of a balanced growth path characterized by a common steady-state trend growth rate for GDP per capita across the EA and RoW. This feature is broadly consistent with the fact that long-run (1960-2023) average GDP per capita growth rates were roughly similar across the EA and RoW (see Section 2). To solve the model numerically, we normalize all variables by their deterministic steady-state balanced growth paths, and we linearize the detrended system. In our framework, trend growth rate shocks induce permanent *level* deviations of GDP and demand components from the deterministic balanced growth path, while preserving the stationarity of the growth rates of all variables. The model has the property that, in each region, the growth rate of per capita GDP converges to the common steady-state growth rate in the (very) long run. The Online Appendix details the solution technique, and compares linearized and nonlinear model solutions.[23]

4. Econometric approach

4.1. Data

Our estimation sample is the period from 1999Q1 to 2024Q2. We use quarterly time series for 32 EA variables, and 5 annual series for RoW (mixed frequency estimation). For the EA, data are drawn from Eurostat, World Bank Development Indicators, and the IMF International Financial Statistics and World Economic Outlook databases.[24] The observables employed in estimation together with details on data construction are presented in the Online Appendix.

4.2. Calibration

The steady-state inflation rate is set at 2% in both regions. Steady-state relative GDP and trade shares are calibrated to (roughly) match sample averages. Specifically, we set the steady-state share of the EA in world GDP at 18% while the foreign trade-to-GDP ratio (trade openness) for EA and RoW are set to 18% and 5%. In line with standard DSGE models (e.g., Kollmann et al., 2016), we set the subjective rate of time preferences at 0.25% per quarter. The steady-state shares of Ricardian households are calibrated to 2/3 following the survey in Dolls et al. (2012). The EA steady-state government debt-to-GDP and fiscal deficit-to-GDP ratios are set to 77% (annual terms) and 3%, respectively. Details on the calibrated parameters are provided in the Online Appendix.

4.3. Estimation procedure

We estimate the remaining model parameters using Bayesian Maximum Likelihood methods. The estimation uses all variables in levels. The global steady-state growth rate of intermediate good productivity is estimated jointly with other model parameters.

[23] The analysis confirms that the linear approximation provides an accurate representation of both simulated dynamics and impulse responses, including those triggered by permanent shocks.
[24] The RoW dataset aggregates data from 57 countries.

To account for the sharp contraction in economic activity during the Covid pandemic, we follow Cardani et al. (2022a, 2023) and assume pandemic-specific heteroskedastic shocks. These shocks are jointly estimated alongside the other structural parameters using a diffuse and heteroskedastic Kalman filter. Posterior distributions are sampled using Gibbs sampling, specifically the slice sampler (Neal, 2003). Point estimates are derived from the posterior mode.

5. Estimation results

This Section first presents the estimated model parameters, followed by impulse response functions and historical shock decompositions.

5.1. Posterior parameter estimates

Table 1 reports estimates of the key parameters driving the persistent processes central to our analysis; other parameter estimates are provided in the Online Appendix. The estimated steady-state annual global growth rate of output is 1.8%. This implies a quarterly steady-state intermediate goods productivity growth rate of 0.3% (given a steady-state quarterly population growth rate of 0.085%). The estimated persistence of intermediate goods productivity and spending-foreign bias, $(1 - s_t^{M,D})$, trend growth rates (parameter $\rho^{g,Y}$ in eq. (6)) are high in both regions (0.98). This enables the model to capture the persistent cross-region trend growth differences and the import share trends observed in the data.[25] By contrast, the persistence of the export sector productivity trend growth rates is lower, between 0.7 and 0.88.

Table 1. Key estimated parameters

Description	Variable	Prior type	Prior Mean	Prior Std.	Posterior Mode	Posterior Std.
Steady-state GDP quarterly growth rate	g^Y	Beta	0.5	0.06	0.45	0.024
Autocorrelation of exogenous variables						
Intermediate productivity trend growth EA	$\rho^{g,Y}$	Beta	0.85	0.1	0.98	0.007
Intermediate productivity trend growth RoW	$\rho^{g,Y,*}$	Beta	0.85	0.1	0.98	0.005
Foreign bias trend growth EA	$\rho^{g,M}$	Beta	0.85	0.1	0.97	0.099
Foreign bias trend growth RoW	$\rho^{g,M,*}$	Beta	0.85	0.1	0.98	0.109
Export sector productivity trend growth EA	$\rho^{g,X}$	Beta	0.85	0.1	0.70	0.073
Export sector productivity trend growth RoW	$\rho^{g,X,*}$	Beta	0.85	0.1	0.88	0.037
Standard deviation (%) of innovation to exogenous variables						
Intermediate productivity trend growth EA	$\sigma^{g,Y}$	Gamma	0.03	0.002	0.03	0.002
Technology trend growth shock RoW	$\sigma^{g,Y,*}$	Gamma	0.03	0.002	0.03	0.002
Foreign bias trend growth EA	$\sigma^{g,M}$	Gamma	0.05	0.02	0.07	0.024
Foreign bias trend growth RoW	$\sigma^{g,M,*}$	Gamma	0.05	0.02	0.04	0.019
Export sector productivity trend growth EA	$\sigma^{g,X}$	Gamma	0.10	0.04	0.42	0.093
Export sector productivity trend growth RoW	$\sigma^{g,X,*}$	Gamma	0.10	0.04	0.21	0.053
Intermediate productivity transitory growth EA	σ^{Y}	Gamma	0.1	0.01	0.09	0.009
Intermediate productivity transitory growth RoW	$\sigma^{Y,*}$	Gamma	0.1	0.01	0.11	0.011

[25] We have also estimated a model version in which home-bias shocks are assumed stationary. This yields a significantly lower marginal likelihood than the model with trend home-bias shocks, indicating that the data support trend home-bias shocks.

