The trade balances of the US and, especially, of the Euro Area (EA) have improved markedly after the Global Financial Crisis. The paper highlights the key role of commodity prices as drivers of US and EA trade balances. The sharp post-2012 fall in commodity prices, and the post-crisis Euro depreciation, contributed to the EA trade balance surge. Commodity prices also affect the transmission of Emerging Market shocks to the US and EA. Emerging Markets productivity growth has muted effect on EA GDP, when the effect of Emerging Markets growth on commodity prices is taken into account. The methodological contribution of this paper is the Bayesian estimation of a three-region (US, EA, rest of world) DSGE model with trade in manufactured goods and in commodities. In the model, world commodity prices reflect global demand and supply conditions (market clearing). The broader lesson of this paper is that Emerging Markets and commodity prices can be key drivers of advanced countries’ trade balances and terms of trade.

JEL Codes: F2,F3,F4

Keywords: EA and US post crisis external adjustment, commodity markets, emerging markets.

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The views expressed in this paper are those of the authors and should not be attributed to the European Commission.
1. Introduction
Since the early 2000s, the world economy has been undergoing substantial changes. Emerging economies have accelerated their growth, while both the US and the EA experienced a boom-bust cycle. Also, wide exchange rates fluctuations occurred. These developments have been accompanied by major trade balance adjustments. In the first half of the 2000s, the US trade balance deteriorated markedly reaching about -6% of GDP in 2005-7, while the EA trade balance fluctuated around zero in the pre-2009 period. However, after the financial crisis, the EA & US trade balances both rose noticeably: the US trade deficit fell markedly, while the EA has been running steadily increasing trade balance surpluses.

This raises a number of questions: Is the growth divergence between the rest of the world (RoW) and the EA/US a major driver of global imbalances, or has the boom bust cycle in advanced economies shaped the trade balance more strongly?

The paper argues that there is no mono-causal explanation for the dynamics of global imbalances. While the boom-bust cycle view could provide a coherent story of, first, a widening trade deficit in the US followed by a contracting deficit, it fails to account for the relatively stable EA trade balance before the crisis. The RoW growth divergence could possibly account for the narrowing US trade balance deficit in recent years, but it fails to explain why the US trade balance decline only occurred after the financial crisis. A possible explanation for the widening pre-crisis US trade deficit could be provided by the savings glut hypothesis (Bernanke, 2005) which suggests that rapid growth in the RoW has been associated with high RoW savings rates, perhaps due to heightened risk aversion as a consequence of the Asian financial crisis of the late 1990s. Thus high savings in the RoW may have outweighed the effect of high RoW productivity growth on the RoW external balance, in the early 2000s.

There is also a third hypothesis (e.g. put forward by McKibbin and Stoeckel (2018)), which could explain some of the broad trade balance facts, namely spectacular fluctuations in commodity prices: commodity prices rose sharply before the great recession, and fell afterwards. This could explain at least a part of the worsening of US trade balance, before the crisis, and the EA and US post-crisis trade balance improvements. Note, however, that this mechanism is only partially independent from the first two hypotheses, since industrial supplies (IS) prices are themselves partly driven by income fluctuations.

This paper augments a fairly standard three-region model of the world economy by including a commodity/raw materials sector, and we estimate that model (with Bayesian Methods), using 1999q1-2017q2 data for the EA, US and an aggregate of ‘rest of the world’
countries (RoW). In the model, commodity prices endogenously reflect global demand and supply conditions. This is particularly interesting since it gives rise to a novel international transmission channel, namely a commodity price channel, through which persistent growth shocks in one region of the world can impact the remaining regions, besides the standard income/demand and competitiveness channels.

We quantify the impact of persistent TFP growth rate shocks on commodity prices and thereby distinguish between endogenous movements of commodity prices, and exogenous commodity shocks (both supply and demand shocks are considered). The use of a rich estimated model allows us to identify periods dominated by specific shocks.

As pointed out above, the trade balances of the US and, especially, of the Euro Area (EA) have improved markedly after the Global Financial Crisis. This is widely viewed as reflecting weak domestic demand. This paper provides a nuanced assessment of that view. It instead highlights the key role of commodity shocks as drivers of US and EA trade balances. The sharp post-2012 fall in commodity prices, and the post-crisis depreciation of the Euro exchange rate, explain more than half of the EA trade balance surge. Commodity prices also play a key role for the transmission of aggregate demand and supply shocks originating in RoW to the EA and US. We find that RoW productivity growth has a negligible effect on EA GDP, when the positive effect of Emerging Markets growth on commodity prices is taken into account. The broader lesson of this paper is that Emerging Markets and commodity prices can be key drivers of advanced countries’ trade balances and terms of trade.

The trade balance developments discussed in this paper have some parallels in the external adjustments triggered by the oil shocks of the 1970s; those shocks triggered a sharp rise in trade balances of oil exporters, and a trade balance deterioration of the groups of advanced and (especially) non-fuel developing countries (see, e.g., Obstfeld and Rogoff (1996)). An important difference between the global macroeconomic environment of the 2000s and that of the 1970s, is that the 2000s saw massive growth in Emerging Market economies, which suggests that the commodity price hikes of the 2000s might be driven by expanding demand for commodities, and less by adverse commodity supply shocks (OPEC) than the price hikes of the 1970s.

Quantitative analyses of recent oil and commodity fluctuations mostly rely on reduced-form statistical models (such as vector auto regressions; see, e.g., Kilian (2009), Kilian et al. (2009), Peersman and Van Robays (2009), Caldara et al. (2017). Some structural DSGE open economy models consider the effect of oil price shocks, but those models mostly assume an exogenous oil price and consider small open economy models (e.g., Miura (2017)). By contrast,
the paper here develops and estimate a DSGE model with endogenous commodity prices. With few exceptions, open economy models developed in the academic literature, and standard policy models, abstract mostly from international trade in commodities. For stylized structural models of the role of energy for international adjustment, see, e.g., Sachs (1981), McKibbin and Sachs (1991), Backus and Crucini (2000) and Gars and Olovsson (2018). The paper here is closest to Forni, Gerali, Notarpietro and Pisani (2015), who estimate a two-country DSGE model of the EA and the non-EA RoW, using data for 1995-2012. Our model differs from that work in that we use a rich three-region model (EA, US, RoW) that allows to analyze the striking differences between the EA and US external adjustment to recent global disturbances. Our paper focuses on the interaction between macroeconomic demand and supply dynamics in the three regions, and we use a sample period that includes the post-2014 commodity price collapse.¹

2. 1999-2016 macroeconomic conditions and external adjustment

This paper studies macroeconomic developments and linkages in the EA, US and an aggregate of the rest of the world (RoW). As an empirical proxy for GDP and other macroeconomic variables in the RoW, we construct an aggregate of the 58 major developed and emerging economies other than the US and the EA member countries (see data Appendix).²

Figures 1-5 plots time series for GDP, trade flows and the terms of trade, during the period 1999q1-2016q4. Fig.1 documents that real GDP growth has been markedly higher in RoW than in the US and the EA. The mean real GDP growth rates of the three regions in 1999-2016 were 1.29% (EA), 1.95% (US) and 3.59% (RoW), respectively. As result of this growth differential, the share of RoW GDP in total world GDP has increased steadily, from close to 40% (1999) to more than 50% (2016). During the 2007-09 financial crisis, GDP contracted in all three regions, but the contraction was milder in RoW than in the EA and US. In 2009-11, RoW growth rebounded to pre-crisis rates, and then declined somewhat. EA and US GDP growth too rebounded in 2009-11, but remained below pre-crisis growth rates. The EA experienced a recession in 2012-13, in the aftermath of the Southern European sovereign debt crisis of 2011.

