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)

February 15, 2026

Based on an estimated two-region dynamic general equilibrium model, we show that the persistent productivity growth differential between the Euro Area (EA) and rest of the world (RoW) has been a key driver of the EA trade surplus since the launch of the Euro. A secular decline in the EA's spending home bias and a trend decrease in relative EA import prices account for the stability of the EA real exchange rate, despite slower EA 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.

JEL Classification: F4, F3, E2, E3, and C5
Keywords: global growth divergences, trade balance, real exchange rate, estimated DSGE model, Euro Area, demand and supply shocks, trend growth shocks

(*) Corresponding author. Address: Prof. R. Kollmann, ECARES, Universite Libre de Bruxelles, 50 Av. Roosevelt, 1050 Brussels, Belgium, robert.kollmann@ulb.be. The views expressed in this paper are those of the authors and should not be attributed to the European Commission. For helpful comments and suggestions, we thank Günter Coenen, Lorenzo Forni, Géraldine Mahieu, Lukas Vogel, and workshop participants at Durham, Lancaster, Strasbourg and Rotterdam Universities, at JRC, the Franco-German Fiscal Policy Seminar, American Economic Association Meetings, North American Winter Meetings of the Econometric Society, and at the CEPR-JIE conference "Global Shocks, Macroeconomic Spillovers and Geopolitical Risks: Policy Challenges".

1. Introduction

Over the last decades, the Euro Area (EA) has exhibited persistently lower output and productivity growth than its global competitors, notably the United States and China. Since the launch of the Euro in 1999, average annual real GDP growth has been 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 into the medium and long term (IMF WEO, 2025).

Over the same period, the EA experienced a steady increase in trade openness vis-à-vis RoW, as measured by the ratio of extra-EA exports and imports divided by EA GDP. This EA foreign trade share rose from approximately 15% in 1999 to 30% in 2023. In contrast, the RoW trade share (EA–RoW trade relative to RoW GDP) remained broadly stable.

In striking contrast to the diverging EA and RoW growth trends, and to the trend in EA trade openness, the EA trade balance/GDP ratio and the EA real exchange rate (RER) have remained stable, and do not exhibit pronounced trends. Since the launch of the Euro, the EA has experienced a persistent trade balance (TB) surplus, averaging 2.6% of GDP.

Our paper's main contribution is to quantify the links between the EA-RoW growth differential, trade, and the RER. 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 EA and RoW data since the launch of the Euro. 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.[1] 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). In addition to permanent productivity and trade disturbances, the framework 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, with a wide array of shocks and transmission channels, is needed to isolate and quantify the role of permanent productivity and trade shocks, which are the central focus of our analysis. A more restrictive model, with fewer alternative disturbances, could risk overstating the macroeconomic role of the permanent productivity and trade shocks.

Our estimated model suggests that region-specific shocks to the productivity trend growth rate have been key drivers of the significant and prolonged GDP growth differential between the EA and RoW. These shocks have also been an important source of the persistent EA TB surplus, accounting for 1/4 to 1/2 of the EA TB, in most periods. We find that the EA TB and RER were driven more by RoW productivity shocks than by EA productivity shocks.

[1] Empirical support for this time series process for productivity can be found, among others, in Aguiar and Gopinath (2007) and Fernald et al. (2017).

A positive shock to the RoW productivity trend growth rate signals a steady future increase in the level of RoW productivity and GDP. In our estimated model, this boosts RoW consumption and investment demand, which triggers a sustained increase in the EA TB. The EA RER depreciates on impact, due to the rise in RoW absorption; however, over time, as the anticipated RoW productivity gains materialize, the EA RER appreciates. Qualitatively similar EA TB and EA RER responses are triggered by a *negative* shock to the EA productivity trend growth rate. When fed into our model, estimated RoW and EA productivity trend growth shocks induce an improvement in the EA TB, coupled with a trend appreciation of the EA RER.

Our results suggest that the observed long-term stability of the EA RER, despite the large and persistent productivity and output growth differential vis-à-vis RoW, primarily results from 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 RER stemming from the persistent positive RoW-EA productivity growth differential. In sum, productivity trend growth rate shocks alone cannot account for the joint dynamics of relative output, the TB, and the trendless RER. These findings underscore the importance of incorporating structural trade trends into a model of EA macroeconomic adjustment.

The literature on TB and RER 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 in-depth discussion of the U.S. TB). 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, 1992; Obstfeld and Rogoff, 1995). Our empirical findings underscore the importance of non-stationary shocks in shaping external adjustment.

The theoretical prediction that a country's TB improves in response to a positive foreign productivity trend growth shock is a feature of basic models with optimizing forward-looking agents (see Obstfeld and Rogoff, 1996, for a textbook treatment). A small number of previous studies have offered quantitative empirical analyses of this effect, but they relied on simpler models and differed in several key respects from the approach taken here. For example, Kollmann (1998) showed that a calibrated two-region RBC model with a widening productivity gap between the U.S. and the rest of the G7 can explain the rising U.S. trade deficit of the 1980s. Related explanations of the US TB deficit (in later sample periods) were provided by Engel and Rogers (2006), who used a model of endowment economies, and by Hoffmann et al. (2017), who estimated a two-country RBC model incorporating survey-based expectations of future growth.[2] In both models, a fully anticipated persistent rise in foreign growth induces a sharp but short-lived rise in the TB – a pattern driven by the immediate surge in foreign absorption. Both studies argue that this model-predicted front-loaded TB adjustment is at odds with the gradual TB dynamics observed in the data, and advocate models with imperfect information, in which agents gradually

[2] 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 TB and consumption in emerging market economies.

learn the persistence of productivity shocks—yielding a smoother TB response. By contrast, the present paper assumes full information regarding the persistence of growth shocks but introduces adjustment frictions in trade flows and aggregate spending (following, e.g., Auclert et al., 2024). We show that such real frictions generate gradual and persistent TB responses to productivity trend growth rate shocks, without the need to invoke imperfect information.

The present paper is also related to a growing literature that studies the macroeconomic effects of trade shocks. For example, 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 TB and induces a persistent RER 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 RER fluctuations at business-cycle frequencies, reducing the explanatory role of uncovered interest parity (UIP) shocks for RER dynamics. In contrast to these studies, 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.

The persistent EA TB surplus vis-à-vis RoW has received 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), Philippon and Martin (2017), Cardani et al. (2022)). These studies stress the role of resource misallocation (Fernandez-Villaverde and Ohanian (2015), Gopinath et al. (2017)) and of financial market imperfections (Kollmann et al. (2016), Kemal Ozhan (2019), Jaccard and Smets (2020)) for TB 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 (2024), 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 other studies have *estimated* multi-country DSGE models that match the scale and empirical richness of the model developed in the present paper. This aspect is central to our contribution. We use Bayesian methods, drawing on 37 time series on prices and quantities for EA and RoW. This setup allows us to test competing hypotheses on the drivers of the TB and RER and to assess their relative importance over time. Existing large-scale estimated models differ in both specification and focus. Coenen et al. (2018) examine the effect of EA productivity shocks in an estimated open economy DSGE model. In contrast to these authors, our framework incorporates persistent growth and trade shocks in *both* the EA and the RoW. Other estimated EA models emphasize cyclical financial shocks (Kollmann et al., 2016) or commodity price shocks (Giovannini et al., 2019), while Cardani et al. (2022, 2023) study output and inflation dynamics during the COVID-19

pandemic. None of these studies analyze the joint behavior of the TB and the RER within a unified framework that incorporates both permanent and transitory productivity and trade shocks.[3]

2. EA and RoW growth trends and macroeconomics 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 RER. 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.[4]

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.[5] 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 (YoY) 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 YoY growth rates of real GDP, over the period 1960–2023; see the solid blue and red lines, respectively. The dashed lines in Fig. 1 are Hodrick–Prescott (HP) trends of the YoY growth rates (smoothing parameter $\lambda = 400$); we use these HP trends as simple, heuristic indicators of the low-frequency (trend) components of EA and RoW growth.

In most years, the GDP growth rate was larger in RoW than in EA. The EA trend growth rate has declined steadily since the 1960s, from close to 6% p.a. to about 1%-1.5% p.a. after 2010. RoW trend growth also fell during the period 1960-90, from 6% to 3%, but rose slightly during the period 1990-2005, before gradually slowing thereafter.

---

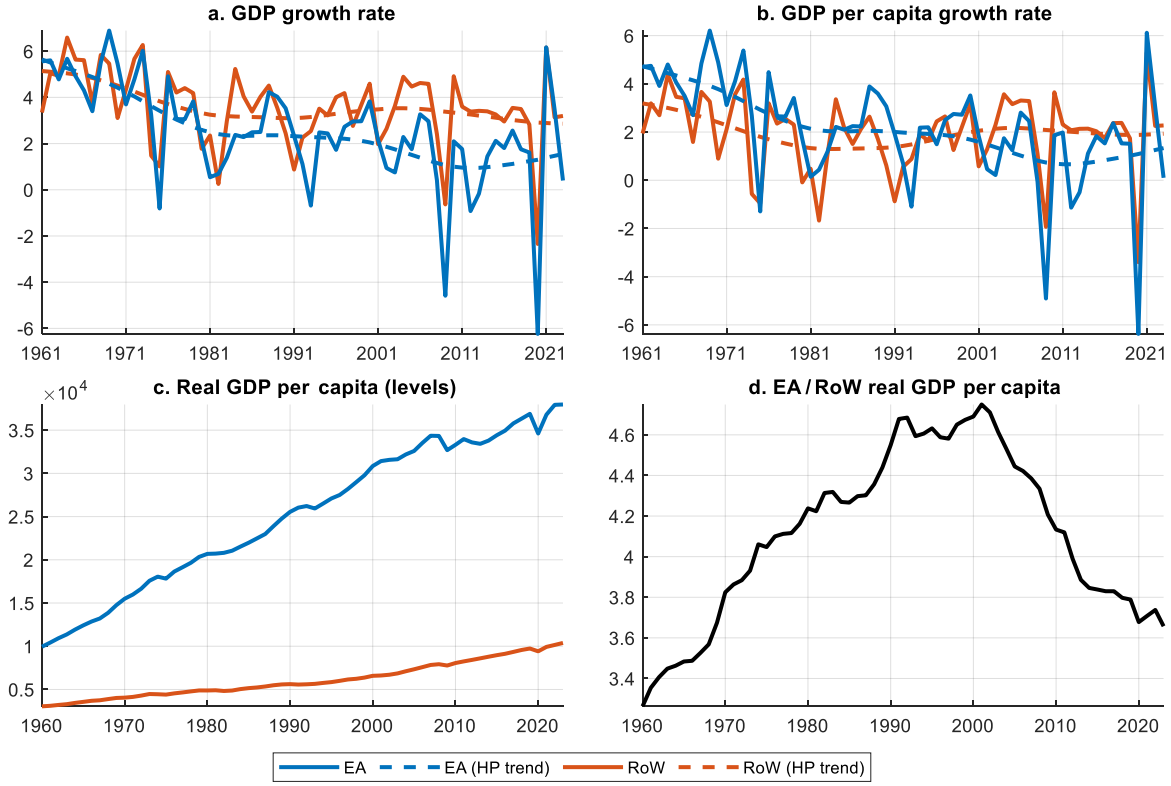
[3] Our framework builds on earlier work by authors of the present paper (see also the European Commission's Global-Multicountry Model (Albonico et al., 2019)), but differs considerably in both specification and research focus. For example, our paper embeds persistent growth-rate processes in both regions (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 wedges.