Fig. 3. Smoothed estimates of intermediate goods productivity trend growth rates (annualized)

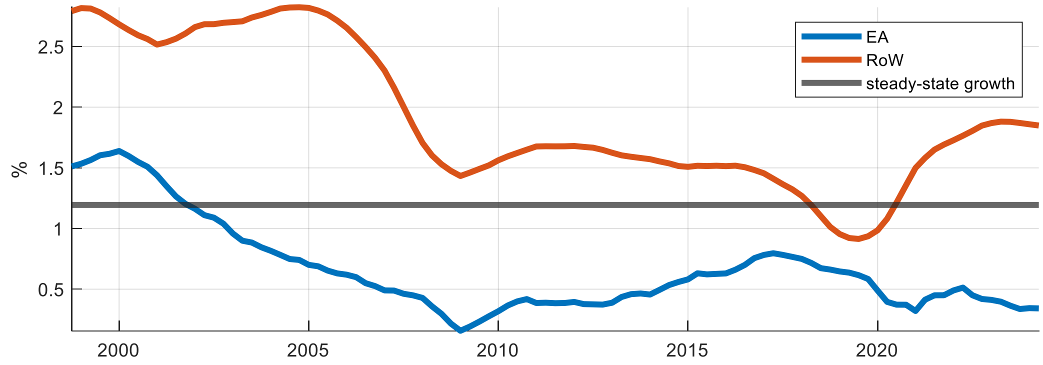


Fig. 3 displays smoothed estimates of intermediate goods productivity trend growth rates (annualized). The estimates reveal a persistent and time-varying differential between EA and RoW productivity trend growth rates. At the start of the sample, RoW experienced strong productivity trend growth well above the steady-state trend growth rate. Although RoW trend growth gradually slowed, it remained consistently above the steady-state growth rate during most of the sample period. In contrast, EA productivity growth dropped below the steady-state rate in the early 2000s and remained subdued thereafter, reflecting a sequence of negative productivity trend growth rate shocks until the global financial crisis. These opposing dynamics led to a widening productivity gap between the RoW and the EA until around 2005. The gap then narrowed before diverging again after 2019.

Turning to the other parameters presented in the Online Appendix, the estimation indicates a relatively high degree of habit formation in consumption for EA (0.85) and RoW (0.74), trade elasticities in line with standard empirical estimates (2 and 1.8 for the EA and RoW, respectively), higher risk aversion coefficient for the EA (1.5) compared to RoW (1.3), nominal rigidities for EA in line with previous studies and similar degrees of real wage rigidities.

5.2. Impulse responses

This Section presents responses of endogenous variables to key technology, trade, and aggregate demand shocks, to illustrate the model's dynamics, given estimated parameters. For each shock, we examine its role in explaining key empirical patterns, specifically, the joint behavior of GDP, trade balance and real exchange rate.

As revealed by historical shock decompositions (see below), negative EA and positive RoW intermediate goods trend productivity growth rate shocks were the drivers of the persistent EA-RoW productivity growth gap (over the empirical sample, the estimated productivity trend growth innovations are, on average, negative for the EA and positive for RoW).

The left panel of Fig. 4 shows dynamic responses to a negative ***intermediate goods productivity trend growth rate shock in the EA.***[26] Responses of the trade balance/GDP ratio and of the imports/GDP ratio are expressed as percentage point deviations from unshocked paths; responses of all other variables are shown as percent deviations from unshocked paths. The shock lowers EA productivity and GDP, on impact. This is followed by further strong and long-lasting EA productivity and GDP decreases, due to the high autocorrelation of the EA productivity trend growth rate (0.98). Fig. 4 shows that the shock strongly decreases EA aggregate consumption, on impact, as domestic Ricardian households consume less, in response to their decreased permanent income. The fall in EA aggregate demand boosts the EA trade balance, and leads to a small, but persistent, decline in RoW consumption, investment and GDP. In response to the steady contraction in EA output supply, the EA real exchange rate shows a sustained appreciation trend.[27] (The negative EA productivity trend growth rate shock lowers the EA real interest rate, which also helps to understand the sustained appreciation trend of the EA real exchange rate.) Over time, EA output growth returns to its trend rate, and EA Ricardian households begin to decumulate the assets accumulated after the shock. The EA trade balance therefore eventually falls below its pre-shock level. This reversal occurs only about 100 quarters after the adverse EA productivity trend growth shock, implying a highly persistent improvement in the EA trade balance.

This protracted improvement in the EA trade balance reflects two key features of the model. First, expenditure switching between domestic and imported tradables only occurs gradually. Second, aggregate expenditure adjusts sluggishly because consumption habits and investment adjustment costs damp the responses of consumption and investment to the shock. The corresponding substitution elasticities and adjustment parameters are estimated jointly with the other model parameters. The Online Appendix shows that, in model variants without these mechanisms, the trade balance response to a productivity trend growth shock is more front-loaded and less persistent. Even in those variants, however, productivity trend growth shocks remain an important driver of the EA trade balance, although their effects are less persistent.[28]

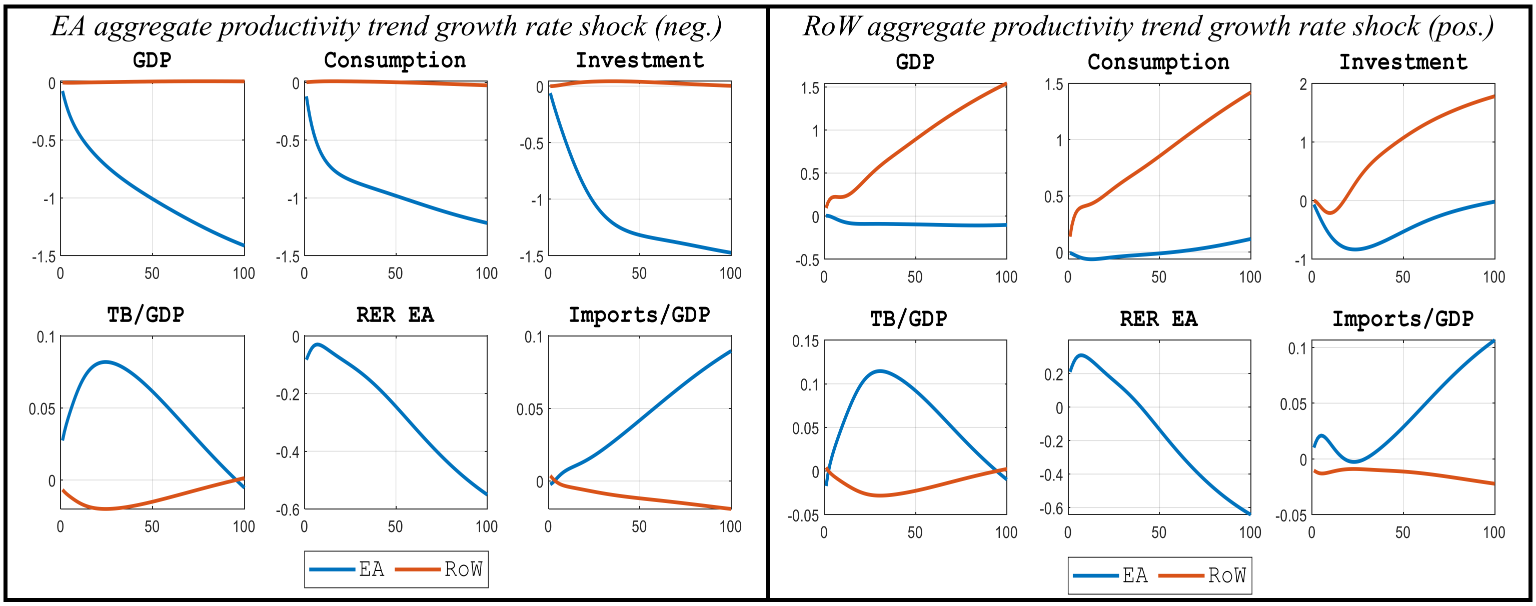
Turning to the ***positive RoW productivity trend growth shock*** (Fig. 4, right panel), the shock induces an immediate rise in RoW consumption, and persistently lowers the RoW trade balance, thereby raising the EA trade balance for close to 100 quarters. The shock also crowds out EA consumption and investment, which causes a small but persistent decline in EA GDP. Importantly, this shock too triggers a trend appreciation of the EA real exchange rate.