These divergent GDP trends and uncoupled cycles were accompanied by a dramatic boom-bust cycle in commodity prices, and by major shifts in trade flows between the three regions and in these region’s trade balances.

¹ Forni et al. (2015) analyze the effects of oil price shocks; by contrast, the paper here considers shocks to a broader bundle of commodities and raw materials.
² The US, EA and RoW together account for more than 95% of world GDP (as reported in the IMF World Economic Outlook database), in 1999-2016.
The prices of a wide range of raw materials and commodities rose sharply during the early 2000s, until the financial crisis (e.g., the oil price (in US$) was multiplied by a factor greater than 5 between 1999 and 2008). This is documented in Fig. 2a, where oil and coal prices as well as two global commodity price indices (in US$) are plotted. Commodity prices contracted sharply during the financial crisis, but rebounded strongly after the crisis; commodity prices then fell again sharply (by more than 50%) in 2014/15. To put these developments into a long-run perspective, Fig. 2b plots an index of real prices (deflated by the US CPI) of 40 commodities for the period 1900-2015, constructed by Jacks (2015). The magnitude of the recent commodity price boom-bust cycle is only comparable of the 1973-86 commodity boom-bust cycle; it dwarfs all other commodity cycles in the past century.

Kilian and Hicks (2012) argue (and document statistically) that the strong rise in commodity prices prior to the financial crisis reflects unexpectedly high growth in Emerging Markets (especially in Emerging Asia), and that the 2008-09 fall in commodity prices was due to a fall in commodity demand triggered by the slowdown in real activity in both emerging and advanced economies, during the global financial crisis. It seems plausible that the rebound of commodity prices in 2009-10 is linked to the strong post-crisis recovery in emerging countries. Finally, the 2014-15 collapse in energy prices might be due to strong growth of oil production in the US, and a weakening of OPEC (see, e.g., Baffes et al. (2015)).

EA net exports fluctuated around a zero balance until the sovereign debt crisis (2011), and then rose steadily, reaching about 2.5% in 2016; see Fig. 3.b. By contrast, the US has been running a sizable trade deficit (goods) during the whole sample period (in fact, since the mid-1980s). The US trade deficit (goods trade) peaked at about 6% of GDP in 2005-08. The goods trade deficit has fallen since the financial crisis, to currently about 4% of US GDP.

To understand whether/how these trade balance reversals might be linked to the commodity boom bust cycle and the decoupled regional growth trends, we plot time series on EA and US trade by trade partners (EA/US/RoW), and by products; see Figs.3-5. We disaggregate foreign trade into: (i) ‘Industrial supplies and materials’ (‘industrial supplies’, IS, henceforth)
comprising petroleum, mineral products and other raw materials; (ii) an aggregate of all other products, henceforth referred to as ‘manufactures’.\textsuperscript{5}

Figs. 5a and 5b show that trade with RoW accounts for the lion share of EA and US foreign trade. More than 80% or EA total exports, and about 70% of total EA imports consist of manufactures sold to/purchased from RoW. The EA is running a sizable and widening trade surplus in manufactures vis-à-vis RoW (see Fig. 5a). Imports of industrial supplies from RoW account for a sizable share of total EA imports: the share of IS purchases from RoW in total EA imports rose from close to 17% in 2003 to about 30% in 2012-2013, and fell to 14% in 2016. The share of IS in total EA imports is positively correlated with the price of commodities. This suggests that the price elasticity of IS import demand is low, so that a rise in the IS price raises the share of IS spending in total imports. The EA is a negligible exporter of IS, and thus EA IS net exports closely track EA IS imports.

As documented in Fig. 3a, the overall EA trade balance (across all products and trade partners) is highly positively correlated with the EA’s IS trade balance: like the overall EA trade balance, the IS trade balance improved markedly after 2012. The EA manufactures trade balance has been positive throughout the sample--that balance increased steadily until 2013, and then declined somewhat (see Fig. 3b). The bilateral EA-US trade balance has been small and stable, during most of the sample period, ranging between about 0.5% and 1% of EA GDP. Thus, the bilateral EA-US trade balance has not been a major driver to the EA and US trade balances.

In contrast to the EA, the US is a net importer of manufactured goods from RoW (see Fig. 4b). US exports and imports of manufactures to/from the RoW have grown less than EA manufactures trade with RoW. The US is a major producer and exporter of oil and other industrial supplies, which helps to explain why US net imports of industrial supplies amount to a smaller share of GDP than EA net IS imports. Since 2015, US net imports of IS have been close to zero. US net imports of manufactured goods are negatively correlated with net IS imports (see Fig. 3e): the ratio of manufactured US net imports fell prior to the financial crisis, and has steadily increased after the crisis.

This overview of the historical data suggests that the post-crisis collapse of commodity prices may have contributed to the rise in EA net exports, and the fall in RoW net exports. Below,\

\textsuperscript{5}Bilateral trade flows US-EA and US-RoW are from the BEA International Trade database; EA-RoW trade flows are from Eurostat COMEXT database. The sum of COMEXT ‘Raw Materials’ and ‘Mineral Fuels and related products’ closely matches the ‘Industrial Supplies’ product category in the BEA database. For simplicity, we refer to COMEXT ‘Raw materials’ and ‘Mineral Fuels and related products’ as ‘industrial supplies’. Importantly, EA exports and imports exclude intra-EA trade. EA and US trade flows to/from RoW represent flows to/from all countries other than the US and the EA.
we use an estimated DSGE model to quantify the contribution of the commodities cycle to the EA external balance, and we disentangle the influence of commodity shocks from other drivers, such as weak domestic demand.

3. Model description
We develop a three-region world consisting of the EA, US and RoW. The three regions are linked via trade in goods, and financial assets (bonds). The EA and US blocks of the model are fairly rich; both blocks have the same structure (but model parameters are allowed to differ across these two regions). The RoW block of the model is simpler. In all three regions, economic decisions are made by forward-looking households and firms; each country exhibits nominal and real rigidities, and is buffeted by a range of supply and demand shocks, as in standard New Keynesian DSGE models. A key structural difference between the regions is that only the RoW produces commodities. Thus, commodities used by the EA and US are imported from RoW. Commodities (also referred to as "industrial supplies" in the following discussion) are an input into US and EA final good production. Commodity demand by RoW manufactured good firms is an increasing function of RoW real GDP. Shocks that raise real activity in the three regions induce, hence, a rise in commodity demand, and trigger a rise in the (relative) price of commodities.

