EUROPEAN CENTRAL BANK
EUROSYSTEM

Working Paper Series

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Macroeconomic effects of tariffs shocks: the role of the effective lower bound and the labour market

No 2434 / July 2020

Abstract

We simulate a version of the EAGLE, a New Keynesian multi-country model of the world economy, to assess the macroeconomic effects of US tariffs imposed on one country member of the euro area (EA), and the rest of the world (RW). The model is augmented with an endogenous effective lower bound (ELB) on the monetary policy rate of the EA and country-specific labour markets with search-and-matching frictions. Our main results are as follows. First, tariffs produce recessionary effects in each country. Second, if the ELB holds, then the tariff has recessionary effects on the whole EA, even if it is imposed on one EA country and the RW. Third, if the ELB holds and the real wage is flexible in the EA country subject to the tariff, or if there are segmented labour markets with directed search within each country, then the recessionary effects on the whole EA are amplified in the short run. Fourth, if the elasticity of substitution among tradables is low, then the tariff has recessionary effects on the whole EA also when the ELB does not hold.

JEL classification: F16, F41, F42, F45, F47

Keywords: DSGE models, protectionism, unemployment, monetary policy.

Non-Technical Summary

Announcements of protectionist measures have renewed the academic and policy interest in the international macroeconomic effects of tariffs. The issue is particularly interesting when tariffs are imposed on some of the countries in the euro area (EA) by an extra-EA country, for the following reasons. First, trade flows among EA countries and between the EA and other extra-EA countries are relatively large. Higher tariffs on extra-EA exports of an EA country and on exports of main EA trading partners could cause (indirect) spillovers also to the rest of the EA (REA). The sign and the size of the spillovers could depend on the degree of substitutability or complementarity among tradables. Second, labour markets are country-specific and their idiosyncratic features, like wage rigidity and cross-sector labour mobility, can affect the impact of tariffs on the region-specific labour market and, thus, on macroeconomic conditions. Last, but not least, the effective lower bound (ELB) could bind the EA-wide monetary policy rate and, thus, affect the macroeconomic impact of tariffs (we do not analyse the role of non-standard monetary policy measures, which are tools for dealing with the ELB).

This paper addresses the above issues by developing and simulating a version of the EAGLE, a four-bloc dynamic general equilibrium model of the world economy. The model is calibrated to the euro area, the US, and the rest of the world (RW). The EA is modelled as a two-region monetary union, one labelled as Home and the other as the REA.

We run several counterfactual scenarios. In all of them we assume the imposition of US tariffs on all imports from the Home country and the RW bloc, but not on imports from the REA.

Our main results are as follows. First, tariffs produce recessionary effects in each country. Second, if the ELB holds, then the tariff has recessionary effects on the whole EA even if it is imposed on one EA country and the RW. Third – if the ELB holds and the real wage is flexible in the EA country subject to the tariff, or if there are segmented labour markets with directed search within each country – then the recessionary effects on the whole EA are amplified in the short run. Fourth, if the elasticity of substitution among tradables is low, then the tariff has recessionary effects on the whole EA also when the ELB does not bind.

The intuition for our results is as follows. The higher tariff has recessionary effects on the Home economy. Given the lower Home economic activity and inflation, the EA central bank reduces the policy rate until the ELB is hit. The constraint implies an increase in Home and

REA real interest rates, that depress aggregate demand in both regions. This amplification effect is further enhanced if Home real wages strongly decrease in the aftermath of the tariff increase, because lower wages are passed-through to lower price dynamics and, thus, higher real interest rates. This is the case also if segmented labour markets with directed search are assumed. Finally, spillovers to the REA are recessionary also in the case when there is no ELB and it is not easy to substitute tradable goods among each other and, thus, the favourable (to REA) trade diversion effect, associated with the higher tariffs on Home and RW exports, is relatively small.