In sum, a negative EA productivity trend growth shock and a positive RoW trend growth shock both generate a persistently positive EA trade balance response but imply a long-lasting appreciation of the EA real exchange rate. The negative EA shock operates via a contraction in EA

[26] This is a negative one-standard deviation innovation in the process for EA intermediate goods productivity A_t^Y (see eq. 2).
[27] The EA real exchange rate is defined as the ratio of the EA and RoW GDP deflators, expressed in a common currency (using the nominal exchange rate).
[28] Hoffmann et al. (2019) show that, in a one-good two-country RBC model, full information generates a sharp and short-lived trade balance response to productivity trend growth shocks, and they appeal to imperfect information to smooth the adjustment. Here, by contrast, gradual and persistent trade balance dynamics arise under full information because of imperfect substitutability of domestic and imported goods and sluggish adjustment in trade and aggregate spending.

absorption, whereas the positive RoW shock works through an expansion in external demand faced by the EA.[29] In the long term, both shocks raise the EA import share (due to a fall in the relative price of RoW exports), but the effect on the import share is muted. This suggests that while EA productivity trend growth shocks have the potential to explain the persistent EA trade balance surplus observed since the launch of the euro, those shocks alone fail to account for the absence of a secular trend in the EA real exchange rate.

Fig. 4. Dynamic responses to aggregate (intermediate goods) productivity shocks



Notes: The shock size corresponds to one estimated standard deviation of the exogenous innovation. Periods correspond to quarters. An upward movement of the real exchange rate (RER EA) indicates a depreciation from the EA viewpoint. Responses of the trade balance/GDP ratio and the imports/GDP ratio are expressed as percentage-point deviations from unshocked paths; responses of all other variables are shown as percent deviations from unshocked paths.

The left panel of Fig. 5 shows dynamic responses to a ***productivity trend growth rate shock in the RoW export sector.*** That shock permanently raises the efficiency with which domestic and imported intermediates are transformed into RoW exports (parameter A_t^X in eq. (1) for sector $D = X$)).[30] The right panel of Fig. 5 shows responses to a permanent positive shock to the ***foreign content*** of EA final goods (i.e. a negative shock to EA home bias).[31]

The ***RoW export sector productivity trend growth shock*** raises RoW GDP. Simultaneously, the EA benefits from lower prices for imports. Unlike the productivity trend growth shock in the RoW

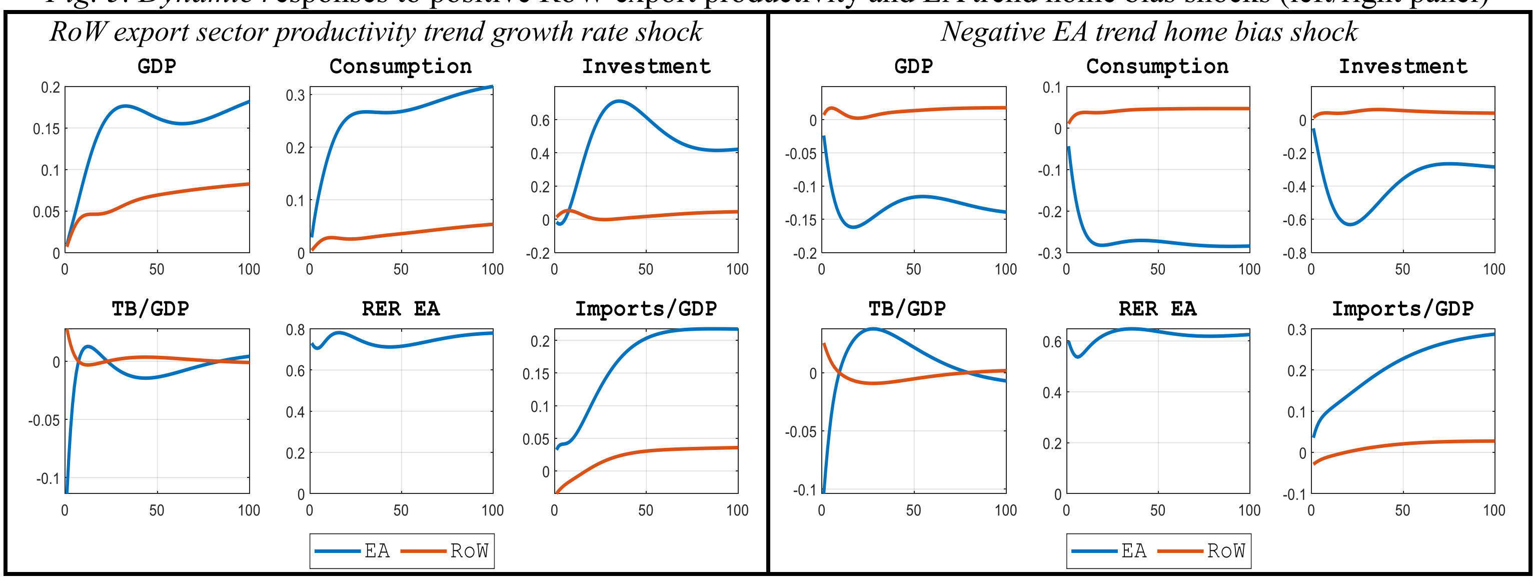
[29] It is insightful to contrast productivity trend growth rate shocks to a ***productivity transitory growth shock*** in the intermediate goods sector. As shown in the Online Appendix, the transitory growth rate shock induces a much more muted response of domestic absorption that more closely tracks GDP. Consequently, this shock has only negligible effects on the EA trade balance.