[4] Data source: World Bank Development Indicators (WDI). As of this writing, the WDI provides annual data for 1960-2023.

[5] 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. Data for EA members Croatia, Estonia, Latvia, Lithuania, Slovakia and Slovenia only begin in 1990, but have negligible impact on aggregate EA19 growth. In this Section, RoW is defined as the WDI 'world' minus EA. WDI world includes China, India, and other major emerging economies throughout (1960-2023), but former Communist countries are only included from 1989/1990. Maddison (2001) provides estimates of pre-1990 world GDP that include Communist countries. WDI and Maddison pre-1990 world growth series are very similar.

The higher average growth rate in RoW partly reflects faster population growth (1.6% in RoW vs 0.4% in EA on average, 1960-2023). Panel b of Fig. 1 shows the growth rate of per capita GDP, which serves as a crude proxy for aggregate productivity growth.[6] 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 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 GDP growth rates for the EA and RoW; Panel b shows year-on-year per capita GDP growth rates (%). Solid blue and red lines depict actual YoY growth for EA and RoW, respectively; dashed lines trace the Hodrick–Prescott (HP) trends. Panel c plots per capita real GDP in the EA and RoW, measured in units of 10^4 constant 2015 USD. Panel d presents the ratio of EA to RoW per capita real GDP.

Table 1 reports autocorrelations (lags 1 to 8) of EA–RoW GDP per capita growth differential over the period 1960–2023. The slow decay of the autocorrelogram indicates a high degree of persistence in the growth differential.

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

Table 1. Autocorrelations of EA-RoW GDP per capita growth differential (annual), 1960-2023

	k=1	*k=2*	*k=3*	*k=4*	*k=5*	*k=6*	*k=7*	*k=8*
Autocorr.	0.51	0.33	0.40	0.33	0.24	0.35	0.33	0.38

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. 1c, d). 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 36% (from 9.6 trillion constant USD (2015) to 13.1 tn USD) compared to 117% real GDP growth in RoW (from 3.6 tn USD to 7.9 tn USD). The EA population increased by 8% (from 325 million to 350 mn), while the RoW population grew by 33% (from 5.7 billion to 7.6 bn).[7]

2.2. EA-RoW trade and RER: 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-19 pandemic (2020).[8] 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 has been more modest; the ratio of RoW imports and exports (i.e., EA exports and imports) to RoW GDP rose before the global financial crisis (GFC), it then fell and stabilized at about 3% to 4%.

In striking contrast to the gap between EA and RoW growth trends, and to the trend in EA trade openness, the EA TB/GDP ratio has remained relatively stable. The EA has maintained a TB surplus every year since 1999, with an average surplus of 2.6% of EA GDP over 1999–2023. The TB/GDP ratio increased by nearly 2 percentage points during the European sovereign debt crisis and has remained elevated since, except in 2022 (Fig. 2c).

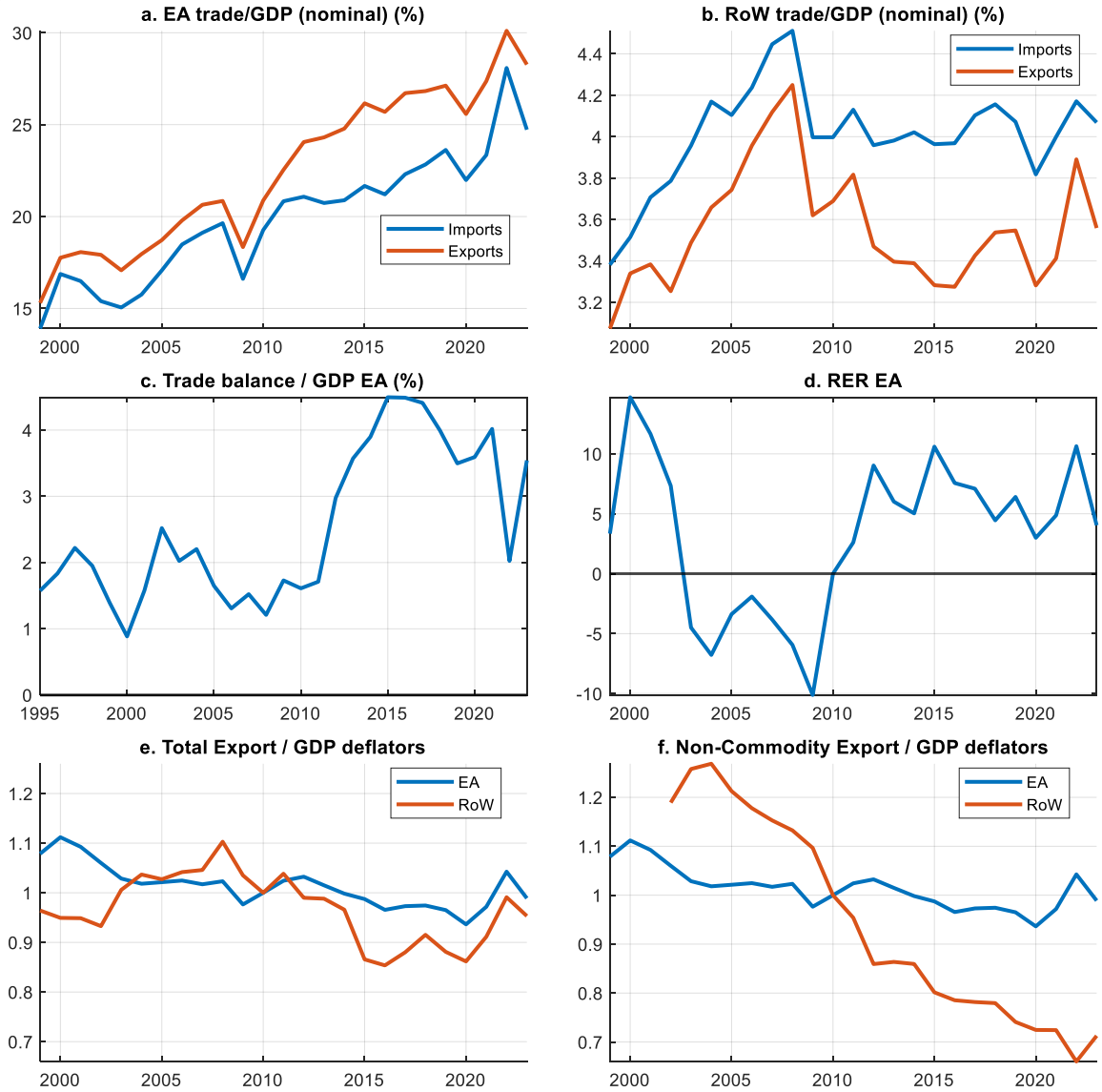
Fig. 2d plots the EA–RoW RER, expressed as a percentage deviation from its 2010 level. Throughout the paper, the RER is constructed using GDP deflators (rather than consumer price indices, due to limited CPI coverage for RoW). An increase in the RER represents a depreciation from the perspective of the EA. After the launch of the Euro, the EA RER initially depreciated (for about one year), and then appreciated by about 20%–25% until the GFC. Following the GFC, the RER depreciated by a similar magnitude and subsequently stabilized near the levels observed at the Euro's introduction. While the RER experienced substantial medium-term fluctuations, it thus displayed no clear trend over the full 1999–2023 period.

[7] Over the same period, the EA labor force expanded by 15% (from 149 mn to 172 mn), compared to a 36% rise in the RoW labor force (from 2.5 bn to 3.4 bn).

[8] 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.

That absence of a long-term RER trend stands in stark contrast to 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 RER trends are generally much more muted than those in relative (domestic/foreign) output.

Fig. 2. EA-RoW trade and RER 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 RER. Panel e: Total export deflators (goods & services) relative to GDP deflators. Panel f: Non-commodity export deflators relative to GDP deflators.

Despite the long-term stability of the EA RER, 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.[9] 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 suggests that productivity growth in RoW's non-commodity export sector has outpaced 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 long-run stability of the EA–RoW RER (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).

Guided by these empirical patterns, the theoretical model (next Section) includes a commodity-producing sector in RoW, and it allows for distinct stochastic productivity trends in non-commodity exporting sectors.

3. Model description

This Section presents our structural model. We focus here on the essential elements.[10] A full description is provided in the Not-for-Publication 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.

Overview. The model comprises two regions: EA and RoW. In each region, the engine of long-term GDP growth is technical progress in the intermediates 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. 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, with two exceptions: (i) RoW produces and exports commodities, whereas the EA does not; and (ii) owing to limited fiscal data for RoW, we abstract from modelling a RoW government, while the EA block includes fiscal variables.

[9] For example, the pre-GFC and post-Covid commodity price surges correspond to sharp increases in the RoW export deflator during those episodes.

[10] 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).

Apart from these differences, the EA and RoW blocks are structurally similar, although parameter values are allowed to differ across regions.