The EA and US blocks assume two (representative) households, firms and a government. EA and US households provide labor services to domestic firms. One of the two households in each region has access to financial markets, and she owns her region’s firms. The other household has no access to financial markets, does not own financial or physical capital, and each period consumes her disposable wage and transfer income. We refer to these agents as ‘Ricardian’ and ‘hand-to-mouth’ households, respectively. Final output in the EA and in the US is generated by perfectly competitive firms that use domestic and imported intermediate goods and commodities as inputs. Intermediates are produced by monopolistically competitive firms using local labor and capital, and commodities. EA and US wage rates are set by monopolistic trade unions. Nominal intermediate goods prices and nominal wages are sticky. Governments purchase the local final good, make lump-sum transfers to local households, levy labor and consumption taxes and issue debt. All exogenous random variables in the model follow independent autoregressive processes.
We next present the key aspects of the EA model block. As mentioned above, the US block has a symmetric structure. The RoW block is described in Sect. 3.5.

3.1. EA households

A household’s welfare depends on consumption and hours worked. EA household \( i=r,h \) (\( r: \) Ricardian, \( h: \) hand-to-mouth) has this period utility function:

\[
U_i^t = \frac{1}{1-\theta} (C_i^t - \theta^N C_{i-1}^t)^{1-\theta} - s_i^N (C_i^t)^{1-\theta - \frac{1}{1-\theta}} (N_i^t - \eta^N N_{i-1}^t)^{1-\theta},
\]

with \( 0 < \theta, \theta^N, s_i^N < 1 \). \( C_i^t \) and \( N_i^t \) are consumption and the labor hours of household \( i \) in period \( t \), respectively. We assume (exogenous) habit persistence for consumption and labor hours.\(^7\) \( s_i^N \) is a stationary exogenous shock to the disutility of labor. The subjective discount factor of EA households, \( 0 < \beta_{t_{i+1}} < 1 \), too is an exogenous random variable. Date \( t \) expected lifetime utility of EA household \( i \), \( V_i^t \), is defined by \( V_i^t = U_i^t + E_{i_{t+1}} V_{i_{t+1}}^t \).

The EA Ricardian household owns all domestic firms, and she holds domestic and foreign bonds. Her period \( t \) budget constraint is:

\[
(1+\tau^C)P_tC_i^t + B_{t+1}^t = (1-\tau^N)W_tN_i^t + B_i^t(1+i_i^t) + \text{div}_i^t + T_i^t,
\]

where \( P_t, W_t, \text{div}_i^t \) and \( T_i^t \) are the consumption price index, the nominal wage rate, dividends generated by domestic firms, and government transfers received by the Ricardian household. \( B_{t+1}^t \) denotes the Ricardian household’s bond holdings at the end of period \( t \), and \( i_i^t \) is the nominal return on the household’s bond portfolio between periods \( t-1 \) and \( t \).\(^8\) \( \tau^C \) and \( \tau^N \) are (constant) consumption and labor tax rates, respectively.

The hand-to-mouth household does not trade in asset markets and simply consumes her disposable wage and transfer income. Her budget constraint is:

\[
(1+\tau^C)P_tC_i^h = (1-\tau^N)W_tN_i^h + T_i^h.
\]

\(^6\)The description here abstracts from factor adjustment costs and variable capacity utilization rates assumed in the estimated model. Also, we only present the main exogenous shocks. The detailed model is available in a Not-for-Publication Appendix. The EA and US blocks build on, but are considerably different than, the EU Commission’s QUEST model of the EU economy; see Ratto et al., 2009; in’t Veld et al. (2015), Kollmann et al. (2015).

\(^7\)To allow for balanced growth, the disutility of labor features the multiplicative term \( (C_i^t)^{1-\theta} \); this term is treated as exogenous by the household.

\(^8\)The household can hold risk-free one-period bonds denominated in EA, US and RoW currency. The model assumes small convex costs to holding foreign-currency bonds; those costs are rebated to agents in a lump sum fashion. The bond-holding costs pin down the household’s bond portfolio in the certainty equivalent (linear) model approximation used below.
3.2. EA firms

Production of total output in the EA is a four-stage process. At the first stage, monopolistically competitive firms produce differentiated intermediate goods using capital and labor. At the second stage, the differentiated intermediate products are bundled by perfectly competitive firms into domestic value added. At the third stage, perfectly competitive firms combine domestic value added and imported industrial supplies (commodities) to obtain a domestic intermediate good. At the final stage, perfectly competitive firms combine the domestic final good and imports to produce total output, which is then used for domestic private and government consumption, and for investment.

3.2.1. EA intermediate goods producers

In the EA, there is a continuum of intermediate goods indexed by \( j \in [0,1] \). Each good is produced by a single firm. As all EA intermediate goods firms face symmetric decision problems, they make identical choices. Firm \( j \) has technology

\[
y_j = \Theta_j (N_j - FN_j) \alpha_j (cu_j K_j)^{1-\alpha_j} - \Theta_j FC_j,
\]

where \( y_j, N_j, K_j \) are the firm’s output, labor input and capital stock, respectively, and where \( FN_j \) and \( cu_j \) are firm-specific levels of labor hoarding and capacity utilization, and \( FC_j \) captures fixed costs of production. Total factor productivity (TFP) \( \Theta_j > 0 \) is exogenous and common to all EA intermediate goods producers. Log TFP is the sum of a stationary autoregressive process and of a unit root process whose first difference is a highly serially correlated.

The law of motion of firm \( j \)'s capital stock is

\[
K_{t+1} = K_t (1-\delta) + I_t,
\]

with \( 0 < \delta < 1 \); \( I_t \) is gross investment. The period \( t \) dividend of intermediate good firm \( j \) is

\[
div_t = p_t y_t - W_t N_t - p_t^K I_t - p_t \kappa_t,
\]

where \( p_t \) and \( p_t^K \) denote the price charged by the firm and the prices of production capital, respectively. At \( t \), each firm faces a downward sloping demand curve for her output, with exogenous price elasticity \( \varepsilon_t > 1 \) that equals the substitution elasticity between different intermediate good varieties (see below). The firm bears a real cost

\[
\kappa_t = \frac{1}{2} \gamma (p_t - (1+\pi) p_{t-1})^2 / p_t,
\]

of changing her price, where \( \pi \) is the steady-state inflation rate.