[30] Rest-of-the-world export prices are not observed; instead, we proxy them using EA import prices. These are recorded on a CIF (cost, insurance, and freight) basis and therefore embed international transport and insurance costs. Rest-of-the-world export-sector productivity shocks help match movements in EA import prices driven by trade costs.

[31] We assume that the shock increases the parameter $s_t^{M,D}$ (see eq. (1)) by the same relative amount in the EA production functions of all final good types, C, I, G, X.

intermediate goods sector, the RoW exports sector shock generates GDP responses that are synchronized across regions. The shock triggers a persistent depreciation of the EA real exchange rate, and raise the EA import share; in the short- to medium term, the EA trade balance deteriorates. Similarly, the ***negative shock to EA trend home bias*** triggers a gradual rise in the EA import share. This is a direct expenditure-switching disturbance that reduces relative demand for EA intermediates; it thus lowers the relative price of EA intermediates and final goods, depresses EA GDP, consumption and investment, and depreciates the EA real exchange rate, while raising RoW output. The demand shift towards EA imports also induces an initial deterioration of the EA trade balance. Over time, the EA trade balance improves, as EA households anticipate higher import spending and therefore save more.

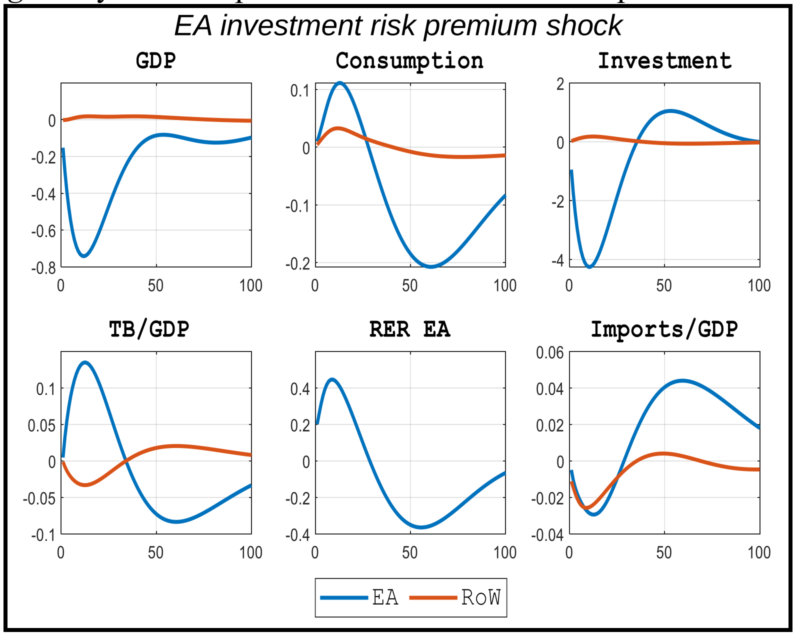
*Fig. 5. Dynamic r*esponses to positive RoW export productivity and EA trend home bias shocks (left/right panel)



Notes: see Fig.4.

We conclude the discussion of impulse responses by a positive (transitory) shock to the **EA investment risk premium** (Figure 6). As discussed further below, historical shock decompositions show that ***EA aggregate demand shocks,*** particularly shocks to the EA investment risk premium ε_t^S (see (3)) played a key role in driving EA real activity around the time of the global financial crisis (our estimates indicate low investment risk premia before the GFC, and high risk premia during and after the GFC). The investment risk premium shock drives a wedge between the marginal product of capital and the interest rate earned by savers (see (3)). Fig. 6 shows that a positive ***EA investment risk premium shock*** reduces EA investment and output, improves the EA trade balance, and leads to a depreciation of the real exchange rate, on impact. In the short term, the shock triggers an EA trade balance response that is *qualitatively* similar to the predicted responses to a positive RoW productivity trend growth rate shock. However, due to its transitory nature, the investment risk-premium shock does not have long-lasting effects on the real exchange rate. Additionally, as a contractionary demand shock, it initially lowers the EA import share.

Fig. 6. Dynamic responses to EA investment risk premium shock



Notes: see Fig. 4.

Summary of main insights from shock responses. The dynamic responses suggest that adverse EA and positive RoW trend productivity growth shocks in the intermediate-goods sector can jointly account for two key empirical regularities: (i) the persistent deviation between RoW and EA output growth trends and (ii) the persistent EA trade balance surplus. However, these shocks also predict a trend appreciation of the EA real exchange rate, which is not observed in the data since the launch of the euro. This suggests that, in the data, other shocks must have offset the appreciation pressure generated by intermediate-goods trend productivity growth shocks.

The trade shocks considered in Fig. 5, namely improved RoW export sector productivity and increased imported content in EA final goods, induce a persistent depreciation of the EA real exchange rate. As such, they are plausible candidates for offsetting the appreciation effects of diverging RoW vs. EA productivity trends. These shocks are also consistent with the observed secular rise in the EA import share.[32]

In sum, the shock responses indicate that a combination of persistent supply-side shocks, both domestic and external, combined with structural trade shocks might jointly account for important features of the dynamics of EA output, trade balance, real exchange rate, and the EA import share since the launch of the euro. Aggregate demand shocks, such as the investment risk premium shock in Fig. 6, also have a powerful effect on the EA real activity, the EA trade balance and the EA real exchange rate. However, their impact on the EA trade balance is less long-lasting, and they do not explain the long-term increase in the EA import share.

[32] The predicted effects of the trade shocks are statistically significant when accounting for posterior parameter uncertainty (see the Online Appendix), supporting their empirical relevance.

The next Section turns to the historical shock decompositions to assess the empirical relevance of these mechanisms over time.