3.1. Exogenous variables

The model incorporates both non-stationary and stationary exogenous processes to capture dynamics at both trend and business-cycle frequencies. The log growth rate of non-stationary variables is modelled as the sum of two components: (i) a serially correlated AR(1) process; and (ii) a white noise disturbance capturing transitory deviations from the trend growth rate. For example, the growth rate of productivity A_t^q in sector q follows:

$$\ln(A_t^q) - \ln(A_{t-1}^q) = g_t^q + \eta_t^q, \tag{1}$$

with
$$g_t^q = \rho^q g_{t-1}^q + (1-\rho^q) g^q + \varepsilon_t^q, \;\; 0 < \rho^q < 1, \tag{2}$$

where η_t^q and ε_t^q are orthogonal *i.i.d.* white noise innovations. *We refer to* g_t^q *as the "trend growth rate" of* A_t^q *and to* ε_t^q *as a "trend growth rate shock";* η_t^q is referred to as a "transitory growth rate shock"; g^q is the growth "drift", i.e. the unconditional mean of the trend growth rate. [11]

Stationary exogenous variables are modeled as AR(1) processes in levels. A generic stationary forcing variable S_t obeys

$$S_t = \lambda \; S_{t-1} + \eta_t \,, \qquad \text{with } 0 \leq \lambda < 1, \tag{3}$$

where η_t is a white noise.

3.2. Multi-stage production

Production follows a multi-stage process. 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.

3.2.1. 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. The model assumes that a share of imports is re-exported, reflecting the EA's role in global value chains. Final good production functions for final good $D \in \{C, G, I, X\}$ are of the following CES (constant elasticity of substitution) form:

$$D_t = A_t^D \left(\left(1 - s_t^{M,D}\right)^{\frac{1}{\sigma_z}} O_t^{D\,\frac{\sigma_z - 1}{\sigma_z}} + \left(s_t^{M,D}\right)^{\frac{1}{\sigma_z}} M_t^{D\,\frac{\sigma_z - 1}{\sigma_z}} \right)^{\frac{\sigma_z}{\sigma_z - 1}} \tag{4}$$

[11] We also experimented with a specification for non-stationary forcing variables that consists of a stochastic trend T_t^q plus a stationary driver σ_t^q: $\ln(A_t^q) = T_t^q + \sigma_t^q$; $T_t^q - T_{t-1}^q \equiv g_t^q = \rho^q g_{t-1}^q + (1-\rho^q) g^q + \varepsilon_t^q$, with $0 < \rho^q < 1$, and $\sigma_t^q = \lambda^q \sigma_{t-1}^q + \eta_t^q$, with $0 \leq \lambda^q < 1$. Model estimation results under the more general specification for non-stationary forcing variables are similar to results based on (1)-(2). We find that, empirically, λ^q is close to unity. We thus focus on the more parsimonious process (1)–(2), which corresponds to the special case $\lambda^q = 1$.

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 determines 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.[12] Steady-state home bias differs across final goods, but stochastic shocks to home bias are common across final goods.

The final good deflator corresponding to (4) is

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

where P_t^O and P_t^M are price indices of domestic and imported intermediate inputs, respectively. Note that the technology shock A_t^D drives a wedge between the deflator of final good D and the prices of the inputs used to produce D.

Time-varying intermediate input elasticities. The estimated model enriches the final good technology (4) by including adjustment frictions. Following Auclert et al. (2024), we incorporate delayed substitution into intermediate input demand functions. Final good firms adjust their domestic and foreign inputs with probability $(1 - \rho^z)$ each period. With probability ρ^z, firms keep their input ratios fixed and adjust only total expenditure. This mechanism mirrors Calvo-style price-setting but applies to input composition: firms reset their inputs bundles based on current and expected future relative prices. As only a fraction $(1 - \rho^z)$ adjust each period, aggregate input ratios evolve gradually over time (see Not-for-Publication Appendix for details).

3.2.2. 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):

$$O_t = \left((1 - s_t^{is})^{1/\sigma_z}(Y_t)^{(\sigma_o - 1)/\sigma_o} + (s_t^{is})^{1/\sigma_o}(IS_t)^{(\sigma_o - 1)/\sigma_o}\right)^{\sigma_o/(\sigma_o - 1)},$$

with $\sigma_o > 0$. Perfectly competitive "packers" aggregate a continuum of differentiated local intermediates using a CES technology with substitution elasticity σ_y: $Y_t = \left[\int_0^1 Y_{i,t}^{\frac{\sigma_y - 1}{\sigma_y}} di\right]^{\frac{\sigma_y}{\sigma_y - 1}}$. [13]

The production function for intermediate good i is

$$Y_{i,t} = \left(A_t^Y N_{i,t}\right)^{\alpha}\left(cu_{i,t} K_{i,t-1}\right)^{1-\alpha}, \tag{5}$$

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.[14] The capital stock

[12] 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 use for model estimation (see Appendix).

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

[14] 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)).

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: $div_{i,t} = P_{i,t}Y_{i,t} - W_t N_{i,t} - P_t^K I_{i,t} - P_t \Gamma_{i,t}$, where $P_{i,t}$ is the firm's output price, P_t^K is the investment price, and $\Gamma_{i,t}$ summarizes nominal and real adjustment costs.[15] 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 rises 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 households' steady state subjective discount factor. The slope coefficient $\vartheta_i > 0$ depends on the degree of price rigidity.

3.2.3. Forcing processes in production sectors

Secular growth in real activity is assumed to originate from trend productivity growth in the intermediate goods sector (as mentioned above). Accordingly, we assume that $\ln(A_t^Y)$ (see (5)) follows a unit root process with positive drift (g^Y>0). As empirical import shares and the relative price of export goods (compared to the GDP deflator) too exhibit trends (see Sect. 2), we also allow for a unit root (but assume zero drift) in the foreign content parameters ($s_t^{M,D}$) of final good technology (see (4)), and in export sector productivity (A_t^X). [16] All other exogenous variables in the production process, and in other model blocks discussed below, follow stationary processes in levels.[17]

3.3. Households and unions

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]

---

[15]Real adjustment costs for investment, labor inputs, and capacity utilization follow standard quadratic forms, as described in the Not-for-publication Appendix.

[16] Kollmann (2019) and Bodenstein et al. (2024) develop DSGE models with stationary home-bias shocks affecting household consumption. By contrast, the present paper incorporates permanent home-bias shocks, allowing the model to capture the observed long-run trends in EA and RoW import shares. In addition, the shocks here are assumed to affect not only private consumption, but also government consumption, investment, and exports.

[17] Productivity in final consumption and investment good production (A_t^C, A_t^G, A_t^I; see (4)) is assumed to be stationary. Allowing for non-stationary processes for these productivity parameters does not affect the estimation results discussed below.

[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).

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.

3.3.1. 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 returns on stocks is equated (up to a linear approximation) to bond returns adjusted for an investment risk premium ε_t^S (reflecting convenience yields) that is assumed to follows an AR(1) process:

$$E_t\left(\frac{P_{t+1}^s + div_t}{P_t^s}\right) = 1 + r_t + \varepsilon_t^S, \tag{6}$$

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

3.3.2. Hand-to-mouth households

Hand-to-mouth households do not participate in asset markets. Their consumption equals disposable income each period: $(1+\tau^C)P_t C_t^h = (1-\tau^N)W_t N_t^h + T_t^h$.

3.3.3. Wage setting

A trade union transforms homogeneous labor hours supplied by the two domestic household types into imperfectly substitutable labor services. These differentiated services are sold to intermediate goods producers, who use a CES aggregator to combine them into the composite labor input N_t in their production function.

The trade union sets the wage as a mark-up μ_t^W over the marginal rate of substitution between leisure and consumption. This target wage mark-up is inversely related to the elasticity of substitution across labor varieties. Wage adjustment costs introduce frictions into wage setting, causing the wage mark-up to fluctuate.

Following Blanchard and Gali (2007), we incorporate real wage inertia by modeling the current-period real wage as a weighted average of the union's desired wage and last period's real wage.

[19] For a micro foundation, see Fisher (2015). Cardani et al. (2023) apply a similar approach to a model of the US economy. See also the Not-for-publication Appendix.

[20] We also allow for exogenous fluctuations in government bond premia.

The real wage equation is: $\frac{W_t}{P_t} = ((1+\mu_t^W) * mrs_t)^{1-\gamma^{wr}} \left(\frac{W_{t-1}}{P_{t-1}}\right)^{\gamma^{wr}}$, where mrs_t is the (weighted) marginal rate of substitution between consumption and leisure across households, and $\gamma^{wr} \in (0,1)$ governs the degree of wage rigidity. Real wage inertia helps the model replicate the persistence of employment fluctuations observed in the data.

3.4. Monetary policy

The monetary policy (nominal) interest rate i_t is set at date *t* by the central bank according to the interest rate feedback rule

$$i_t = (1-\rho^i)\bar{i} + \rho^i i_t + (1-\rho^i)\{\eta^\pi [ln(P_t^C/P_{t-4}^C) - \pi] + \eta^Y [ln(Y_t/Y_{t-1}) - g^Y]\} + \varepsilon_t^i,$$

where π is the steady state inflation rate; $0 \leq \rho^i < 1$ is an interest rate smoothing parameter; η^π and η^Y are policy response coefficient to CPI inflation and to GDP growth; ε_t^i is a white noise policy shock.

3.5. International financial markets

The only internationally traded asset is a one-period bond denominated in RoW currency. Ricardian households face a quadratic cost when their net foreign bond holdings, relative to nominal GDP, deviate from a predetermined target (these costs are rebated to households as lump-sum transfers). As a result, the interest rate spread between domestic and foreign assets depends on the level of foreign bond holdings, consistent with the framework in Kollmann (2002, 2004, 2005) and Itskhoki and Mukhin (2021).

The Ricardian household's first-order conditions for domestic and foreign bonds yield the following uncovered interest parity (UIP) condition (up to a linear approximation):

$$1 + i_{EA,t} = (1 + i_{RoW,t}) \frac{E_t(\mathcal{E}_{t+1})}{\mathcal{E}_t} exp\left[\alpha^{BW}\left(\frac{NFA_t}{P_t^Y Y_t} - \overline{b^*}\right) + \varepsilon_t^{BW}\right], \quad (7)$$

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. $\frac{NFA_t}{P_t^Y Y_t}$ is the EA's net foreign bond position normalized by nominal GDP; $\overline{b^*}$ denotes the target level of foreign bond holdings. α^{BW} indexes the curvature of the bond-holding cost (and the degree of international bond market integration). ε_t^{BW} is a serially correlated UIP shock that represents an exogenous shift in the marginal cost of holding foreign bonds. (Departures from interest parity are also induced by the endogenous term on the right-hand side of (7) that depends on NFA; according to the estimated model, that term fluctuates less than ε_t^{BW}.)