1 Introduction

Announcements of protectionist measures have renewed the academic and policy interest in the international macroeconomic effects of tariffs. The issue is particularly interesting when tariffs are raised on goods produced predominantly in some of the countries in the euro area (EA), by an extra-EA country. The reasons are as follows. First, trade flows among EA countries and between the EA and other extra-EA countries are relatively large. Higher tariffs on extra-EA exports of an EA country and on exports of main EA trade partners could cause (indirect) spillovers also to the rest of the EA (REA). The sign and the size of the spillovers could depend on the degree of substitutability or complementarity among tradables (for example, because of a cross-country value chain, lower extra-EA exports by one EA country could induce the same country to reduce imports from its trading partners). Second, labour markets are country-specific and their idiosyncratic features, like wage rigidity and cross-sector labour mobility, can affect the impact of tariffs on region-specific labour market and, thus, on macroeconomic conditions. Last, but not least, the effective lower bound (ELB) could constrain the response of the EA-wide monetary policy rate and, thus, affect the macroeconomic impact of tariffs.

This paper addresses the above issues by developing and simulating a version of the EAGLE, a four-bloc dynamic general equilibrium model of the world economy. The model is calibrated, for illustrative purposes, to the euro area, the US, and the rest of the world (RW). The EA is modelled as a two-region monetary union, one labelled as Home (calibrated, for illustrative purposes, to Germany) and the other as the rest of the EA. There are three key novel features that we introduce in an otherwise standard New Keynesian framework with nominal price rigidities. First, there are country-specific labour markets with search-and-matching framework à la Mortensen and Pissarides (1999).[1] Second, we add real wage rigidities and imperfect cross-sector labour mobility. Third, there is the ELB, which can endogenously constrain the EA monetary policy rate, limiting the stabilization role of the (standard) monetary policy (we do not analyse the role of non-standard monetary policy measures, which are tools for dealing with the ELB).

In each region of the model, final consumption and investment goods are bundles of non-tradable and tradable goods. The tradable good is a bundle of domestic and imported goods,

[1] For a detailed description of the version of the model with the standard frictionless labour market, see Gomes et al. (2010, 2012).

where imports are themselves a bundle of imported goods from all other regions. These intermediate imported goods can be subject to tariffs, exogenously set by the domestic government. Firms in the intermediate sectors produce tradable and non-tradable goods using capital and labour, supplied by domestic households. The assumption of local currency pricing (i.e., nominal prices of exports are set in the currency of the destination market) implies international price discrimination and, thus, incomplete exchange rate pass-through to import and export prices in the short run.

The monetary policy rate systematically responds to domestic consumer price inflation (gross of tariff) and economic activity according to a Taylor rule. In the case of the EA, the policy rate reacts to the weighted average of Home and REA CPI inflation rates and economic activities. The weights are the steady-state regional shares of EA GDP. We assume that the ELB can limit the response of the EA monetary policy rate, as dictated by a Taylor-type rule, in the aftermath of the tariff shock.

Labour markets are region-specific and modelled using search frictions. Labour firms hire unemployed workers (the extensive margin) by posting vacancies and sell labour services to firms in the intermediate sectors. We consider alternative specifications of country-specific labour markets in the EA. The benchmark version of the model has, within each region, rigid real wages and a single labour market, where employees can move between tradable and non-tradable sectors without friction. We also consider flexible wages and, alternatively, frictions for labour moving from one sector to the other. This alternative setup has separate labour markets in the tradable and in the non-tradable sectors, but unemployed are allowed to decide in which sector to search. We refer to this setup as *segmented labour markets with directed search*. Compared to the benchmark model, workers moving among sectors are subject to a matching friction and labour firms post vacancies in each sector.

We run several counterfactual scenarios. In all of them we assume, as a working hypothesis, a long-lasting (ten-year) imposition of US tariffs of 20 percentage points on all imports from the Home country (an EA member) and the RW bloc (but not on imports from the REA). In the first scenario, the ELB endogenously binds the EA monetary policy rate. We then compare this scenario with the one in which the ELB does not bind. We run the above scenario under alternative assumptions on wage flexibility, labour mobility across tradable and non-tradable sectors, and elasticity of substitution between domestic and imported tradable goods. All scenarios are run under perfect foresight and tariffs are specified as ad-valorem duties imposed at the dock.

Our main results are as follows. First, the tariff has recessionary effects in each country. Second, if the ELB holds, then the tariff has recessionary effects on the whole EA even if it is imposed on only one EA country and on the RW. Third – if the ELB holds and the real wage is flexible in the EA country subject to the tariff, or if there are segmented labour markets with directed search within each country – then the recessionary effects on the whole EA are amplified in the short run. Fourth, if the elasticity of substitution among tradables is low, then the tariff has recessionary effects on the whole EA also when the ELB does not hold.