5.3. Historical shock decompositions

This Section presents historical shock decompositions, which quantify the contribution of *smoothed* estimates of exogenous shocks to the historical paths of the endogenous variables (based on the estimated model parameters).[33]

The discussion here focuses on shock decompositions of *quarterly* time series of EA log real GDP, EA trade balance/GDP ratio, and log real exchange rate. Shock decompositions of other variables are reported in the Online Appendix.[34] In each Figure, the thick black line shows the historical time series of a variable, in deviation from its estimated deterministic trend (i.e. the balanced growth path it would have followed absent any stochastic shocks). For example, a value of -0.1 in the decomposition for EA real GDP at a given date indicates that GDP was 10% below the steady-state trend at that date. (The model is calibrated so that the steady-state trade balance is zero. The steady-state log real exchange rate is normalized at zero.)

In each sub-panel, the black area shows the estimated contribution of a particular shock (or group of shocks), while the grey area shows the combined contribution of all other shocks.[35] Black or grey areas above the horizontal axis represent positive shock contributions, while areas below show negative shock contributions. All shocks together recover the detrended empirical time series.

Given the large number of shocks, we group together the contributions of related shocks. Specifically, the following shocks (or groups of shocks) are considered: (1) productivity trend growth rate shocks in the EA intermediate goods sector (see subplots labelled "Trend Productivity EA"); (2) productivity trend growth rate shocks in the RoW intermediate goods sector ("Trend Productivity RoW"); (3) other EA aggregate supply shocks (including transitory productivity growth shocks, as well as price and wage markup shocks) ("Other Aggregate Supply EA"); (4) EA aggregate demand shocks, including shocks to the household rate of time preference and investment risk premium shocks (monetary and fiscal shocks are not included in this group, but in a separate group, see below); (5) other RoW aggregate supply shocks; (6) RoW aggregate demand shocks; (7) EA trend home bias shocks; (8) RoW trend home bias shocks; (9) productivity trend growth shocks in EA and RoW export sectors ("Export Sector Trend Productivity"); (10) shocks to EA and RoW monetary and fiscal policy rules ("Policy"); (11) international financial market shocks (uncovered interest parity shocks and international transfer (net foreign asset) shocks); (12)

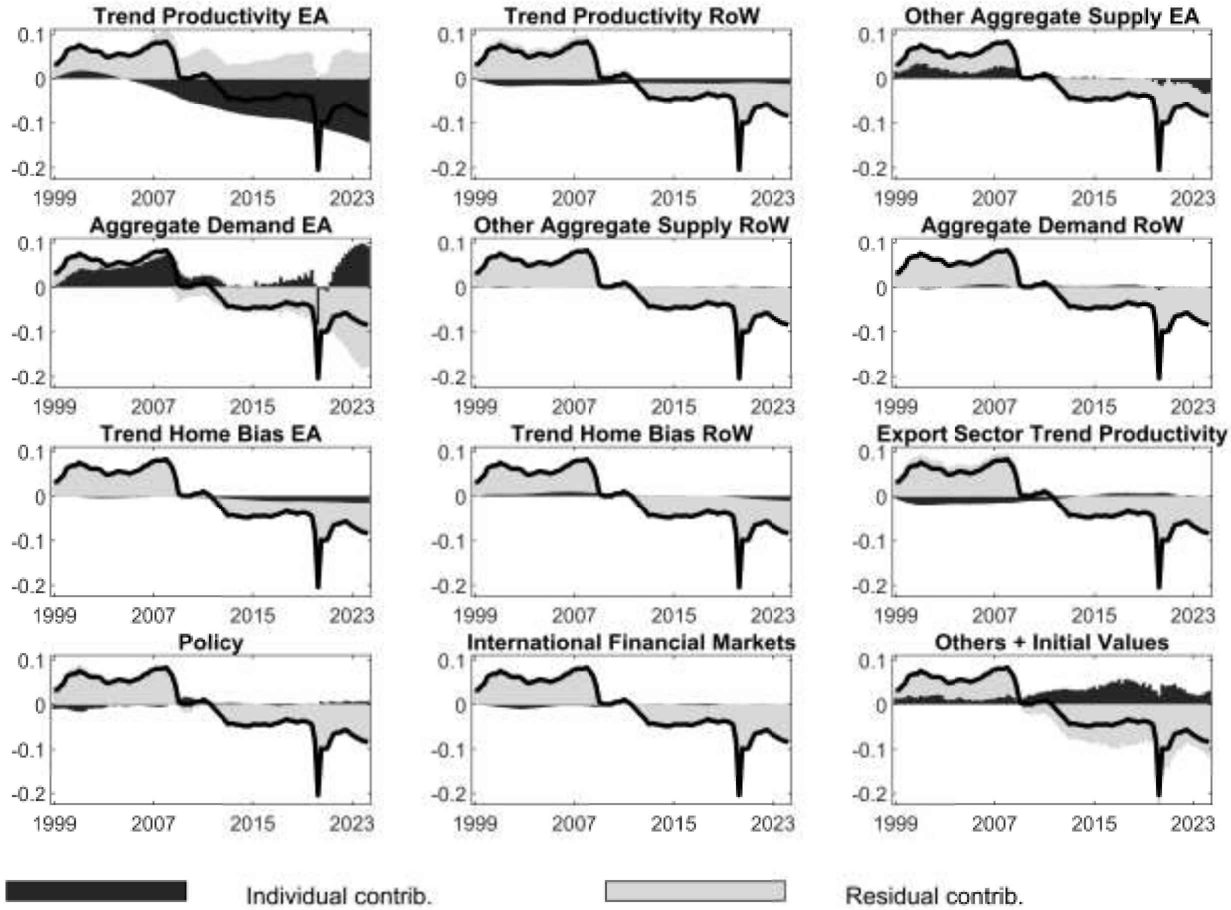
[33] The Online Appendix presents shock decompositions based on filtered estimates of the shocks (using information only up to the date of the shock) as an alternative to the smoothed shock estimates (based on full-sample information). Our main results are robust to using filtered shocks. The Online Appendix also quantifies the role of model parameter estimation uncertainty for shock decompositions. Accounting for parameter uncertainty preserves our main insights.

[34] The shock decompositions are computed for quarterly data; this explains why the plotted data series in the shock decompositions appear more jagged than those plotted in Section 2, where annual data were used to allow for a longer sample.

[35] At each date t, the contribution attributed to a shock includes both the effects of innovations up to and including t, and the effect of the initial value of the corresponding exogenous forcing variable, i.e. its value in the period immediately preceding the sample.

all remaining exogenous shocks (including RoW commodity shocks) and initial conditions for endogenous state variables (such as physical capital).