Total net foreign assets (NFA) evolve as:

$$NFA_{EA,t} = (1 + i_{RoW,t}) NFA_{EA,t-1} + TB_{EA,t} + \varepsilon_{EA,t}^{NFA} \quad (8)$$

where $\varepsilon_{EA,t}^{NFA}$ represents international remittances and other income transfers (this variable is treated as exogenous; it is needed to reconcile the empirical NFA and TB series used as observables in model estimation).

3.6. Region-specific features

3.6.1. RoW commodity supply

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

3.6.2. EA fiscal policy

We model EA fiscal variables using simple government decision rules. EA real government consumption, G_t, is set according to the rule $c_t^G = \overline{c^G} + \varepsilon_t^G$, where $c_t^G \equiv P_t G_t / \left(P_t^y Y_t^{pot}\right)$ is government consumption normalized by domestic potential output (with steady state $\overline{c^G}$); ε_t^G is a serially correlated exogenous variable. Government investment and transfers follow similar policy rules. Government investment builds a public capital stock, which enters private sector production (see the Not-for-Publication Appendix for details). Lump-sum taxes follow a feedback rule that links them to the government budget deficit and public debt levels.

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 the Rest of the World (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.[21] The observables employed in estimation together with details on data construction are presented in Appendix B.

4.2. Calibration

We assume that steady-state growth rates of intermediate goods productivity and the steady state population growth rate are common across the two regions. This assumption implies a common steady-state trend growth rate for GDP per capita across the EA and RoW. It also ensures the existence of a balanced growth path, and is 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). 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. We calibrate the steady-state annual growth rates of population (at 0.34%), but we estimate the steady state productivity growth rate. 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 EA in world GDP at 18% while the foreign trade/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. al. (2016)), we set the subjective rate of time preferences at 0.25% per quarter; the share of Ricardian households is set to 2/3 for both regions. The steady-state government debt/GDP and fiscal deficit/GDP ratios are set to 77% (annual terms) and 3%, respectively. We report the full list of calibrated parameters in the Appendix (Table C3).

4.3. Model solution and approximation

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*

[21] The RoW dataset aggregates data from 57 countries.

deviations of GDP and spending from the deterministic balanced growth path, while preserving the stationarity of the growth rates of all variables. The Appendix details the stationarization technique, and compares linearized and nonlinear model versions.[22]

4.4 Estimation procedure

We use a Bayesian Maximum Likelihood estimation method to estimate the model parameters. The estimation uses all variables in levels. The global steady state growth rate of intermediate good productivity is estimated jointly with other model parameters (as mentioned above).

To account for the sharp contraction in economic activity during the Covid pandemic, we follow Cardani et al. (2022, 2023) and assume pandemic-specific heteroskedastic shocks.[23] These pandemic 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 model-predicted business cycle statistics, impulse response functions and historical shock decompositions.

5.1. Posterior parameter estimates

Table 2 reports estimates of the key parameters driving the persistent processes central to our analysis; the full list of estimated parameters is provided in Appendix C. The estimated steady-state annual global growth rate of output is 1.76%. 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-home bias trend growth rates (parameter ρ^q in (2)) is high in both regions, between 0.93 and 0.99. This enables the model to capture the persistent cross-region trend growth differences and the import share trends observed in the data.[24] By contrast, the persistence of the export sector productivity trend growth rates is lower, around 0.65.

Fig. 3 displays smoothed estimates of intermediate goods productivity trend growth rates (quarterly). 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 shocks until the

[22] The analysis confirms that the linear approximation provides an accurate representation of both simulated dynamics and impulse responses, including those triggered by permanent shocks, with relatively small approximation errors arising during the COVID period due to the magnitude and nature of the shocks.

[23] All our results are robust to excluding the Covid pandemic from the estimation sample.

[24] We have also estimated a model version in which home-bias shocks are assumed stationary. This yields a significantly lower marginal likelihood (log data density: 10851) than the baseline model with permanent home-bias shocks (log data density: 10864), indicating that the data strongly supports permanent home-bias shocks.

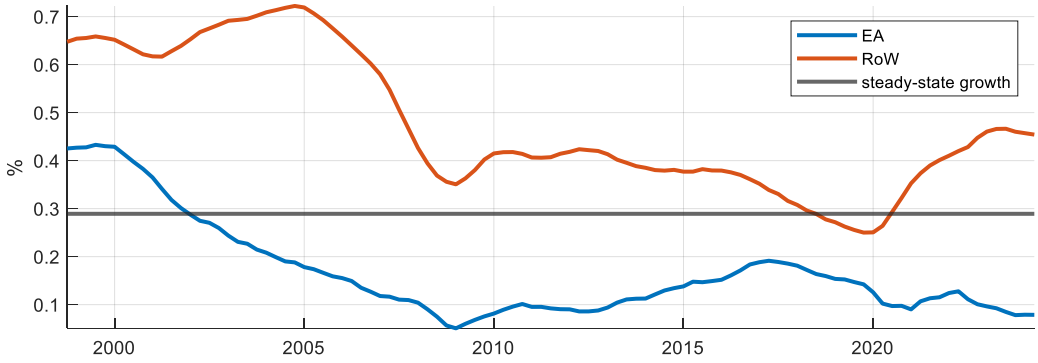
global financial crisis. These opposing dynamics led to a widening productivity gap between the RoW and the EA until around 2005. The gap then narrowed before diverging again after 2019.

Turning to the other parameters presented in Appendix C, the estimation indicates a relatively high degree of habits in consumption for EA (0.84) and RoW (0.66), trade elasticities in line with standard empirical estimates (2.6/1.8 for EA/RoW), higher risk aversion coefficient for EA (1.5) compared to RoW (1.3), nominal rigidities for EA in line with previous studies and similar degrees of real wage rigidities.

Table 2. Key Estimated parameters

Description	Prior type	Prior Mean	Prior Std.	Posterior Mode	Posterior Std.
Persistence intermed. productiv. trend growth E/	Beta	0.85	0.1	0.99	0.012
Persistence intermd.productiv. trend growth RoW	Beta	0.85	0.1	0.98	0.005
Persistence foreign content trend growth EA	Beta	0.85	0.1	0.94	0.072
Persistence foreign content trend growth RoW	Beta	0.85	0.1	0.93	0.106
Persist. export sect trend productiv. growth EA	Beta	0.85	0.1	0.64	0.060
Persist. export sect trend productiv. growth RoW	Beta	0.85	0.1	0.66	0.039
Std. technology trend growth shocks EA (%)	Gamma	0.03	0.002	0.03	0.002
Std. technology trend growth shock RoW (%)	Gamma	0.03	0.002	0.03	0.002
Std. foreign content growth shock EA (%)	Gamma	0.05	0.02	0.05	0.021
Std. foreign content growth shock RoW (%)	Gamma	0.05	0.02	0.05	0.022
Std. export sect. productiv. growth shock EA (%)	Gamma	0.10	0.04	0.5	0.041
Std. export sect. productiv. growth shock RoW(%	Gamma	0.10	0.04	0.59	0.011
Std. transitory technology shocks EA (%)	Gamma	0.1	0.01	0.09	0.009
Std. transitory technology shocks RoW (%)	Gamma	0.1	0.01	0.11	0.011
Steady-state GDP quarterly growth rate (%)	Beta	0.4	0.04	0.44	0.017

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



5.2. Model-predicted and historical business cycle statistics

We report key simulated moments and compare them with their empirical counterparts to assess the model's ability to replicate salient features of the data. The model reproduces well the main patterns in observed volatilities and co-movements of key macroeconomic variables. Notably, it captures the weak empirical international correlation of GDP growth rates and generates a RER that is roughly twice as volatile as GDP. It also matches the low correlation between the consumption growth differential and RER growth (consumption – real exchange rate disconnect; Kollmann, 1991, 1995; Backus and Smith, 1993).

Table 3. Data and model moments

Moments	**EA**		**RoW**	
	data	model	data	model
Volatility				
$\boldsymbol{std}(\Delta \boldsymbol{c})/\boldsymbol{std}(\Delta \boldsymbol{y})$	0.68	0.81	0.73	0.76
$\boldsymbol{std}(\Delta \boldsymbol{inv})/\boldsymbol{std}(\Delta \boldsymbol{y})$	3.02	3.47	2.29	3.49
Domestic correlations				
$\boldsymbol{corr}(\Delta \boldsymbol{y}, \Delta \boldsymbol{c})$	0.74	0.57	0.88	0.53
$\boldsymbol{corr}(\Delta \boldsymbol{y}, \Delta \boldsymbol{inv})$	0.81	0.63	0.88	0.78
International statistics				
$\boldsymbol{corr}(\Delta \boldsymbol{y}^{\boldsymbol{EA}}, \Delta \boldsymbol{y}^{\boldsymbol{ROW}})$	0.39	0.23		
$\boldsymbol{corr}(\Delta \mathcal{E}^{\boldsymbol{EA}}, \Delta \boldsymbol{RER}^{\boldsymbol{EA}}))$	0.95	0.69		
$\boldsymbol{corr}(\Delta \boldsymbol{TBY}^{\boldsymbol{EA}}, \Delta \boldsymbol{RER}^{\boldsymbol{EA}})$	-0.20	-0.11		
$\boldsymbol{corr}(\Delta \boldsymbol{c}^{\boldsymbol{EA}} - \Delta \boldsymbol{c}^{\boldsymbol{ROW}}, \Delta \boldsymbol{RER}^{\boldsymbol{EA}})$	-0.06	-0.016		
$\boldsymbol{std}(\Delta \boldsymbol{RER}^{\boldsymbol{EA}})/\boldsymbol{std}(\Delta \boldsymbol{y}^{\boldsymbol{EA}})$	2.60	2.19		
$\boldsymbol{std}((\Delta \boldsymbol{RER}^{\boldsymbol{EA}})/\Delta \boldsymbol{E}^{\boldsymbol{EA}})$	1.00	0.90		

Note:Statistics are computed at annual frequency; data moments are computed for the sample 1999-2019 while model moments are computed as mean across 1000 simulations of the same length as the sample using the covariance matrix of the smoothed shocks, excluding the exceptionally large shocks of the COVID period.