Firm \( j \) maximizes the present value of dividends

\[
V_t = div_t + E_{\alpha_{t+1}} (P_t / P_{t+1}) \cdot V_{t+1},
\]

where \( \rho_{t,t+1} \) is a stochastic discount factor that is smaller than the intertemporal marginal rate of
substitution of the domestic Ricardian household (denoted by \( \rho_{t+1}^r \)): \( \rho_{t+1}^r = (1-z_t)\rho_{t+1}^r \), where \( 0 \leq z_t < 1 \) is an exogenous random variable. This is a short-cut for capturing financial frictions facing the firm; \( z_t \) can, e.g., be interpreted as a ‘principal agent friction’ between the owner and the management of the firm (Hall (2011)).\(^9\) The firm’s Euler equations for capital is

\[
1 = (1-z_t)E_t\rho_{t+1}^r (P_t^f/P_{t+1}^f) [(1-1/c_{t+1}) p_{t+1}^i MPK_{t+1}^j/p_t^j + (1-\delta)p_{t+1}^K/p_t^K + \Psi_t^j],
\]

where \( MPK_{t+1}^j = \Theta(K_{t+1}^j, (N_t^{j-1})^{1-\alpha} \) is the date \( t+1 \) marginal product of capital. The term \( \Psi_t^j \) depends on the future marginal price-adjustment cost (\( \Psi_t^j \) is zero, in steady state). \( z_t \) drives a wedge between the risk-free interest rate and the firm’s expected return on physical capital.\(^10\) We thus refer to \( z_t \) as a (capital) ‘investment risk-premium’.

Quadratic price adjustment costs imply that the inflation rate of local intermediates, \( \pi_t = \ln(p_t^i/p_{t-1}^i) \), obeys an expectational Phillips curve, \( \pi_t - \pi = \rho^j E_t(\pi_{t+1} - \pi) + \delta^j (p_t^i/MC_t - \varepsilon/\varepsilon-1) \), up to a linear approximation. Here \( MC_t^j \) is the marginal cost of intermediate good firms and \( \varepsilon/(\varepsilon-1) \) is the steady state mark-up factor. \( \rho^j \) is the steady state subjective discount factor of intermediate good firms, and \( \delta^j > 0 \) is a coefficient that depends on the cost of changing prices. A weighted backward-looking term is introduced for expectation formation to allow firms to be less forward-looking in their price setting.

### 3.2.2. EA production of new capital goods

New production capital is generated using final output. Let \( J_t = \Xi_t \xi(I_t) \) be the amounts of EA final output needed to produce \( I_t \) units of EA capital, respectively. \( \xi \) is an increasing, strictly convex functions, while \( \Xi_t \) is an exogenous shock. The price of production capital is \( p_t^K = \Xi_t \xi(I_t)P_t^f \). The dividends of the investment good sector is \( div_t^K = p_t^K I_t - P_t J_t \).

---

\(^9\)Following Bernanke and Gertler (1999), one can also view \( z_t \) as a non-fundamental shock that generates an investment bubble, i.e. fluctuations in physical investment and in the price of capital that are not related to (conventional) fundamentals.

\(^10\)The firm’s Euler equation can be written as \( 1 = (1-z_t)E_t\rho_{t+1}^r (P_t^f/P_{t+1}^f) [(1-1/c_{t+1}) p_{t+1}^i MPK_{t+1}^j/p_t^j + (1-\delta)p_{t+1}^K/p_t^K + \Psi_t^j] \), where \( \rho_{t+1}^K \) is the firm’s real return on physical capital between \( t \) and \( t+1 \). The Ricardian household’s Euler equation for a nominal one-period risk-free bond with interest rate \( i_{t+1} \) is \( 1 = E_t\rho_{t+1}^r (P_t^f/P_{t+1}^f) [1+i_{t+1}] \). Thus, up to a (log-)linear approximation: \( i_{t+1} - E_t\ln(P_{t+1}^f/P_t^f) \approx E_t \rho_{t+1}^K - z_t \).
3.2.3. EA final good sector

The EA final good is produced using domestic (D) and imported (M) inputs, using the technology \( O_t = (s_t^d)^{\phi^D} (D_t)^{1-\phi^D} + (s_t^m)^{\phi^M} (M_t)^{1-\phi^M} \), with a random home bias parameter \( 0.5 < s_t^d < 1 \). The domestically produced intermediate \( D_t = (1-s_t^d)^{\phi^d} (Y_t)^{1-\phi^d} \) and industrial supplies \( IS_t \) (energy and non-energy commodities) imported from RoW. \( s_t^{is} \) is a region-specific shock to the demand for industrial supplies. \( s_t^{is} \) for the EA and the US are grouped together as ‘commodity demand’ shocks in the historical shock decompositions presented below.

Finally, domestic value added \( Y_t = \int_0^t (O_t^d)^{1-\phi} d\nu \) is an aggregate of the local intermediates produced by monopolistically competitive domestic firms (see 3.2.1), where \( \phi > 1 \) is the exogenous substitution elasticity between varieties. The imported input \( M_t \) used for the final good is a composite of intermediates imported from the US and the RoW. The price (=marginal cost) of the final output good is \( P_t^o = (s_t^d)^{\phi^d} (P_t^m)^{1-\phi^d} + (s_t^m)^{\phi^m} (P_t^m)^{1-\phi^m} \), where \( P_t^m \) is the import price index. The price of the domestically produced intermediate good is \( P_t^d = (1-s_t^d)(P_t^d)^{1-\phi^d} + s_t^{is}(P_t^{is})^{1-\phi^d} \); that price reflects the price of domestic value added, \( P_t^d \), which follows from the aggregation of the pricing decision of intermediate goods producers, and the price of imported industrial supplies, \( P_t^{is} \). The price of imported industrial supplies is given by \( P_t^{is} = e_t^{EAROW} P_t^{is,ROW} \), where \( e_t^{EAROW} \) is the nominal exchange rate of euro to RoW currency, and \( P_t^{is,ROW} \) is the price of industrial supplies in RoW currency.

The final good \( O_t \) is used for domestic private and government consumption, and for investment. The model allows for sector specific home bias \( s_t^d \) in demand, i.e. heterogeneity in the steady-state import share of private consumption, investment, and government purchases.

3.3. Wage setting in the EA

We assume an EA trade union that ‘differentiates’ homogenous EA labor hours provided by the two domestic households into imperfectly substitutable labor services; the union then offers those services to intermediate goods-producing firms--the labor input \( N_t \) in those firms’ production functions is a CES aggregate of these differentiated labor services. The union sets wage rates at a
mark-up $\mu_t^W$ over the marginal rate of substitution between leisure and consumption. The wage mark-up is inversely related to the degree of substitution between labor varieties in production. Because of wage adjustment cost, the mark-up is countercyclical. We follow Blanchard and Gali (2007) and allow for real wage inertia; the current period real wage rate set by the union is a weighted average of the desired real wage and the past real wage: 

$$W_t/P_t = ((1 + \mu_t^W) \cdot mrs_t)^{1-\xi} (W_{t-1}/P_{t-1})^\xi,$$

where $mrs_t$ is a weighted average of the two households’ marginal rates of substitution between consumption and leisure. The parameter $\xi$ can be interpreted as an index of real wage rigidity. Real wage rigidity is crucial for capturing the high persistence of employment rate fluctuations in both the US and the EA.

### 3.4. EA monetary and fiscal policy

The EA monetary policy (nominal) interest rate $i_{t+1}$ is set at date $t$ by the EA central bank according to the interest rate feedback rule

$$i_{t+1} = (1-\rho^i)\hat{i} + \rho^i i_t + (1-\rho^i)[\eta^\rho \{1/\rho^2 \ln(P_t/P_{t-4}) - \pi\} + \eta^\rho Y_t^{gap}] + \varepsilon^i_t,$$

where $Y_t^{gap}$ is the EA output gap, i.e. the (relative) deviation of actual GDP from potential GDP. $\varepsilon^i_t$ is a white noise disturbance.