The intuition for our results is the following one. A higher tariff has recessionary effects on the Home economy and the RW. Given the lower Home economic activity and inflation, the EA central bank reduces the policy rate until the ELB is hit. The constraint implies a raise in Home and REA real interest rates that depress aggregate demand in both regions. This amplification effect is further enhanced if the Home wages strongly decrease in the aftermath of the tariff increase, because lower wages are passed-through to lower price dynamics and, thus, higher real interest rates. This is the case if wages are flexible or if we assume segmented labour markets with directed search. Finally, spillovers to the REA are recessionary also in the case of no ELB if it is not easy to substitute tradable goods among each other and, thus, the favourable trade diversion effect (for the REA), associated with the higher tariffs on Home and RW exports, is relatively small. For other countries, output and employment decline, but the decline is stronger in Home and the REA because interest rates are constrained by the ELB.

Our paper is related to the literature on macroeconomic effects of tariffs and their interaction with monetary policy and the labour market. Bergin and Corsetti (2020) study the optimal monetary policy responses using a New Keynesian model that includes global value chains in production, firm dynamics, and comparative advantage between two traded sectors. They find that, in response to a symmetric tariff war, the optimal policy response is generally expansionary. Bolt et al. (2019) use a global model similar to ours to analyse the effects of the US-China trade war, but do not focus on the intra-EA imbalances or consider the endogenous ELB and the role of labour market frictions. Different from them, our model considers intra-EA trade flows, both intensive and extensive labour margins, and the *endogenous* ELB for the EA monetary policy rate. Thus, our model has the main features to assess the impact of tariffs on EA trade, labour-market, and monetary policy. Lindé and Pescatori (2019) study the robustness of the Lerner symmetry result in an open economy New Keynesian model similar to ours. The Lerner symmetry result, i.e. the absence of allocative and trade-flow effects of an equally-sized change in import tariff and export subsidy, holds up approximately for a number of alternative assumptions that are satisfied also by our model. Different from Lindé and Pescatori (2019), we do not consider export subsidy in our analysis. Instead, we show the effect of import tariffs. Pisani and Vergara-Caffarelli (2018) evaluate the macroeconomics effects of tariffs implied by the Brexit on the U.K and the euro area, in a model featuring very detailed trade flows, but without search-and-matching frictions in the labour market. Barattieri et al. (2019) provide VAR-based evidence that protectionism acts as a supply shock, causing output to fall and inflation to rise in the short run. Moreover, protectionism has at best a small positive effect on the trade balance. Our results are qualitatively in line with theirs. Faruqee et al. (2008) analyse the effects of tariffs in a model of the global economy, but, among other differences, with different grouping of the regions (e.g., EA is grouped together with Japan).

The relationship between international trade and labour markets has received some attention (e.g., Helpman and Itshkoki, 2010, Felbermayr et al., 2011, Dix-Carneiro, 2014, Artuc and McLaren, 2015), but these papers tend to have a different focus than ours. Empirically, Dutt et al. (2009) find a positive relationship between protection and unemployment.

The paper is organized as follows. The next section reports the main equations affected by the tariffs, i.e., pricing and demand equations, and those of the labour market. Section 3 contains the calibration of the model. Section 4 illustrates the main results. Finally, Section 5 concludes.

2 Model

We develop and simulate a dynamic general equilibrium model (based on the EAGLE model as in Jacquinot et al., 2018) calibrated to the euro area, the US, and the RW, with tariffs on imported goods and search-and-matching frictions in the labour market.[2] The EA is modelled

[2]Following Merz (1995) and Andolfatto (1996), at the end of every period all household members (employed and unemployed) pool their income (together with any dividends and transfers received) and the household as a whole decides on saving and consumption. This is required to avoid dealing with individual heterogeneity.

as a two-country monetary union.