5.3. Impulse responses

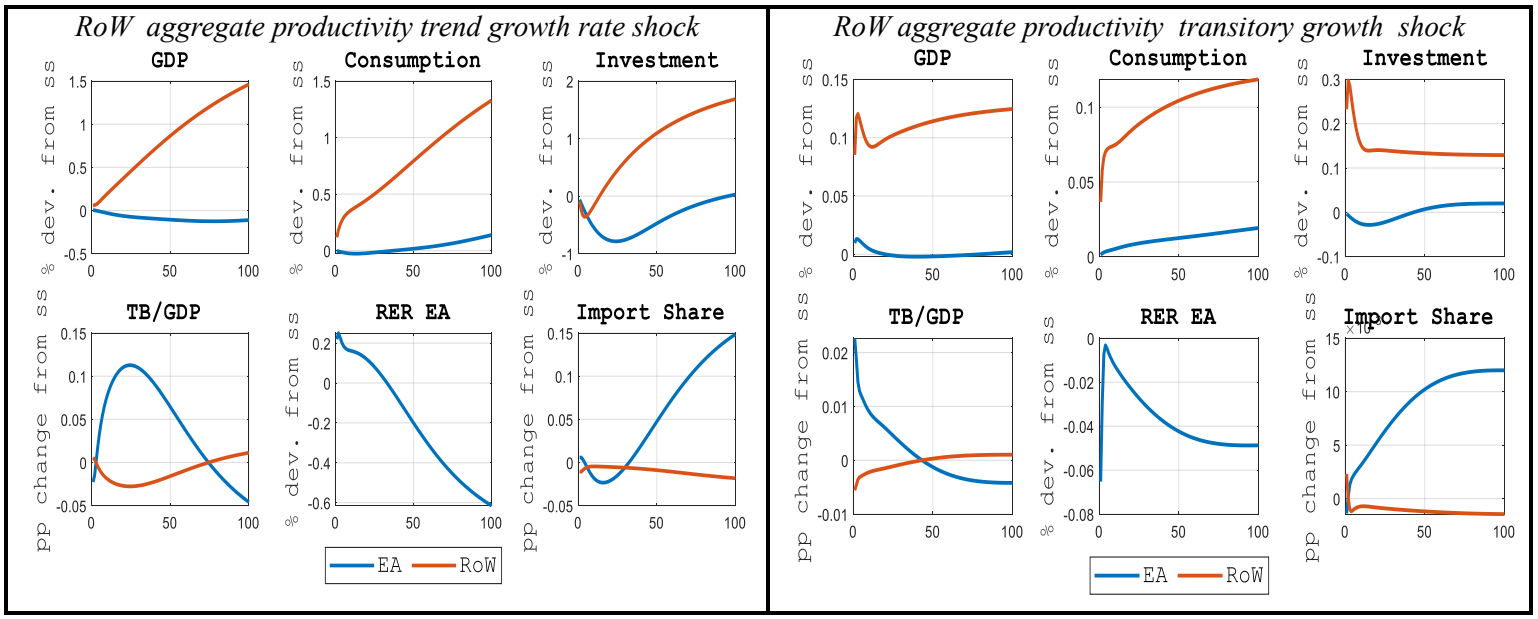
This Section presents responses of endogenous variables to key technology, trade, and aggregate demand shocks, to illustrate the model's dynamics, given estimated parameters. For each shock, we examine its role in explaining key empirical patterns, specifically, the joint behavior of GDP, TB and RER.

The left panel of Fig. 4 shows dynamic responses to an ***intermediate goods productivity trend growth rate shock in RoW.*** [25] The shock raises RoW productivity and GDP, on impact. This is followed by strong and long-lasting future productivity and GDP increases, due to the high autocorrelation of the RoW productivity trend growth rate (0.98). Fig. 4 shows that this strongly boosts RoW consumption, on impact, as RoW Ricardian households consume more, in response to their increased permanent income. The rise in RoW aggregate demand boosts the EA TB, and it crowds out EA consumption and investment, which causes a persistent decline in EA GDP. The strong immediate boost to RoW absorption also improves the RoW terms of trade, and it

[25] This is a shock ε_t^q in the process of format see (1),(2) for the RoW counterpart of A_t^Y in EA (see (5)).

appreciates the RoW RER, i.e. the EA RER depreciates, on impact. After the impact depreciation, the EA RER shows a sustained appreciation trend.[26] Over the longer term, when the anticipated higher RoW productivity and output materializes, EA consumption and investment rise above pre-shock levels, the EA TB falls below its pre-shock level. Note, however that this EA TB reversal occurs only about 70 quarters after the RoW productivity growth rate shock. In other terms, a positive RoW productivity growth rate shock triggers a very persistent EA TB improvement. This extended TB response is driven by a very gradual adjustment of EA absorption. As mentioned above, the model assumes real frictions that delay the adjustment of consumption and investment to shocks (those frictions are estimated alongside the other model parameters). Below we show that model versions that do not feature those adjustment frictions predict a much more front-loaded TB adjustment to a productivity trend growth rate shock (Sect. 6).

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



Notes: The shock size corresponds one estimated standard deviation of the exogenous innovation. Periods correspond to quarters. An upward movement of the RER indicates a depreciation from the EA viewpoint.

In sum, the RoW productivity trend growth shock generates a persistently positive EA TB response but implies a long-lasting appreciation of the EA RER. In the long term, the shock raises 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 RoW productivity trend growth shocks have the potential to explain the persistent EA TB surplus observed since the launch of the Euro, those shocks alone fail to account for the absence of a secular trend in the RER and the secular rise in the EA import share.

[26]The RoW productivity growth rate shock raises the real interest rate in both regions--during the adjustment, the RoW real interest rate exceeds the EA rate, which also helps to understand the sustained appreciation trend of the EA RER, *after* the shock.

It is insightful to contrast the RoW productivity trend growth rate shock to ***transitory productivity growth rate shock*** in the RoW intermediate goods sector;[27] see right panel in Fig. 4. While a productivity trend growth rate shock induces a sharp immediate increase in RoW absorption (see above), the transitory growth rate shock induces a much more muted response of RoW absorption that more closely tracks RoW GDP. Consequently, the transitory growth rate shock has only negligible effects on the TB. Initially, the EA RER appreciates, and the EA TB improves.

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. (4) for sector $D = X$)). 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); we assume that the shock increases the parameter $s_t^{M,D}$ (see (4)) by the same relative amount in the EA production functions of all final good types, C, I, G, X.

The ***RoW export sector productivity trend growth shock*** raises RoW GDP. Simultaneously, the EA benefits from lower prices for imported consumption and investment goods. Unlike the productivity trend growth shock in the RoW *intermediate* goods sector, the RoW exports sector shock generates synchronized GDP responses across regions. By reducing EA import prices, the RoW export shock reduces EA inflation, and triggers a persistent depreciation of the EA RER. In the short to medium run, cheaper EA imports also raise the EA import share and it worsens the EA TB.

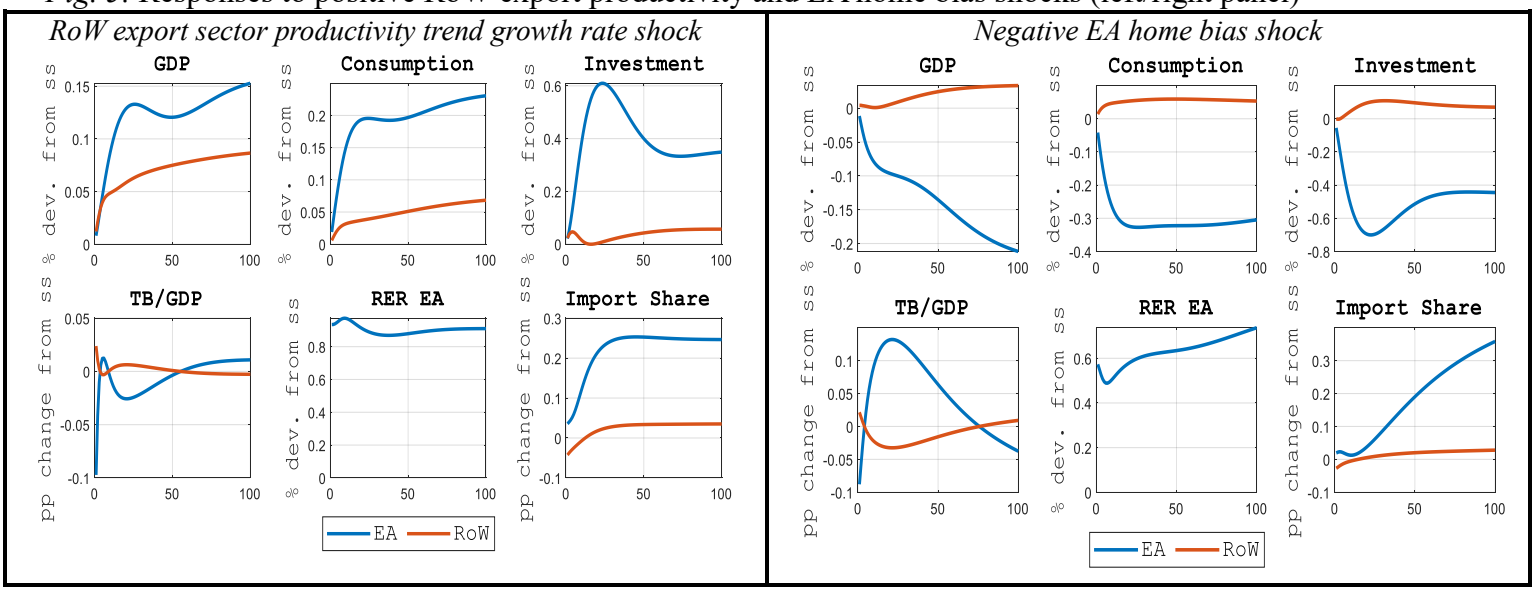
Similarly, the ***permanent negative shock to EA home bias*** triggers a gradual rise in the EA import share. The resulting decline in relative demand for EA intermediates lowers EA GDP, consumption and investment, while boosting foreign output. The shift in EA demand toward imports also drives a depreciation of the EA RER and an initial deterioration in the EA TB. Over time, the TB improves, as households anticipate higher future import spending and therefore save more.

We conclude the discussion of impulse responses by considering two shocks originating in the EA: an **EA intermediate goods productivity trend growth rate shock** (left panel of Fig. 6) and a positive (transitory) shock to the **EA investment risk premium** (right panel).

The effects of a positive ***EA intermediate goods productivity trend growth rate shock*** largely mirror those of the RoW productivity trend growth rate shock considered in Fig. 4 (left panel). EA GDP rises, while the EA TB declines persistently. Thus, a *negative* EA productivity trend growth shock is predicted to improve the EA TB persistently.