Fig. 7. Historical shock decomposition: EA real GDP (log deviation from steady-state trend)



5.3.1 Historical shock decomposition of EA GDP (Fig.7)

Fig. 7 shows that, according to the model estimates, weak EA GDP growth was primarily driven by negative EA intermediate good productivity trend growth shocks ("Trend Productivity EA"). RoW productivity trend growth shocks had a small but noticeable negative effect on EA GDP. The secular decline in EA home bias exerted modest, but gradually stronger, downward pressure on EA GDP. This drag was partly offset by positive RoW export sector productivity shocks which raised EA GDP towards the end of the sample (by stimulating EA investment).[36]

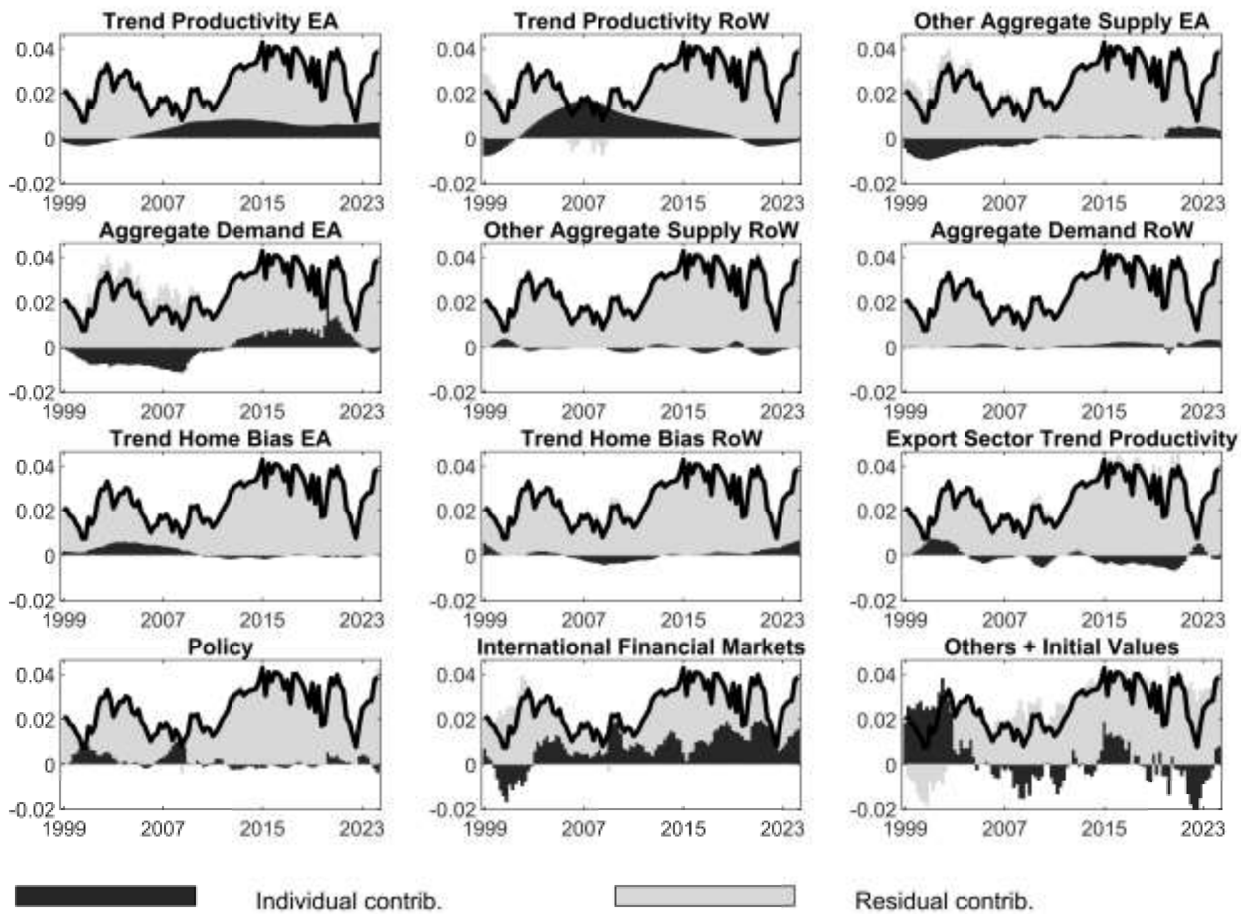
EA aggregate demand shocks (especially investment risk premium shocks) and "Other aggregate supply EA" shocks had a more transitory, cyclical influence on EA GDP. Falling EA investment risk premia contributed to the EA GDP expansion before the global financial crisis (2008-09), while a rise in investment risk premia during and after the global financial crisis, was a key driver of the (post-)crisis slump. The 2011–12 period saw a renewed decline in EA aggregate demand, linked to the EA sovereign debt crisis. While "Other aggregate supply EA" shocks (such as shocks

[36] RoW export sector productivity shocks had a markedly greater effect on EA GDP than EA export sector shocks (due to limited space, Fig. 7 plot the combined effect of those EA and RoW shocks).

to wage markups) supported activity before 2008, their contribution turned negative toward the end of the sample. RoW aggregate demand shocks had a negligible effect on EA GDP. Fiscal and monetary policy shocks (deviations from estimated policy rules) were broadly neutral, with limited stabilizing effects.

The same forces that shaped EA GDP dynamics also drove the evolution of EA consumption and investment (see Online Appendix). Overall, the results here indicate that domestic shocks were the dominant source of fluctuations in EA GDP and EA final demand components. RoW GDP dynamics (see Online Appendix) was likewise primarily determined by domestic shocks, most notably RoW productivity trend growth rate shocks. Favorable RoW supply shocks at the beginning of the sample were partially offset by negative RoW aggregate demand shocks. EA disturbances had negligible effects on RoW GDP.

Fig. 8. Historical shock decomposition of EA trade balance/GDP ratio



5.3.2 Historical shock decompositions of EA trade balance-to-GDP ratio (Fig.8)
Adverse EA intermediate-goods trend productivity growth shocks (“Trend Productivity EA”) exerted sustained upward pressure on the EA trade balance, except at the beginning of the sample, by compressing EA absorption relative to output. RoW trend productivity growth shocks (“Trend Productivity RoW”) likewise made an important positive contribution to the EA trade balance surplus, especially in the run-up to the global financial crisis and in its aftermath (toward the end of the sample, however, the contribution of RoW productivity shocks turned negative, reflecting

the moderation in RoW trend growth). Overall, EA and RoW trend productivity growth shocks thus emerge as key drivers of the persistent EA trade balance surplus.