In each region there is a representative household, a representative firm in the final goods sector, a representative firm in the intermediate goods sector, a central bank (which is common in the case of Home and the REA), and a fiscal sector. The household is infinitely lived, consumes a final good, and allocates her time between work and leisure. She offers her labour services to domestic labour firms. The household owns the portfolio of domestic firms and domestic physical capital stock. The latter is rented to domestic firms in a competitive market. Labour and physical capital are internationally immobile. The representative household also buys and sells two (one-period) bonds: a domestic bond issued by the local public sector denominated in domestic currency paying the domestic monetary policy rate, and an international bond issued in zero net supply worldwide, denominated in US dollars and paying the US monetary policy rate. When undertaking positions in the international bond, the household pays a premium to financial intermediaries, whose size is a function of the aggregate net asset position of the country. Households residing in the EA also trade a one-period bond denominated in the common currency paying the EA policy rate.

On the production side, there are firms producing non-tradable final goods under perfect competition, and firms producing differentiated intermediate goods under monopolistic competition. There are three non-tradable final goods: a consumption good, an investment good, and a public good. The public good is produced only with non-tradable intermediate goods, while consumption and investment goods are produced using all available intermediate goods (domestic tradable, domestic non-tradable, and imported intermediate goods), combined according to a constant elasticity of substitution technology. There are many varieties of intermediate goods, which are imperfect substitutes. Each variety is produced by a single firm under monopolistic competition. The market power implies that each firm sets the nominal price of the produced good charging a mark-up over marginal costs, taking into account demand conditions and nominal price rigidities. Each intermediate good is produced using domestic labour and capital that are combined according to a Cobb-Douglas technology. Intermediate goods are sold both in the domestic and in the export market. There is international price discrimination as firms set prices in the currency of the importing country (as such, markets are segmented across countries and local currency pricing holds).

As for the monetary policy, the central bank sets the national short-term nominal interest rate according to a Taylor-type rule, by reacting to increases in consumer price index inflation and real activity. To capture the inertia in the conduct of monetary policy, we assume that the current period policy rate reacts to its one-period lagged value. In the EA, CPI inflation is defined as the weighted average of two region-specific CPI inflation rates and GDP as the sum of the regional gross domestic products.

As for the fiscal policy, we assume that it is conducted at a regional level. Each country sets government consumption expenditures, lump-sum taxes, labour taxes (split in social security contributions paid by labour firms and employees, respectively), capital income taxes, and consumption taxes. Moreover, in each country the public debt is stabilised through a fiscal rule that induces lump-sum taxes to endogenously adjust. Tax rates are exogenously set and kept constant throughout all simulations. Finally, the government exogenously sets ad valorem equivalent tariffs on imports.

The various regions are linked with each other through bilateral trade relations and participation in international financial markets.

2.1 Tariffs

This section describes how tariffs enter the main pricing and demand equations of the model. The notation follows Gomes et al. (2010, 2012).

2.1.1 Optimal price setting of imported intermediate goods

Let us consider firms producing intermediate goods in the Home (H) country tradable sector. They sell their good domestically and export it to the generic country CO. The generic H firm acts under monopolistic competition and sets the nominal price of its variety in the currency of the destination market CO subject to nominal rigidities à la Calvo (1983) and local CO demand conditions. That is, local currency pricing (international price discrimination) is assumed. Each firm resets the price of its exported variety in country CO with probability (1-ξ_X), where $0 \leq \xi_X \leq 1$. In any given period, firms that change their price optimally set the same price $\tilde{P}_{IM,t}^{CO,H}$ of H goods exported to region CO. The implied first order condition (FOC) is

$$\frac{\tilde{P}^{CO,H}_{IM,t}\left(1+\tau^{CO,H}_{X,t}\right)}{P^{CO,H}_{IM,t}\left(1+\tau^{CO,H}_{X,t}\right)} = \frac{\theta_T}{\theta_T - 1}\frac{f^{H,CO}_{X,t}}{g^{H,CO}_{X,t}}, \tag{1}$$

where $P^{CO,H}_{IM,t}$ is the price in CO of the bundle composed by H varieties, $\theta_T > 1$ is the elasticity of substitution among H varieties, and $\tau^{CO,H}_{X,t}$ are tariffs imposed by the CO government on H goods. The terms $f^{H,CO}_{X,t}$ and $g^{H,CO}_{X,t}$ are, respectively,