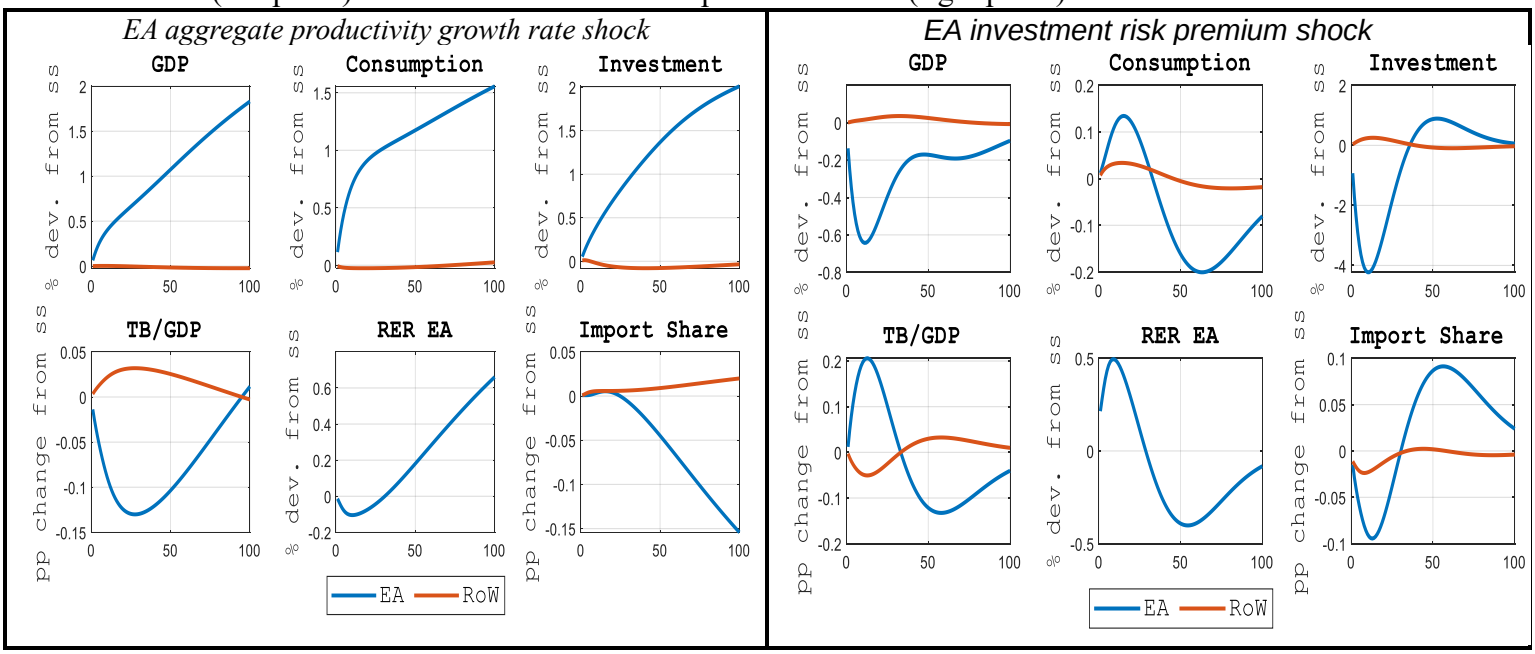
[27] I.e. a shock η_t^q of RoW intermediates productivity (see (1)).

Fig. 5. Responses to positive RoW export productivity and EA home bias shocks (left/right panel)



Notes: The shock size corresponds one estimated standard deviation of the exogenous innovation. Periods correspond to quarters. An upward movement of the RER indicates a depreciation from the EA viewpoint.

Fig. 6. Dynamic responses to aggregate (intermediate goods) productivity trend growth rate shock in EA (left panel) and to EA investment risk premium shock (right panel)



Notes: The shock size corresponds one estimated standard deviation of the exogenous innovation. Periods correspond to quarters. An upward movement of the RER indicates a depreciation from the EA viewpoint.

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 (6)) played a key role in driving EA real activity around the time of the global financial crisis. An investment risk premium

shock drives a wedge between the marginal product of capital and the interest rate earned by savers (see (6)). Fig. 6 (right panel) shows that a positive ***EA investment risk premium shock*** reduces EA investment and output, improves the EA TB, and leads to a depreciation of the RER, on impact. In the short and medium term, the shock triggers an EA TB responses 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 RER. Additionally, as a contractionary demand shock, it initially lower the EA import share.

Summary of main insights from shock responses. The dynamic responses suggest that a combination of positive RoW intermediate goods productivity trend growth rate shocks and of negative EA productivity trend growth rate shocks can jointly account for two key empirical patterns: (i) the persistent deviation between RoW and EA output growth trends and (ii) the persistent increase in the EA TB. However, these shocks also predict a trend appreciation of the EA RER, a trend not observed in the historical data since the launch of the Euro. This discrepancy implies that, in the data, intermediate goods productivity trend growth rate shocks must have been offset by other shocks that stabilized the RER.

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 RER. 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. [28]

Adverse EA aggregate demand shocks, such as the investment risk premium shock in Fig. 6, are other possible drivers of the EA TB surplus. However, their impact on the EA TB is less long-lasting, and they do not explain the long-term increase in the EA import share.

In sum, the dynamic shock responses indicate that a combination of persistent supply-side shocks, both domestic and external, combined with structural trade shocks might jointly account for the evolution of EA output, TB, RER, and import share dynamics since the launch of the Euro. The next Section turns to the historical shock decompositions to assess the empirical relevance of these mechanisms over time.

5.4. Historical shock decompositions

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

The discussion here focuses on SDs of *quarterly* time series of EA log real GDP, EA TB/GDP and log RER. SDs of other variables are reported in Appendix A.[29] In each Figure, the thick black line shows the historical time series of a variable, in deviation from its deterministic trend (i.e. the balanced growth path it would have followed absent any stochastic shocks). For example, a value

[28] The predicted effects of the trade shocks are statistically significant when accounting for posterior parameter uncertainty (see Fig. F3-F5 in Appendix F), supporting their empirical relevance.

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

of -0.1 in the SD 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 TB is zero. The steady-state RER is normalized at unity.)

In each sub-plot of the SD Figures, the black area display the contribution of a specific shock (or group of shocks), while the grey area shows the contribution of all remaining shocks. Black or grey areas above the abscissa (horizontal axis) represent positive shock contributions, while areas below the abscissa 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 technology EA"); (2) productivity trend growth rate shocks in the RoW intermediate goods sector ("Trend technology 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); (5) other RoW aggregate supply shocks; (6) RoW aggregate demand shocks; (7) EA home bias shocks; (8) RoW home bias shocks; (9) productivity trend growth shocks in EA and RoW export sectors ("Export sector productivity shocks"); (10) shocks to EA and RoW monetary and fiscal policy rules ("Policy"); (11) international financial market shocks (UIP shocks and international transfer (NFA) shocks); (12) all remaining shocks (including RoW commodity shocks) and initial conditions.

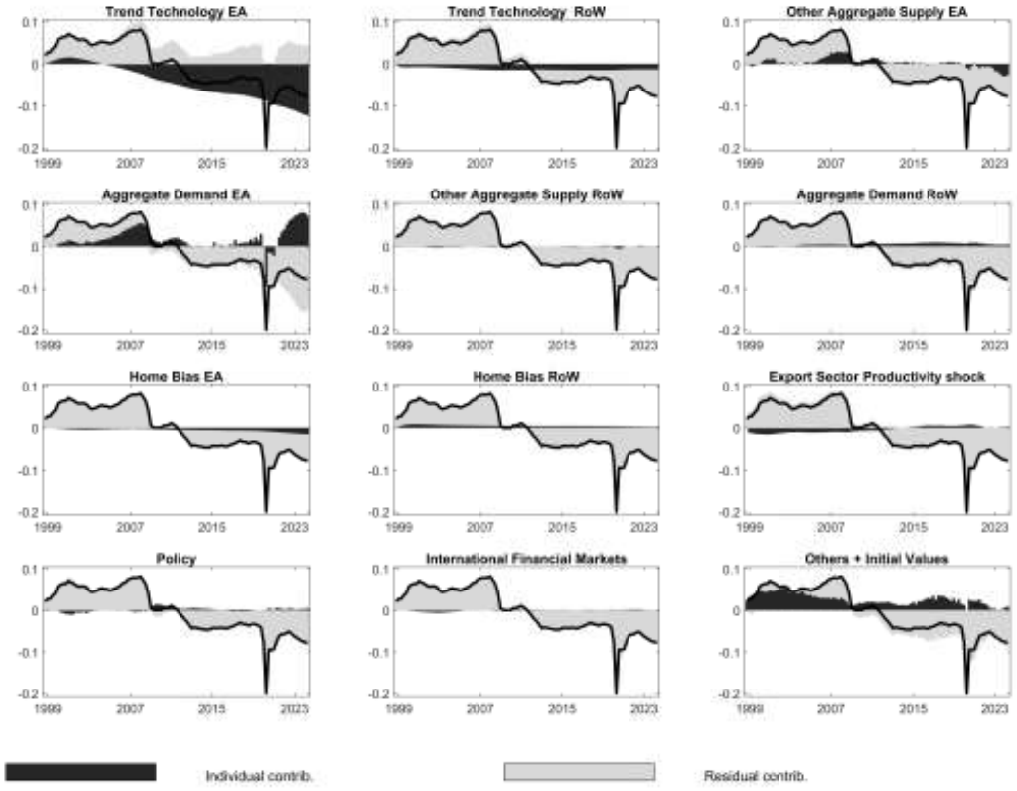
5.4.1 Historical shock decomposition of EA GDP (Fig.7)

Fig. 7 shows that, according to the model estimates, weak EA GDP growth was primarily driven by negative EA productivity trend growth shocks. Positive RoW productivity trend growth shocks had a small but noticeable negative on EA GDP, by inducing capital outflows from the EA, and depressing EA investment. From 2015 onward, a 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 by stimulating EA investment. [30]

Cyclical fluctuations in EA GDP were shaped mainly by EA aggregate demand shocks (especially by investment risk premium shocks), and by "Other aggregate supply EA" shocks. Falling investment risk premia contributed to the EA GDP expansion before the global financial crisis (GFC), while a rise in investment risk premia during the GFC, was a key driver of the (post-)GFC 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 to wage markups) supported activity before 2008, their contribution turned negative toward the end of the sample. Fiscal and monetary policy shocks (deviations from estimated policy rules) were broadly neutral, with limited stabilizing effects.