EA real government consumption, $G_t$, is set according to the following rule:

$$c^G_t - c^G_{t-1} = \rho^G (c^G_{t-1} - c^G_t) + \varepsilon^G_t,$$

where $c^G_t = G_t/Y_t$ is government consumption normalized by GDP, while $\varepsilon^G_t$ is a white noise shock. The model assumes government capital investment that raises private sector productivity (government investment follows a rule that is analogous to the government consumption rule). EA government transfers to households follow a feedback rule that links transfers to the government budget deficit and to government debt:

$$\tau_t = \rho^\tau (\tau_{t-1} - \tau) + \eta^{def} (\Delta B^{G_t}_t / GDP_{t-1}^{nom} - def) + \eta^B (B^{G_t}_t / GDP_{t-1}^{nom} - b) + \varepsilon^\tau_t,$$

where $\tau_t = T_t / GDP_{t}^{nom}$ are nominal transfers ($T_t$), normalized by nominal GDP; $B^{G_t}_{t+1}$ is EA nominal public debt. The EA government budget constraint is $B^{G}_t = (1+i_t)B^{G}_t - R^{G}_t + P_G + T_t$, where $R^{G}_t$ is nominal tax revenue.

---

11 Date $t$ potential GDP is defined as GDP that would obtain under full utilization of the date $t$ capital stock and steady state hours worked, if TFP equaled its trend (unit root) component at $t$.
3.5. The RoW block

As mentioned above, the model of the RoW economy is a simplified structure with fewer shocks. Specifically, the RoW block consists of a budget constraint for the representative (Ricardian) household, demand functions for domestic and imported goods (derived from CES consumption good aggregators), a production technology that uses labor as the sole factor input, a New Keynesian Phillips curve, and a Taylor rule for monetary policy. There is no capital accumulation in RoW.

In RoW, a competitive sector supplies two distinct commodities, namely energy and non-energy materials, to domestic and foreign firms. The RoW commodity supply schedules are increasing functions of the real commodity prices (relative to the RoW GDP deflator). Commodity supply schedules are shifted by random exogenous disturbances that capture exogenous commodity supply shocks (such as the discovery of new raw material deposits). RoW demand for industrial supplies is assumed to be proportional to real RoW GDP. EA and US demand for industrial supplies is determined by final good producers in these regions (see above). Our ‘industrial supplies’ variables are broad composites--no data on RoW production of IS, and on RoW demand for IS are available. However, the model estimation uses volume and price data on IS exports by RoW to the EA and US. Empirically, the price indices of RoW IS exports differ across the EA and US (but are highly positively correlated). To account for destination-specific export price indices (which may reflect different commodity mixes), we assume CES production functions that aggregates energy and non-energy materials into a composite bundle. Shocks to RoW commodity supply schedules are referred to as "commodity supply" shocks in the historical shock decompositions in section 5.

In RoW, there are shocks to labor productivity, price mark-ups, the subjective discount rate, the relative preference for domestic versus imported goods, to monetary policy, and to commodity supplies (described above).

3.6. International financial markets

Ricardian households in the EA hold net foreign assets (NFA) \( B^W_t \) that are in zero net supply and denominated in RoW currency. The law of motion of the NFA position in terms of EA currency is:

\[
B^W_t = (1 + i_{\text{ROW}}) e^{ROW}_{EA,t} B^W_{t-1} + TB_t + ITR\cdot PY_t,
\]

where \( TB_t \) is the trade balance. \( ITR \) is steady-state net international transfers received by EA and constant in terms of nominal GDP. The trade balance is the difference between the value of EA exports and the value of EA imports. The latter
include the imports of goods and services from US and RoW and the imports of industrial supplies from the RoW.

EA household utility includes preferences for portfolio holdings of domestic government bonds, domestic equity, and foreign bonds. There is a quadratic cost associated with the deviation of $B^W_t$ from its steady-state value of zero, which yields the following UIP condition as a FOC for foreign bond holdings (e.g., Kollmann (2001))

$$(1 + i_{ROW})E_t \left[ \frac{e^{ROW}_{EA,t+1}}{e^{ROW}_{EA,t}} \right] = (1 + i_t) + \alpha^{bw0} + \alpha^{bw1} \frac{e^{ROW}_{EA,t} B^W_t}{P_t Y_t} + \varepsilon_t^{bw},$$
in which $\varepsilon_t^{bw}$ is an autocorrelated exogenous shock to the preference for domestic assets.

The steady-state trade balance $TB_t$ is calibrated to the sample average, and $ITR$ is calibrated to make the non-zero $TB$ compatible with zero net foreign assets in steady state. The steady-state value of the "effective" stochastic discount factor is equal in all three regions in line with the zero steady-state NFA position, whereas the overall discount factor is region-specific in line with region-specific trend growth rates of consumption.

3.7. Exogenous shocks

The estimated model assumes 66 exogenous shocks. Other recent estimated DSGE models likewise assume many shocks (e.g., Kollmann et al. (2015)), as it appears that many shocks are needed to capture the key dynamic properties of macroeconomic and financial data. The large number of shocks is also dictated by the fact that we use a large number of observables (time series data for 60 variables, and initial values for 4 further variables) for estimation, to shed light on different potential causes of the post-crisis slump. Note that the number of shocks has to be at least as large as the number of observables to avoid stochastic singularity of the model.12

4. Model solution and econometric approach

We compute an approximate model solution by linearizing the model around its deterministic steady state. Following the recent literature that estimates DSGE models, we calibrate a subset of

---

12We follow the empirical DSGE literature (e.g. Lindé et al. (2015)), and select observables such that each shock has at least one associated observable that is strongly impacted by the shock (e.g. as we assume trade shocks, we use trade data to identify the trade shocks). The number of shocks exceeds the number of observables because we assume that TFP in each region is driven by a combination of transitory and permanent shocks. All shocks have a sufficiently distinct impact on observables so that shock identification is possible.
parameters to match long-run data properties, and we estimate the remaining parameters using Bayesian methods.\textsuperscript{13} The observables employed in estimation are listed in the Appendix.\textsuperscript{14}

One period in the model is taken to represent one quarter in calendar time. The model is thus estimated using quarterly data (bilateral trade flows disaggregated by products are only available at an annual frequency). The estimation period is 1999q1-2017q2.

We calibrate the model so that steady state ratios of main economic aggregates to GDP match average historical ratios for the EA and the US. The EA (US) steady state ratios of private consumption and investment to GDP are set to 56% (67%) and 19% (17%), respectively. The steady state shares of EA and US GDP in world GDP are 17% and 25%. The steady state trade share (0.5*(exports+imports)/GDP) is set at 18% in the EA and 13% in the US, and the quarterly depreciation rate of capital is 1.4% in the EA and 1.7% in the US. We set the steady state government debt/annual GDP ratio at 80% of GDP in the EA and 85% in the US. The EA and US steady state real GDP growth rate and inflation are set at 0.35% and 0.4% per quarter, respectively. We set the effective rate of time preferences to 0.25% per quarter.