By contrast, positive RoW export-sector productivity shocks exerted a persistent negative effect on the EA trade balance, as their stimulative effect on EA absorption through cheaper imports outweighed their support to EA supply. However, this effect was weaker than that of the intermediate-goods trend productivity growth shocks. The effects of EA and RoW trend home-bias shocks on the EA trade balance were relatively small and mixed, in line with the impulse responses discussed above.

EA aggregate demand shocks, which above were shown to have exerted a noticeable cyclical influence on EA GDP, also had a marked effect on the EA trade balance. During the pre-2008 boom, positive EA domestic demand shocks reduced the EA trade balance, at times by more than 1% of EA GDP. After the global financial crisis, these shocks changed sign, and their contribution to the EA trade balance therefore turned positive, in some periods exceeding 1% of EA GDP. EA aggregate demand shocks were thus an important driver of the post-crisis increase in the EA trade surplus.

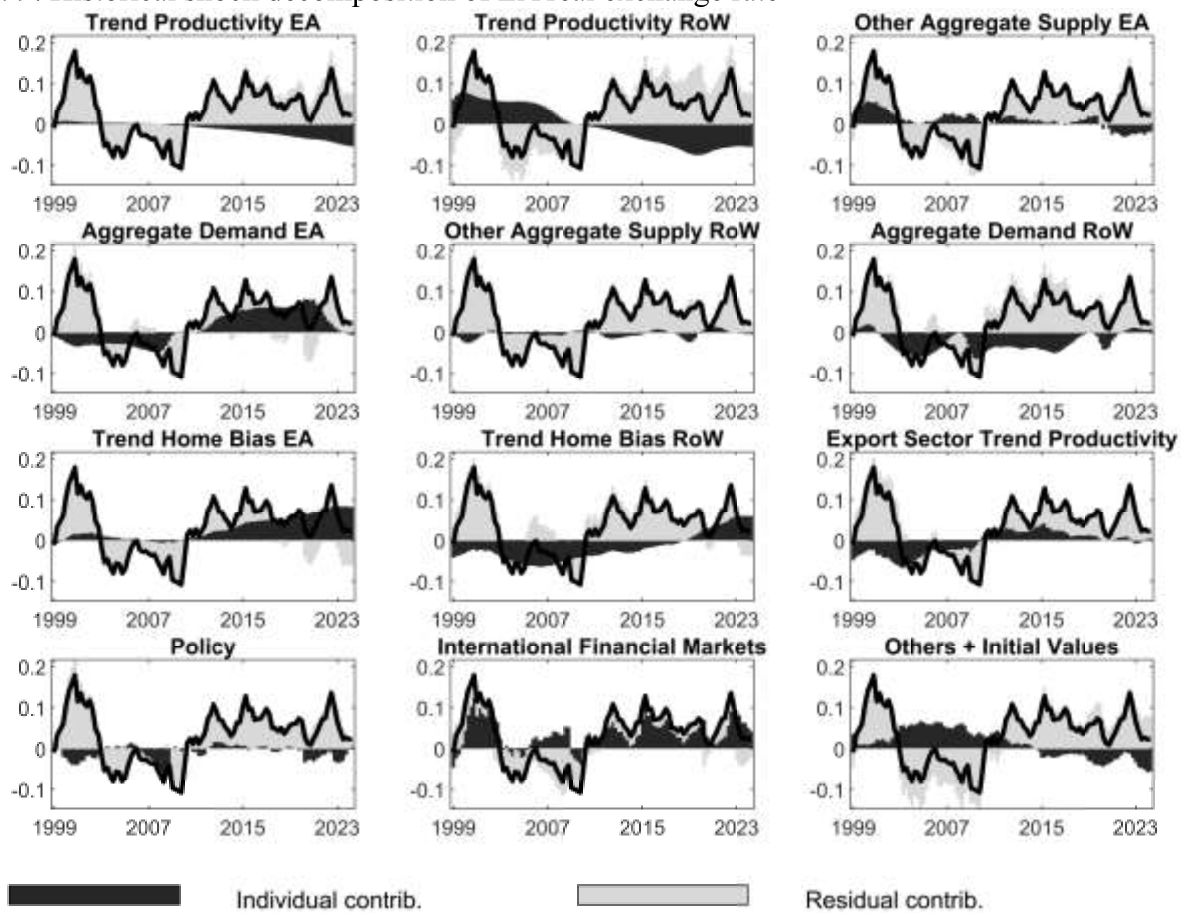
The decomposition is thus consistent with the view that weaker domestic demand, linked to tighter financial conditions, contributed to the widening of the EA external surplus (e.g., Darvas et al., 2026; Draghi, 2024a, 2024b). However, over the full sample, the contribution of EA aggregate demand shocks to the EA trade balance averages out, as negative contributions before the global financial crisis are broadly offset by positive contributions in the post-crisis period. The historical shock decomposition therefore suggests that a purely aggregate-demand interpretation of the EA surplus is incomplete, as it cannot account for the positive average EA trade balance observed in the data. By contrast, productivity trend growth differentials between the EA and the RoW help explain the persistence of the EA surplus

This conclusion should, however, be interpreted with some caution, as it rests on the baseline assumption that trend productivity growth is exogenous. In Section 6.1, we relax that assumption by allowing EA trend productivity growth to respond, in reduced-form fashion, to indicators of domestic demand conditions. We find that the estimated feedback is small and statistically insignificant, leaving the main historical decompositions largely unchanged. The results thus confirm the baseline model's implication that demand-side shocks contributed to the post-crisis increase in the EA surplus, and they leave unchanged the conclusion that persistent productivity growth differentials are an important driver of the elevated EA trade balance.

RoW aggregate demand shocks generated smaller and less persistent effects on the EA trade balance than EA aggregate demand shocks. Fiscal and monetary policy shocks in both regions had a negligible effect on the trade balance overall, although they mattered modestly in some episodes.

The shocks grouped under 'international financial markets'—uncovered interest parity disturbances and exogenous international transfer shocks—also made a persistent positive contribution to the EA trade balance, especially after 2002. Within this group, the positive average contribution the reflects cross-country transfer shocks assumed in the model, which capture systematic positive net transfers from the EA to the RoW, including government development aid and private remittances. The higher-frequency trade balance movements attributed to this shock category in Fig. 8 mainly reflect uncovered interest parity disturbances.