[30] 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).

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



The same forces that shaped EA GDP dynamics also drove the evolution of EA consumption and investment (Appendix, Fig. A2). Overall, the results here indicate that domestic shocks were the dominant source of fluctuations in EA GDP and final demand components.

RoW GDP dynamics (Appendix, Fig. A3) were likewise primarily determined by domestic shocks—most notably RoW productivity trend growth 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.

5.4.2 Historical shock decompositions of EA trade balance/GDP ratio and EA RER (Fig. 8)
Panel a) of Fig. 8 shows that positive RoW intermediate sectors' trend productivity growth rate shocks were a major contributor to the EA's TB surplus at the start of the sample (see subplot "Trend Technology RoW"). Adverse EA intermediate goods trend productivity growth shocks exerting sustained upward pressure on the EA TB by compressing absorption relative to output. Intermediate sector productivity trend growth shocks in both regions thus emerge as key drivers of the enduring EA TB surplus, jointly accounting for roughly 1/4 to 1/2 of the EA TB surplus in most periods.

Positive RoW export sector productivity shocks, by contrast, had a persistent negative effect on the EA TB, as their impact on EA absorption via cheaper EA imports outweighed their support to EA supply. However, this effect was weaker than that of the intermediate goods trend productivity

growth rate shocks. Other aggregate supply shocks (such as markup shocks), in both EA and RoW, played only a minor role for the TB.

EA and RoW aggregate demand shocks had a noticeable, but more cyclical impact on the TB. Before the GFC, positive EA aggregate demand shocks (see discussion above) depressed the EA TB by up to 1.5% of EA GDP. After the GFC, weaker EA aggregate demand had a gradually more positive effect on the EA TB, with a marked increase during the COVID-19 recession. RoW aggregate demand shocks induced smaller and more short-lived effects on the EA TB. Fiscal and monetary policy shocks in both regions had a negligible influence on the TB overall, though they mattered modestly in some episodes. Over the full sample, EA and RoW aggregate demand shocks made an average net contribution to the EA TB that was close to zero.

Finally, international financial markets shocks (interest parity disturbances and international transfer shocks) made a persistent and positive contribution to the TB, especially after 2010.[31] The secular decrease in EA goods home bias too had a small but discernible positive impact on the EA TB.

Panel (b) of Fig. 8 presents the historical decomposition of the EA RER. The EA and RoW productivity trend growth shocks exerted appreciation pressure on the RER, while the long-run decline in EA goods home bias pushed in the opposite direction, especially after the GFC. Home bias shocks influenced the EA RER more strongly than the EA TB. In addition, persistent productivity shocks in the export sector—more pronounced in the RoW than in the EA—also exerted trend depreciation pressure on the EA RER, and thereby helped offset the trend appreciation induced by the EA and RoW intermediate goods productivity trend growth shocks.

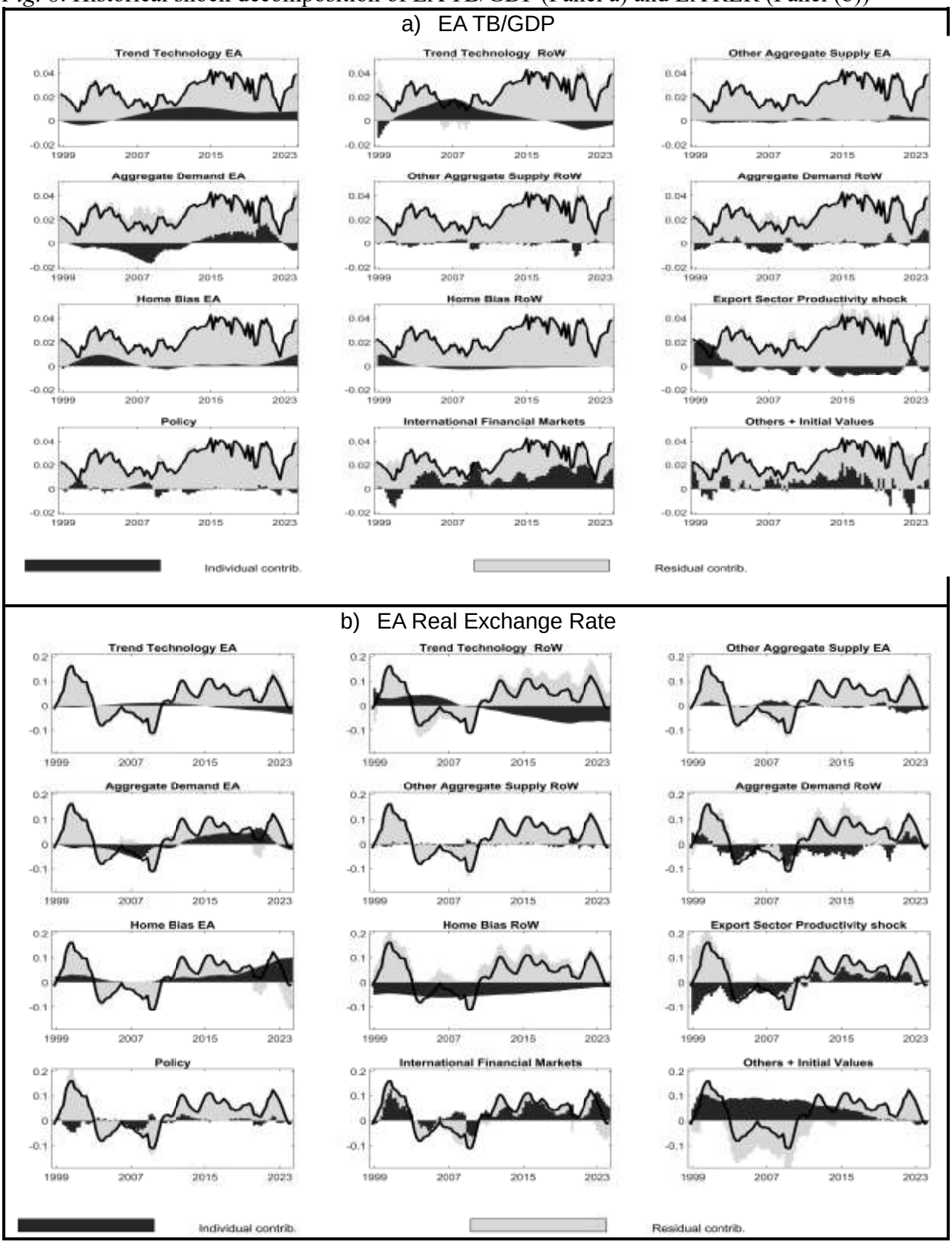
Other shocks too had noticeable effects on the RER, but those effects mainly operated at a short- to medium-term frequency, and thus did not affect the RER trend. This holds, for example, for EA and RoW aggregate demand shocks. Positive EA aggregate demand shocks contributed to the EA RER appreciation in the run-up to the GFC (and supported EA GDP, see above), with peak effects exceeding 5 percent. The collapse in EA aggregate demand during the GFC induced RER depreciation. Persistent RoW aggregate demand weakness after the GFC (see above) also contributed to the weaker EA RER in the post-GFC period, though without inducing a sustained RER trend.

As for the EA TB, international financial market shocks accounted for a sizable share of short-run RER fluctuations. Other factors, including "other supply disturbances" (e.g., mark-up shocks) and policy shocks, made only modest contributions to RER movements.

Taken together, the different forces largely offset each other on average, helping to explain the overall stability of the EA RER since the launch of the Euro, despite notable shorter-term fluctuations.

[31] The mean contribution of "international financial markets" shocks to the EA TB is positive, reflecting systematic net transfers from the EA to the RoW (including government development aid and private remittances). High-frequency EA TB fluctuations induced by "international financial markets" shocks mainly reflect UIP shocks.

Fig. 8. Historical shock decomposition of EA TB/GDP (Panel a) and EA RER (Panel (b))



Filtered shock estimates and parameter uncertainty. Appendix D presents SDs 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) reported in Fig. 7 and 8. This is particularly relevant given the presence of several large persistent shocks in our sample, which could cause filtered and smoothed shock estimates to diverge and thus affect SDs. However, Fig. D1 and D2 in the Appendix show that our main results are robust to using filtered shocks. In addition, Appendix F quantifies the role of model parameter estimation uncertainty for SDs. Accounting for parameter uncertainty preserves our main insights, although the contribution of home bias shocks is more uncertain than that of other groups.

6. Gradual trade balance adjustment to productivity trend growth rate shocks

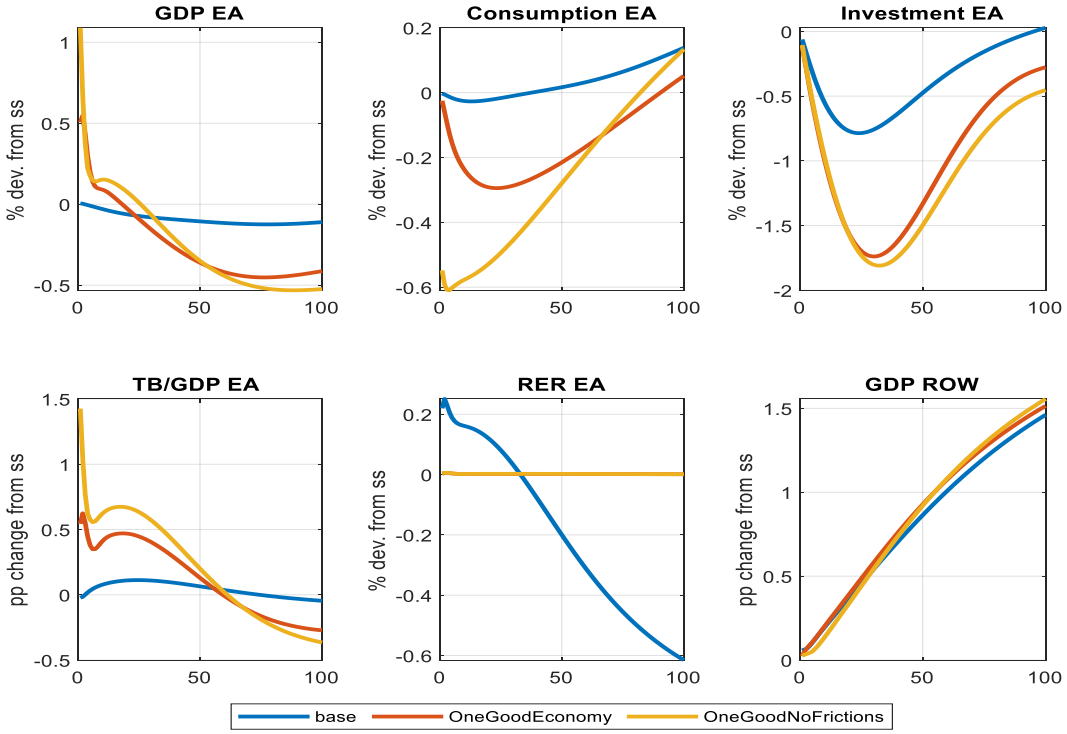
This Section further investigates the mechanism through which a persistent productivity growth rate shock affects the TB. In the estimated model, such a shock—despite inducing a large and persistent divergence between domestic and foreign GDP—generates only a gradual and relatively muted TB response. This contrasts with the results of Hoffmann et al. (2019), whose theoretical two-country, one-good DSGE model predicts a large, front-loaded TB adjustment to a productivity trend growth rate shock, under full information.