5. Estimation results\textsuperscript{15}

5.1. Posterior parameter estimates

The posterior estimates of key model parameters are reported in Table 1. (Estimates of other parameters can be found in the Not-for-Publication Appendix.) The steady state consumption share of the Ricardian household is estimated at 0.78 in the EA and 0.83 in the US. Estimated consumption habit persistence is high in the EA (0.85) and the US (0.76), which indicates a sluggish adjustment of consumption to income shocks. The estimated risk aversion coefficient is 1.74 in the EA and 2.28 in the US. The parameter estimates suggest a slightly higher labor supply elasticity in the EA than in the US. Price elasticities of aggregate non-commodity imports are 1.2 for the EA and 1.3 for the US. The model estimates also suggest substantial nominal price stickiness and strong real wage rigidity. Estimated price adjustment costs and wage stickiness are both higher in the EA than in the US. By contrast, the estimated monetary and fiscal policy

\textsuperscript{13} We use the DYNARE software (Adjemian et al., 2011) to solve the linearized model and to perform the estimation. 
\textsuperscript{14} The observables are not demeaned or detrended prior to estimation. The model is estimated on first differences of real GDP, real demand components, and price indices, and on nominal ratios of aggregate demand components, trade flows and trade balances to GDP.
\textsuperscript{15} The presentation of results below focuses on key parameter estimates, impulse responses and historical shock decomposition. Additional results can be found in the Not-for-publication Appendix [TO BE ADDED]. There, we i.a. report predicted business cycle statistics (standard deviations and cross-correlations of key macro variables) for the EA, US and RoW; these statistics are broadly consistent with empirical statistics.
parameters are quite similar across both regions. The estimated EA and US interest rate rules indicate a strong response of the policy rate to domestic inflation, and a weak response to domestic output. The estimates also suggest that most exogenous variables are highly serially correlated, except commodity supply and demand shocks. The standard deviation of innovations to TFP, subjective discount factors, price and wage mark-ups and trade shares are sizable. The model properties discussed in what follows are evaluated at the posterior mode of the model parameters.

5.2. Impulse response functions

This section discusses dynamic responses to key shocks. We concentrate on the impact of supply and demand shocks originating in the RoW on EA and US growth, and EA and US trade balances. Throughout the discussion, we highlight the novel transmission mechanisms due to endogenous industrial supplies prices. The effects of supply and demand shocks originating in the EA and the US on domestic output are qualitatively similar to those predicted by standard DSGE models, but in the setting here, those effects are smaller because of the endogenous response of industrial supplies prices. In all impulse response plots, the responses of RoW, EA and US variables are represented by blue, red and black lines, respectively.

Effects of a persistent TFP shock in RoW

Our estimates suggest that sustained high GDP growth in RoW was mainly due to persistent positive RoW productivity shocks (see historical shock decomposition in Fig. 8a, discussed below). Figure 7a. shows the dynamic responses of a persistent positive shock to the RoW TFP growth rate which permanently raises the level of RoW GDP by about 2% within about 10 years. In response to that shock, EA and US trade balances fall initially, but quickly move into surplus. The TFP growth shock leads to a persistent increase of RoW intermediate goods output which can only be sold in world markets at a lower price, and it triggers an immediate nominal and real depreciation of the RoW currency. The expectation of a persistent rise in RoW GDP generates a significant push on RoW absorption because of rising income expectations. This also explains why RoW inflation increases. Because of adjustment frictions (consumption habits, investment adjustment costs), the domestic demand expansion is nevertheless quite gradual. On impact, the increase in RoW import demand leads to a fall in the RoW trade balance, and the RoW trade balance then improves because the supply of RoW manufactures increases continuously (and their price declines). The RoW productivity growth shock leads to a fall in EA and US
manufactures terms of trade. It is interesting to notice that EA and US GDP are (essentially) unaffected by the RoW productivity increase. This is due to a substantial rise in commodity prices. This commodity price increase is strong enough to induce an improvement of the overall RoW terms of trade.

The endogenous commodity price channel operating in this model makes the transmission of RoW income growth to the RoW less positive or even slightly negative (relative to standard models without that channel).

**Negative demand shock in RoW**

Demand shocks in RoW (modeled as persistent shocks to the subjective discount rate of RoW households) too are key drivers of RoW GDP growth, and these shocks also matter significantly for the RoW trade balance and they have strong spillover effects on EA and US GDP. Fig. 7b shows dynamic responses to a positive shock to RoW saving that triggers a 0.20% fall in RoW GDP, on impact. The shock reduces RoW imports demand, and it depreciates the RoW currency. It has a strong spillover effect to EA and US GDP: EA and US GDP are reduced by about 0.2%, on impact. The adverse demand shock in the RoW reduces commodity prices, which *dampens* the negative international spillover effect (compared to a model without commodities). The fall in commodity prices is stronger than the fall in RoW manufactures prices. RoW demand shocks thus contribute to the high volatility of industrial supply prices and (together with a low price elasticity of commodity demand) to the high volatility of EA and US imports of industrial supplies. The fall of industrial supply prices also mitigates somewhat the fall in EA and US trade balances.

**Commodity price shock**

The previous discussion shows that commodity prices respond strongly to TFP shocks and to aggregate demand shocks. In addition, commodity prices also exhibit strong responses to exogenous shocks to commodity supply, and to shocks to the efficiency of commodities in final good production (see the shock $s_i^{x}$ in the final good technology; see Sect. 3.2.3). The model estimates suggest that commodity supply and demand shocks are highly persistent. Fig. 7c. presents dynamic responses to a permanent positive shock to RoW commodity supply. The shock triggers a permanent fall in commodity prices, and it permanently raises GDP as well as aggregate demand in the EA and US. Due to the low price elasticity of commodity demand, a positive RoW commodity supply shock *lowers* commodity export revenues received by RoW.
This explains why RoW (real) consumption falls permanently. The fall in RoW commodity export revenue deteriorates the RoW trade balance, and it raises EA and US trade balances. This is accompanied by a depreciation of the RoW currency.

5.3. Shock decompositions

To quantify the role of different shocks as drivers of endogenous variables in the period 1999-2017 we plot the estimated contribution of these shocks to historical time series. Figures 8a-8f shows historical shock decompositions of year-on-year growth rates of the industrial supplies (IS) price (in Euro), and of EA, US and RoW GDP; also shown are historical decompositions of EA and US trade balance/GDP ratios. In each sub-plot, the continuous line shows historical time series, from which the sample average has been subtracted. The vertical black bars show the contribution of a different group of shocks (see below) to the data, while stacked light bars show the contribution of the remaining shocks. Bars above the horizontal axis represent positive shock contributions, while bars below the horizontal axis show negative contributions.