$$f^{H,CO}_{X,t} = \frac{s^{CO}}{s^H} IM^{CO,H}_t MC_{T,t} + \xi_X \beta E_t \frac{\Lambda_{t+1}}{\Lambda_t}\left(\frac{\Pi^{CO,H}_{IM,t+1}\frac{\left(1+\tau^{CO,H}_{X,t+1}\right)}{\left(1+\tau^{CO,H}_{X,t}\right)}}{\left(\Pi^{CO,H}_{IM,t}\frac{\left(1+\tau^{CO,H}_{X,t}\right)}{\left(1+\tau^{CO,H}_{X,t-1}\right)}\right)^{\chi_X}\left(\overline{\Pi}^4\right)^{\frac{1}{4}(1-\chi_X)}}\right)^{\theta_T} f^{H,CO}_{X,t+1}, \tag{2}$$

$$\begin{aligned} g^{H,CO}_{X,t} = &\left(1+\tau^{CO,H}_{X,t}\right) S^{H,CO}_t P^{CO,H}_{IM,t}\frac{s^{CO}}{s^H} IM^{CO,H}_t + \\ &+ \xi_X \beta E_t \frac{\Lambda_{t+1}}{\Lambda_t}\left(\frac{\Pi^{CO,H}_{IM,t+1}\frac{\left(1+\tau^{CO,H}_{X,t+1}\right)}{\left(1+\tau^{CO,H}_{X,t}\right)}}{\left(\Pi^{CO,H}_{IM,t}\frac{\left(1+\tau^{CO,H}_{X,t}\right)}{\left(1+\tau^{CO,H}_{X,t-1}\right)}\right)^{\chi_X}\left(\overline{\Pi}^4\right)^{\frac{1}{4}(1-\chi_X)}}\right)^{\theta_T-1} g^{H,CO}_{X,t+1}, \end{aligned} \tag{3}$$

where $0 < s^{CO}, s^H < 1$ are the sizes of the CO and the H economies, respectively, the term $IM^{CO,H}_t$ represents CO imports of H goods, $MC_{T,t}$ are marginal costs of H firms expressed in H currency, E_t is the expectation operator, Λ_t is the H household's marginal utility of consumption, and $0 < \beta < 1$ her discount factor.[3] $S^{H,CO}_t$ is the bilateral nominal exchange rate of the CO currency vis-à-vis the H currency (number of CO currency units per unit of H currency). Parameter χ_X denotes the rate of indexation of H prices ($0 \leq \chi_X \leq 1$). Specifically, those H firms that are not able to change prices in country CO index them to two terms. The first is

$$\Pi^{CO,H}_{IM,t}\frac{\left(1+\tau^{CO,H}_{X,t}\right)}{\left(1+\tau^{CO,H}_{X,t-1}\right)} = \frac{P^{CO,H}_{IM,t}\left(1+\tau^{CO,H}_{X,t}\right)}{P^{CO,H}_{IM,t-1}\left(1+\tau^{CO,H}_{X,t-1}\right)}\Pi_t, \tag{4}$$

i.e., the previous-period change in the price of H imported goods bundle and the change in

[3] We assume firms are owned by the domestic households.

tariffs between the previous and current period, while $\Pi_t \equiv P_t/P_{t-1}$ is the overall CO gross CPI inflation. The second term to which H prices are indexed to is the CO annual central bank inflation target $\overline{\Pi}^4$ (assumed to be the same across all countries and constant across simulations).

Given the price setting described above, the price in CO of the bundle of imported intermediate H goods is defined as:

$$\left(P_{IM,t}^{CO,H}\left(1+\tau_{X,t}^{CO,H}\right)\right)^{1-\theta_T} = (1-\xi_X)\left(\tilde{P}_{IM,t}^{CO,H}\left(1+\tau_{X,t}^{CO,H}\right)\right)^{1-\theta_T} + \\ + \xi_X\left(\frac{P_{IM,t-1}^{CO,H}\left(1+\tau_{X,t-1}^{CO,H}\right)}{\Pi_t}\left(\Pi_{IM,t-1}^{CO,H}\frac{\left(1+\tau_{X,t-1}^{CO,H}\right)}{\left(1+\tau_{X,t-2}^{CO,H}\right)}\right)^{\chi_X}\left(\overline{\Pi}^4\right)^{\frac{1}{4}(1-\chi_X)}\right)^{1-\theta_T}. \quad (5)$$