We now show that the gradual TB adjustment predicted by our model stems from two features: imperfect substitution between domestic and foreign traded goods, and real adjustment frictions. Fig. 9 illustrates dynamic responses of key variables to a RoW intermediates productivity trend growth rate shock, across three model variants: (i) the estimated baseline model (blue lines); (ii) a one-traded-good version (perfect substitution between domestic and foreign tradables, all other parameters kept at baseline values; red); and (iii) a version of (ii), with all real adjustment frictions removed (yellow).[32]

With perfect substitutes (red lines), the terms of trade and the RER hardly respond to the trend productivity growth shock. This amplifies the response of EA absorption and of the EA TB to the shock, relative to the baseline model. Eliminating real frictions further amplifies the TB response (yellow lines). Hoffmann et al. (2019) argue for a theoretical setting with imperfect information—where agents gradually learn about the persistence of shocks—as a mechanism for generating smoother TB responses to trend growth shocks (see also Engel and Rogers, 2006). By contrast, our model assumes full information, yet still produces gradual TB dynamics. Fig. 9 shows that this outcome can be attributed to imperfect substitution and real frictions.

[32] Namely, consumption habits, trading frictions of international assets, "hand-to-mouth" households, and delayed input substitution were removed.

Fig. 9. Sensitivity analysis of positive RoW trend productivity growth rate shock



Note: The blue line ("base") depicts the dynamics from the estimated model, the red line shows a one-good economy version of the model (assuming perfect substitutability between domestic and foreign intermediates) while the yellow line presents a one-good economy version of the model without the following frictions: consumption habits, trading frictions of international assets costs, "hand-to-mouth" households, delayed input substitution

7. Conclusion

This paper analyzes the effect of global productivity trend growth differences on real activity, trade, and the real exchange rate (RER). 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. 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.

References

Albonico, A., Calés, L., Cardani, R., Croitorov, O., Di Dio, F., Ferroni, F., Giovannini, M., Hohberger, S., Pataracchia, B., Pericoli, F., Pfeiffer, P., Raciborski, R., Ratto, M., Roeger, W., and Vogel, L. (2019). The Global Multi-Country Model (GM): An estimated DSGE model for euro area countries (European Economy Discussion Paper No. 102). Directorate-General for Economic and Financial Affairs, European Commission.

Aguiar, M., and Gopinath, G. (2007). Emerging market business cycles: The cycle is the trend. Journal of Political Economy, 115(1), 69–102.

Auclert, A., Rognlie, M., Souchier, M., Straub, L., 2024. Exchange Rates and Monetary Policy with Heterogeneous Agents: Sizing up the Real Income Channel. Working Paper, Stanford University.

Backus, D. K., Kehoe, P. J., and Kydland, F. E. (1992). International real business cycles. Journal of Political Economy, 100(4), 745–775.

Backus, D.K., and Smith, G. W. (1993). Consumption and real exchange rates in dynamic economies with non-traded goods. Journal of International Economics, 35(3–4), 297–316.

Blanchard, O., and Galí, J. (2007). Real wage rigidities and the New Keynesian model. Journal of Money, Credit and Banking, 39, 35–65.

Bodenstein, M., Cuba-Borda, P., Gornemann, N., and Presno, I. (2024). Exchange rate disconnect and the trade balance. International Finance Discussion Papers 1391. Washington: Board of Governors of the Federal Reserve System.

Cardani, R., Hohberger, S., Pfeiffer, P., and Vogel, L. (2022). Domestic versus foreign drivers of trade (im)balances: How robust is evidence from estimated DSGE models? Journal of International Money and Finance, 121, 102509.

Cardani, R., Croitorov, O., Giovannini, M., Pfeiffer, P., Ratto, M., and Vogel, L. (2022). The euro area's pandemic recession: A DSGE-based interpretation. Journal of Economic Dynamics and Control, 143, 104512.

Cardani, R., Pfeiffer, P., Ratto, M., and Vogel, L. (2023). The COVID-19 recession on both sides of the Atlantic: A model-based comparison. European Economic Review, 158, 104556.

Clancy, D., Smith, D., and Valenta, V. (2024). The macroeconomic effects of global supply chain reorientation. International Journal of Central Banking, 20(2), 151–193.

Coenen, G., Karadi, P., Schmidt, S., and Warne, A. (2019). The New Area-Wide Model II: An extended version of the ECB's micro-founded model for forecasting and policy analysis with a financial sector. ECB Working Paper 2200. European Central Bank.

Croitorov, O., Giovannini, M., Hohberger, S., Ratto, M., and Vogel, L. (2020). Financial spillover and global risk in a multi-region model of the world economy. Journal of Economic Behavior & Organization, 177, 185–218.

Draghi, M. (2024). The future of European competitiveness. European Commission.

Engel, C. and Rogers, J., (2006). The U.S. current account deficit and the expected share of world output. Journal of Monetary Economics, 53, 1063-1093.

Fernald, J., Cette, G., van Ark, B., and Gordon, R. J. (2020). The productivity slowdown in advanced economies: Common trends and future prospects. Review of Income and Wealth, 69(2), 225–252.

Fernandez-Villaverde, J., and Ohanian, L. (2015). The political economy of European economic stagnation. University of Pennsylvania.

Engel, C., and Rogers, J. H. (2006). The U.S. current account deficit and the expected share of world output. Journal of Monetary Economics, 53(5), 1063–1093.

Fisher, J. D. (2015). On the structural interpretation of the Smets–Wouters "risk premium" shock. Journal of Money, Credit and Banking, 47(2–3), 511–516.

Gagnon, J. (2008). Growth-Led Exports: Implications for the Cross-Country Effects of Shocks to Potential Output. The B.E. Journal of Macroeconomics: Vol. 8: Iss. 1 (Contributions), Article 2.

Gopinath, G., Kalemli-Ozcan, S., Karabarbounis, L. and Villegas-Sanchez, C. (2017). Capital Allocation and Productivity in South Europe. Quarterly Journal of Economics, 132, 1915-1967.

Giovannini, M., Hohberger, S., Kollmann, R., Ratto, M., Roeger, W., and Vogel, L. (2019). Euro area and U.S. external adjustment: The role of commodity prices and emerging market shocks. Journal of International Money and Finance, 94, 183–205.

Hoffmann, M., Krause, M. U., and Laubach, T. (2019). The expectations-driven U.S. current account. The Economic Journal, 129(618), 897–924.

International Monetary Fund. (2025). World Economic Outlook, April: A Critical Juncture amid Policy Shifts.

Itskhoki, O., and Mukhin, D. (2021). Exchange rate disconnect in general equilibrium. Journal of Political Economy, 129(8), 2183–2232.

Jaccard, I., and Smets, F. (2020). Structural asymmetries and financial imbalances in the Eurozone. Review of Economic Dynamics, 36, 73–102.

Ozhan, G. K. (2019). Financial intermediation, resource allocation, and macroeconomic interdependence. Journal of Monetary Economics, 104, 39–55.

Kollmann, R. (1991). Essays on International Business Cycles. PhD dissertation, University of Chicago.

Kollmann, R. (1995). Consumption, Real Exchange Rates and the Structure of International Asset Markets, *Journal of International Money and Finance*, 14, 191-211.

Kollmann, R. (1998). U.S. trade balance dynamics: The role of fiscal policy and productivity shocks and of financial market linkages. Journal of International Money and Finance, 17(4), 637–669.

Kollmann, R. (2002). "Monetary Policy Rules in the Open Economy: Effects of Welfare and Business Cycles, Journal of Monetary Economics, 49, 989-1015.

Kollmann, R. (2004). Welfare Effects of a Monetary Union: the Role of Trade Openness, Journal of the European Economic Association, 2, 289-301.

Kollmann, R. (2005). Macroeconomic effects of nominal exchange rate regimes: New insights into the role of price dynamics. Journal of International Money and Finance, 24(2), 275–292.

Kollmann, R., in't Veld, J., Pataracchia, B., Ratto, M., Roeger, W. (2014). "International Capital Flows and the Boom-Bust Cycle in Spain. Journal of International Money and Finance, 48, 314-335.

Kollmann, R., Pataracchia, B., Raciborski, R., Ratto, M., Roeger, W., and Vogel, L. (2016). The post-crisis slump in the Euro Area and the US: Evidence from an estimated three-region DSGE model. European Economic Review, *88*, 21–41.

Kollmann, R. (2017). Exchange Rate Dynamics and International Business Cycles with Trade Shocks. Working Paper, Université Libre de Bruxelles.

Krugman, P. (1989). Differences in income elasticities and trends in real exchange rates. European Economic Review, 33(5), 1031–1046.

Maddison, A. (2001). The World Economy: a Millenial Perspective. Development Centre Studies, OECD.

Martin, P., and Philippon, T. (2017). Inspecting the mechanism: Leverage and the Great Recession in the Eurozone. The American Economic Review, 107(7), 1904–1937.

Neal, R. M. (2003). Slice sampling. Annals of Statistics, 31(3), 705–767.

Obstfeld, M. and Rogoff, K. (1995). Exchange rate dynamics redux. Journal of Political Economy, 103(3), 624–660.

Obstfeld, M. and Rogoff, K. (1996). Foundations of International Macroeconomics. MIT Press.

Obststfeld, M. (2025). The U.S. Trade Deficit: Myths and Realities. Brookings Papers on Economic Activity.