Given the large number of shocks, we group together shocks that have similar effects. Specifically, ‘TFP RoW’, ‘TFP EA’ and ‘TFP US’ represent the contributions of permanent and transitory productivity shocks in RoW, the EA and in the US, respectively. ‘Savings RoW’ captures RoW aggregate demand shocks. ‘Demand EA’ and ‘Demand US’ include investment risk premium shocks, household savings shock, as well as fiscal spending and monetary policy shocks. ‘Bond premium’ shocks represent shocks to EA and US uncovered interest parity conditions. Finally, as mentioned above, ‘Commodity supply’ shock include shocks to RoW commodity supply, while ‘Commodity demand’ shocks represent shocks to the energy efficiency of EA and US final good production.

Industrial supplies price

Industrial supply prices are mainly driven by commodity supply and commodity demand shocks, as well as by RoW saving (aggregate demand) shocks (see Fig. 8a). Permanent positive RoW TFP shocks have exerted upward pressure on commodity prices, during the pre-crisis boom, and during the post-crisis rebound. By contrast, EA and US TFP shocks have only had a modest effect on commodity prices. Interestingly, the steep fall in industrial supply prices between 2014 and 2016 is entirely driven by positive commodity supply prices (that fall in commodity prices
cannot be driven by weak GDP growth, since after 2013 growth resumed both in the US and the EA and recovered earlier in the RoW).

**RoW GDP growth**

Long-lasting high RoW GDP growth is mainly driven by permanent positive TFP growth shocks (see Fig. 8b). RoW TFP growth was, however, interrupted in 2001 and 2009, i.e. by the recessions caused by the bursting of the dot-com bubble, and the global financial crisis. Since 2010 we detect steady positive TFP contribution to growth in the RoW.

Demand shocks too are key drivers of RoW GDP fluctuations. The model identifies a negative demand shock in the late 90s associated with the Asian crisis (after 1997). RoW demand stayed low until the mid-2000 and therefore did not contribute positively to RoW GDP growth in the first years of 2000. A large negative RoW demand shock occurred during the global financial crisis, which was however followed by a positive shock in 2010.

**GDP growth in EA and US**

Compared to the RoW, the contribution of TFP shocks has been much smaller in the EA and US; see Figs. 8c and 8d. The model estimates suggest that EA and US GDP are fluctuating more closely around their long run trends than RoW. Fluctuations in EA and US GDP growth were largely due to saving and investment shocks, especially during the pre-crisis boom, and during the 2009 bust. After the crisis, the US has been recovering more quickly, than the EA, which experienced a second dip recession in 2012/13. Both in the US and the EA, monetary and fiscal policy provided some stabilization.

EA is hardly negatively affected by higher TFP growth in the RoW, while in the US a slight negative effect is visible. As already suggested by the impulse responses (see Figure 7), EA and the US benefits from RoW TFP growth are outweighed by upward pressure on industrial supply prices. Growth in EA and US since 2014 has been supported by a decline in industrial supply prices, mostly due to positive commodity supply shocks.

**EA and US trade balance to GDP ratios**

The stability of the EA trade balance before the great recession was due to a number of offsetting developments (see Fig. 8e). Negative RoW demand shocks had a negative effect on the trade balance in the period before the financial crisis, as well as after the crisis. During the early 2000s, this is was partly compensated by a negative effect on the trade balance generated by a reduced
risk premia on Euro denominated assets, possibly reflecting an increasing acceptance of the Euro in international financial markets.

Including industrial supplies in the model improves our understanding of the EA trade balance along various dimensions. Commodity supply shocks, triggering temporary changes in commodity prices help understand high frequency fluctuations of the trade balance. The fall in commodity prices after 2012 (due largely to positive commodity supply shocks) has also contributed significantly towards the improvement of the EA trade balance, during that period. Up to one half of the recent increase in the EA trade balance during the 2010s can be explained by commodity supply and demand shocks. Commodity shocks also help explain why the EA trade balance continued to increase after the start of the sustained output recovery in 2014.

As discussed above, the US trade balance fell sharply before the great recession; this was followed by a rapid and persistent trade balance improvement increase in 2009. The US boom (interrupted by the mild recession in 2002) is a key driver, another factor is rising US demand for industrial supplies (see ‘commodity demand’ shocks in Figure); see Fig. 8e. The RoW savings glut also plays a role (see ‘Saving RoW’ shocks), especially before 2003.

It has been observed by various authors (see Kollmann et al (2016)), that the recovery from the great recession was faster in the US--nevertheless the trade balance increased persistently in the US. Our model estimates suggest that the persistent post-crisis trade balance improvement is mostly explained by falling demand for imported commodities. This ‘commodities demand’ effect is stronger in the US (than in the EA) because of better possibilities to substitute imports by domestic production. More than two thirds of the improvement of the US trade balance after 2011 is due to commodity demand shocks.

6. Conclusion
This paper identifies key shocks that have driven economic fluctuations and external adjustment, in the Euro Area, the US and the rest of the world (RoW). In particular we highlight the key role of persistent RoW supply shocks (TFP), of commodity shocks, and of boom bust shocks in the EA and the US but also in the RoW. Our empirical analysis is based on an estimated three region model of the world economy, with endogenous commodity prices.

Of particular interest is our assessment of the rising EA trade surplus and persistent reduction of the US trade deficit, after the great recession. The model analysis does not interpret these developments as permanent phenomena. As shown in the impulse response analysis, even very persistent shocks, such as TFP growth shocks and permanent commodity supply shocks
merely have temporary effects on the trade balance. The period since 2014 is characterized by a sharp decline of industrial supply prices; this has supported growth in the EA and US, and increased the trade balances of both regions. However, even if industrial supply prices were to remain permanently at a lower level this should not have a permanent effect on US and EA trade balances. There are also a number of demand shocks which explain a significant fraction of current account fluctuations, but due to their nature only affect the trade balance temporarily. For example, there is a sizeable contribution from low domestic aggregate demand, especially in the EA.
References


Fig. 1a. Growth rate of real GDP (YoY, in %)

Fig. 1b. Shares in World nominal GDP (in US$ based on nom. exch. rates)

Fig. 2a. Commodity prices (in USD, 2009=100)

Fig. 2b. Real commodity price index, 1900-2015 (40 commodities; deflator: US CPI), 1900=100. Source: Jacks (2015)
Fig. 3a. EA Net exports by product

Fig. 3b. EA Net exports by region

Fig. 3c. US Net exports by product

Fig. 3d. US Net exports by region
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Fig. 3f. RoW Net exports by region, in % of RoW GDP
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Fig. 6a. EA import prices relative to EA CPI

Fig. 6b. US import prices relative to US CPI

Fig. 6c. EA terms of trade

Fig. 6d. US terms of trade
Fig. 7a Dynamic effects of a positive shock (1 standard deviation) to trend growth rate of RoW TFP
Note: blue, red and black responses pertain to RoW, EA and US variables, respectively. Trade balance (normalized by GDP), inflation (p.a.) and interest rate (p.a.) responses are expressed as percentage point responses from unshocked paths. Other responses are percent responses from unshocked paths. A fall in the exchange rate represents an appreciation. Horizontal axis: quarters after shock. The responses of RoW, EA and US variables are represented by blue, red and black lines, respectively.
Fig. 7b. Dynamic effects of a negative demand shock in RoW (1 standard deviation)