2.1.2 Demand for imported goods

In a generic country CO there are final non-tradable consumption and investment goods, produced by local firms under perfect competition by assembling intermediate goods according to a constant elasticity of substitution (CES) technology. Tradable goods consist of domestic and imported goods. Imports, in turn, are also a CES-aggregated good, consisting of imports from all (non-CO) regions. When imports are purchased, they are subject to tariffs. In the case of firms in the CO final consumption sector, the implied demand for (imported) intermediate goods produced by the (generic) H country is

$$IM_t^{C,CO} = \nu_{IM^C}^{CO,H}\left(\frac{(1+\tau_{X,t}^{CO,H})P_{IM^C,t}^{CO,H}}{P_{IM^C,t}\Gamma_t^{CO,H}}\right)^{-\mu_{IM^C}}\frac{IM_t^C}{1-\Gamma_t^{CO,H}}, \quad (6)$$

where $0 < \nu_{IM^C}^{CO,H} < 1$ is the weight of H goods in the CO CES aggregator, $\mu_{IM^C} > 0$ is the (long-run) intratemporal elasticity of substitution between imports from different regions, and $\Gamma_t^{CO,H}$ represents adjustment costs paid by CO to import H intermediate goods (thus, the short-run import intratemporal elasticity of substitution is lower than its long-run counterpart).

The corresponding CO price index for overall imported goods is

$$P_{IM^C,t} = \left[\sum_{H\neq CO}\nu_{IM^C}^{CO,H}\left(\frac{(1+\tau_{X,t}^{CO,H})P_{IM^C,t}^{CO,H}}{\Gamma_t^{H,CO}}\right)^{1-\mu_{IM^C}}\right]^{\frac{1}{1-\mu_{IM^C}}}. \quad (7)$$

Analogous equations hold for firms in the CO final investment goods sector.

2.2 The labour market

This section provides an overview of the main equations of the labour bloc of the model. The full set of equations is in Appendix A.

In each bloc the labour market is modelled using search-and-matching frictions (Mortensen and Pissarides, 1999). In particular, we assume that there is a continuum of labour firms, each employing one worker. Labour firms hire workers by posting vacancies. Using hired workers, labour firms produce labour services, which they sell to firms in the intermediate tradable and non-tradable sectors. Labour firms also negotiate wages and hours worked with households. Our benchmark version of the model has sticky wages and a labour market where employees can move between tradable and non-tradable sectors without friction, but movements from unemployment to employment are subject to search frictions.[4] Thus, in this framework wages and hours worked are the same across sectors.

The setup of the labour market implies that when a tariff is imposed on goods from a particular bloc, the after-tariff prices of imports from that bloc increase. This reduces demand for imported goods. Thus, producers of exported goods have to reduce their demand for labour services, which leads to lower profits of labour firms. The latter respond by reducing the number of vacancies. The implied increase in unemployment reduces wages in the exporting economy. In principle, everything else equal, this would stimulate employment in the intermediate non-tradable sector, because firms in that sector are not directly affected by tariffs. However, a recession induced by the negative shock in the tradable sector also typically implies a reduction in aggregate demand in the non-tradable sector. We describe these mechanisms in more detail when we discuss each of the simulations.

We introduce equilibrium wage stickiness using the wage norm advocated by Hall (2005). We assume that the household and the labour firm bargain over the real wage, but that wages adjust only by a fraction, so that the real wage, w_t, is a weighted average of the steady-state wage, $\overline{w}$, and the fully flexible wage that would be the outcome of the Nash bargaining for wages,

[4]Separations are exogenous.

$w_{Nash,t}$.[5]

$$w_t = \lambda_W w_{Nash,t} + (1 - \lambda_W)\overline{w}, \tag{8}$$

where $0 < \lambda_W < 1$ is the weight the currently-negotiated wage in the wage norm. Note that with rigid wages, the value of a worker for a firm does not depend on the flexible wage $w_{Nash,t}$, but on the rigid wage. The value of a worker and the probability that a firm finds a worker determine vacancy posting.

An advantage of using sticky wages is that it addresses the so-called Shimer puzzle. In his paper, Shimer (2005) argues that the standard search and matching model is not able to generate sufficient volatility of (un)employment and vacancies. As suggested by Shimer (and many others since), adding some wage rigidity to the model is one of the features that helps the model to generate sufficient volatility in unemployment and vacancies.