Fig. 9. Historical shock decomposition of EA real exchange rate



5.3.3 Historical shock decompositions of EA real exchange rate (Fig. 9)

Fig. 9 presents the historical decomposition of the EA real exchange rate. The EA and RoW productivity trend growth shocks exerted appreciation pressure on the real exchange rate, while the long-run decline in EA goods home bias pushed in the opposite direction, especially after the global financial crisis. Home bias shocks influenced the EA real exchange rate more strongly than the EA trade balance. Persistent productivity shocks in the export sector—especially in RoW—also exerted trend depreciation pressure on the EA real exchange rate, and thereby helped offset the trend appreciation induced by the EA and RoW intermediate sector productivity trend growth shocks.

Other shocks too had noticeable effects on the EA real exchange rate, but those effects did not produce pronounced real exchange rate trends. Positive EA aggregate demand shocks tended to appreciate the EA real exchange rate in the run-up to the global financial crisis (these shocks also supported EA GDP, see above), with peak appreciation effects of close to 5 percent. The collapse in EA aggregate demand during and after the crisis induced a real exchange rate depreciation. RoW aggregate demand shocks exerted temporary appreciation pressure during several episodes, though without inducing a sustained real exchange rate trend. In the post-crisis period, negative EA and RoW aggregate demand shocks exerted opposing effects on the EA real exchange rate. As for the EA trade balance, international financial market shocks accounted for a sizable share of short-run real exchange rate fluctuations, possibly linked to portfolio reallocation forces (e.g., Itskhoki and Mukhin, 2021). Other factors, including "other supply disturbances" (e.g., mark-up shocks) and policy shocks, made only modest contributions to real exchange rate movements. Taken together, the different forces largely offset each other on average, helping to explain the absence of a clear trend in the EA real exchange rate since the launch of the Euro, despite notable shorter-term fluctuations.

6. Robustness and mechanisms

This section shows that our main findings about the important role of productivity trend growth rate shocks for the EA trade balance are not sensitive to mechanisms that affect the transmission of aggregate demand shocks to real activity and the trade balance. Section 6.1 considers a model specification in which demand-side conditions may affect trend productivity growth. Section 6.2 considers model variants without nominal rigidities and household heterogeneity.

6.1. Endogenous productivity growth

This subsection examines whether the baseline model understates the role of aggregate demand by ruling out endogenous movements in trend productivity growth. The issue is directly related to the policy question, emphasized by Draghi (2024a, 2024b), of whether weak aggregate demand contributed to the EA productivity slowdown, so that demand disturbances may also affect external adjustment through trend growth.

A full analysis of this channel would require an endogenous growth framework with explicit decisions on R&D, innovation, and human-capital accumulation, which lies beyond the scope of this paper.[37] We therefore adopt a reduced-form specification in which EA trend productivity growth depends not only on exogenous shocks, but also on the investment risk premium, as a proxy for financial conditions, and on "discretionary fiscal effort" (as defined in European Commission, 2013), as a proxy for the fiscal stance. We then re-estimate the model under this alternative specification. This allows us to test for an empirical link from demand-side conditions to trend productivity growth without taking a stand on the precise microeconomic mechanism through which that feedback operates.

The results, reported in the Online Appendix, indicate that the estimated feedback coefficients from demand-side conditions to trend productivity growth are small and statistically insignificant. This finding is consistent with the historical evolution of EA trend TFP growth shown in Figure 3: trend productivity growth slowed before 2008, despite strong aggregate demand and a credit boom, and it recovered modestly after 2010 despite fiscal consolidation. Incorporating these weak estimated feedback effects into the model leaves the impulse responses and historical decompositions of the trade balance and the real exchange rate largely unchanged relative to the

[37] Related work considers endogenous productivity responses to demand and financial conditions, including stagnation traps and demand-induced slowdowns (Benigno and Fornaro, 2018; Anzoategui et al., 2019; Fornaro and Wolf, 2023), industrial policies (Cesa-Bianchi et al., 2026) as well as pre-crisis supply-side forces (Cozzi et al., 2021).

baseline specification with exogenous trend productivity growth. Thus, within this reduced-form exercise, we do not find evidence for a quantitatively important demand–productivity feedback for EA external adjustment or real activity. Exogenous shocks to EA and RoW trend productivity growth remain an important driver of the persistent EA trade surplus.

6.2. Nominal rigidities and household heterogeneity

In the baseline model, nominal rigidities and household heterogeneity are included to ensure that demand-side disturbances have a quantitatively meaningful effect on real activity. We thereby address influential interpretations of the EA external surplus that assign an important role to weak domestic demand. Simulations reported in the Online Appendix indicate that eliminating price and wage rigidities weakens the short-run real effects of monetary and fiscal disturbances, while removing hand-to-mouth households attenuates the response of domestic demand to fiscal transfers. At the same time, the trade-balance effects of trend productivity growth shocks remain largely unaffected.

7. Conclusion

This paper analyzes the effect of global productivity trend growth differences on real activity, trade, and the real exchange rate. Based on an estimated large-scale two-region DSGE model, we show that the persistent productivity growth differential between the Euro Area (EA) and the rest of the world (RoW) has been a key driver of the EA's trade surplus, since the launch of the euro. Aggregate-demand shocks are important for its post-2009 widening. A secular decline in the EA's spending home bias and a trend decrease in relative EA import prices accounted for the stability of the EA real exchange rate, despite weak EA trend productivity growth. By incorporating trend shocks to growth and trade, the analysis departs from much of the open-economy macroeconomics literature, which has focused on stationary disturbances. Our results highlight the relevance of non-stationary shocks for the analysis of external adjustment. While productivity trend growth is modeled as exogenous in the baseline specification, the framework can be extended to allow for endogenous innovation dynamics.

An important avenue for future research is to relax the two-region structure and allow for heterogeneity within both RoW and the EA. Within RoW, productivity growth, saving behavior, and reserve accumulation may be concentrated in specific economies (e.g., China), while absorption dynamics may be driven by others (e.g., the US), implying intra-RoW demand reallocation that our aggregate framework abstracts from. Within the EA, country-specific saving behavior, labor-market reforms, and housing cycles (most prominently in Germany and Southern Europe) have generated substantial intra-area imbalances alongside the area-wide productivity slowdown emphasized in this paper.

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