Note: blue, red and black responses pertain to RoW, EA and US variables, respectively. Trade balance (normalized by GDP), inflation (p.a.) and interest rate (p.a.) responses are expressed as percentage point responses from unshocked paths. Other responses are percent responses from unshocked paths. A fall in the exchange rate represents an appreciation. Horizontal axis: quarters after shock. The responses of RoW, EA and US variables are represented by blue, red and black lines, respectively.
Fig. 7c. Dynamic effects of positive shock to RoW commodity supply (1 standard deviation)

Note: blue, red and black responses pertain to RoW, EA and US variables, respectively. Trade balance (normalized by GDP), inflation (p.a.) and interest rate (p.a.) responses are expressed as percentage point responses from unshocked paths. Other responses are percent responses from unshocked paths. A fall in the exchange rate represents an appreciation. Horizontal axis: quarters after shock. The responses of RoW, EA and US variables are represented by blue, red and black lines, respectively.
Fig. 8a. Historical shock decomposition: Industrial supplies price, in Euro (year-on-year growth rate)

Fig. 8b. Historical shock decomposition: RoW GDP growth (yoy)
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Fig. 8d. Historical shock decomposition: US GDP growth (yoy)
Fig. 8e. Historical shock decomposition: EA trade balance/GDP ratio

Fig. 8f. Historical shock decomposition: US trade balance/GDP ratio
Table 1. Prior and posterior distributions of key estimated model parameters

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<tr>
<td>Investment risk premium</td>
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<td>0.02</td>
<td>0.94</td>
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<tr>
<td>Trade share</td>
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<td>0.01</td>
<td>0.85</td>
<td>0.05</td>
<td>B</td>
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<td>0.2</td>
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<tr>
<td>Commodities demand AR(1)</td>
<td>1.39</td>
<td>0.10</td>
<td>1.27</td>
<td>0.10</td>
<td>N</td>
<td>1.4</td>
<td>0.25</td>
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<td>Commodities demand AR(2)</td>
<td>-0.44</td>
<td>0.09</td>
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<td>0.10</td>
<td>N</td>
<td>-0.4</td>
<td>0.15</td>
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<table>
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<tr>
<th>Standard deviations (%) of innovations to forcing variables</th>
<th>Mode (1)</th>
<th>Std (2)</th>
<th>Mode (3)</th>
<th>Std (4)</th>
<th>Distrib. (6)</th>
<th>Mean (7)</th>
<th>Std (8)</th>
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<td>Monetary policy</td>
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<td>Gov. transfers</td>
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<td>0.03</td>
<td>0.68</td>
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<td>Permanent TFP level</td>
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<td>0.01</td>
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<td>Permanent TFP growth</td>
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<td>Subjective discount factor</td>
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<td>Investment risk premium</td>
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<td>0.05</td>
<td>0.21</td>
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<td>Domestic price mark-up</td>
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<table>
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<th>RoW</th>
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<th>Std (2)</th>
<th>Mode (3)</th>
<th>Std (4)</th>
<th>Distrib. (6)</th>
<th>Mean (7)</th>
<th>Std (8)</th>
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<td>Autocorr. Materials supply shock</td>
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Notes: Cols. (1) lists model parameters. Cols. (2)-(3) and Cols. (4)-(5) show the mode and the standard deviation (Std) of the posterior distributions of EA parameters and of US parameters, respectively. Cols. (6)
(labelled ‘Distrib.’) indicates the prior distribution function (B: Beta distribution; G: Gamma distribution; N: Normal distribution). Identical priors are assumed for EA and US parameters.
APPENDIX: DATA

1. Data sources
Data for the EA (quarterly national accounts, fiscal aggregates, quarterly interest and exchange rates) are taken from Eurostat. Corresponding data for the US come from the Bureau of Economic Analysis (BEA) and the Federal Reserve. Bilateral trade flows for manufacturing goods and industrial supplies are based on BEA data, IMF data (Direction of Trade Statistics), and the Eurostat Comext database. RoW series are constructed on the basis of the IMF International Financial Statistics (IFS) and World Economic Outlook (WEO) databases.

2. Constructing of data series for RoW variables
Series for GDP and prices in the RoW starting in 1999 are constructed on the basis of data for the following 58 countries: Albania, Algeria, Argentina, Armenia, Australia, Azerbaijan, Belarus, Brazil, Bulgaria, Canada, Chile, China, Colombia, Croatia, Czech Republic, Denmark, Egypt, Georgia, Hong Kong, Hungary, Iceland, India, Indonesia, Iran, Israel, Japan, Jordan, Korea, Lebanon, Libya, FYR Macedonia, Malaysia, Mexico, Moldova, Montenegro, Morocco, New Zealand, Nigeria, Norway, Philippines, Poland, Romania, Russia, Saudi Arabia, Serbia, Singapore, South Africa, Sweden, Switzerland, Syria, Taiwan, Thailand, Tunisia, Turkey, Ukraine, United Arab Emirates, United Kingdom, and Venezuela. The RoW data are annual data from the IMF International Financial Statistics (IFS) and World Economic Outlook (WEO) databases.
For details about the construction of RoW aggregates, see the Not-for-Publication Appendix.

3. List of observables
The estimation uses the time series information for 60 endogenous variables and initial values for additional 4 variables. The observables are:
Total Factor Productivity: EA, US;
Population: EA, US, RoW;
Labor force participation rate: EA, US;
Imports of Industrial Supplies (from RoW): EA, US;
Price of Imports of Industrial Supplies (from RoW): EA, US;
Change in Inventories (residually computed): EA, US;
Trade balance of Services (residually computed as difference of trade balance of goods and services and trade balance of goods): EA, US;
GDP deflator: EA, US, RoW;
Real GDP: EA, US, RoW;
CPI deflator (as a share of GDP deflator): EA, US;
Total Investment (private+public) deflator (as a share of GDP deflator): EA, US;
Exports (Goods) Deflator (as a share of GDP deflator): EA, US;
Imports (Goods) Deflator (as a share of GDP deflator): EA, US;
Potential GDP: RoW;
Total Hours: EA, US;
Nominal Interest Rate: EA, US, RoW;
Gov’t consumption (as a share of GDP): EA, US;
Gov’t investment (as a share of GDP): EA, US;
Transfers (as a share of GDP): EA, US;
Gov’t debt (as a share of GDP), computed as cumulative sum of budget deficits: EA, US;
Gov’t investment deflator (as a share of GDP deflator): EA, US;
Gov’t consumption deflator (as a share of GDP deflator): EA, US;
Private consumption (as a share of GDP): EA,US;
Total Investment (private + public) (as a share of GDP): EA,US;
Wages (as a share of GDP): EA,US;
Exports (Goods) (as a share of GDP): EA,US;
Gov’t Interest payments (as a share of GDP): EA,US;
Stock of physical capital (Only initial value): EA,US;
Oil price (Brent) in USD
Nominal Exchange Rate Euro/Dollar;
Nominal Effective Exchange Rate Euros;
Net Foreign Assets (as a share of GDP) (Only initial value) : EA,US;