We also consider, in the robustness analysis, two alternative setups. First, we assume that wages are flexible instead of being rigid. Thus,

$$w_t = w_{Nash,t}. \tag{9}$$

Second, we keep the sticky wage assumption, as in the benchmark setup, but introduce frictions, in the form of sector-specific matching functions, for labour moving from one sector to the other and where unemployed are allowed to decide in which sector to search. We refer to the latter setup as *segmented labour markets with directed search.* In each sector, denoted by the superscript s, where $s \in [T, N]$, and where T stands for tradable and N for non-tradable, there is a separate matching function, and a separate set of matching probabilities:[6]

$$M_t^s = \phi_{mat}^s un_t^{s\ \mu_{mat}^s} vac_t^{s\ 1-\mu_{mat}^s}, \tag{10}$$

where M_t^s is the matching function that denotes the number of matches within the sector s in

[5]While this approach might be considered as a short-cut compared with wage bargaining based on nominal wages and wage rigidity obtained by the Calvo wage setting, it has the advantages that it is simpler and that wage never leaves the bargaining set (see Hall (2005) for details).

[6]When s denotes a sector it is always used as a superscript. When it denotes country size, it is never used as a superscript.

each period, un_t^s is the number of unemployed workers searching for a job in sector s, vac_t^s is the number of vacancies in sector s, $\phi_{mat}^s > 0$ is the sectoral efficiency of the matching process, and $0 < \mu_{mat}^s < 1$ is the sectoral elasticity of the matching function with respect to employment. The probabilities for a searching worker in sector s to find a job, $p_t^{s,W}$, and for a firm searching for a worker, $p_t^{s,F}$, are standard:

$$p_t^{s,W} \equiv \frac{M_t^s}{un_t^s} = \phi_{mat}^s \left(\frac{vac_t^s}{un_t^s}\right)^{1-\mu_{mat}^s}, \tag{11}$$

$$p_t^{s,F} \equiv \frac{M_t^s}{vac_t^s} = \phi_{mat}^s \left(\frac{vac_t^s}{un_t^s}\right)^{-\mu_{mat}^s}. \tag{12}$$

The value functions share the specification in the benchmark model, with the only difference that the matching probabilities above replace matching probabilities in each sector. Similarly, each sector has its own Nash bargaining setup for hours and wages. While these functions and definitions are common to both sectors, differences among the setups arise in how worker flows are determined, and we discuss these separately below.

We allow workers to move among sectors by allowing directed search (see Quadrini and Trigari (2007), Afonso and Gomes (2014), or Jacquinot et al. (2018) for the application to the private-public sector search). This setup implies that workers are free to move among sectors, but are subject to matching frictions before they find a job in the other sector. Importantly, directed search ensures that wages in both sectors are equalised (and that they move together), unless there are differences in, say, sectoral wage rigidity.[7]

If the number of employed workers in sector s is nde_t^s, the number of searching workers is un_t^s, the sectoral separation rate is $0 < \delta_x^s < 1$, then the aggregate number of employed workers, nde_t, is

$$nde_t = nde_t^T + nde_t^N \tag{13}$$

and the law of motion for employment in each sector is

[7] Searching workers move to the sector where the expected value of searching is higher, and this value is mainly determined by wages. If wages in one sector were higher, this would cause workers to move into this sector, pushing its wages down (and pushing wages up in the sector from which they move).

$$nde_t^s = (1 - \delta_x^s) nde_{t-1}^s + M_t^s. \tag{14}$$

Total population in a country corresponds to its size, but in per-household terms, the mass of household members is 1, so that the total number of unemployed in a country *at the end of the period t* is is defined as

$$une_t = 1 - nde_t. \tag{15}$$

The aggregate number of searching workers, un_t, includes those workers who have separated *in the beginning of period t*, but have not yet found jobs:

$$un_t = 1 - nde_{t-1}^T + \delta_x^T nde_{t-1}^T - nde_{t-1}^N + \delta_x^N nde_{t-1}^N, \tag{16}$$

and the total number of searching workers is

$$un_t = un_t^T + un_t^N. \tag{17}$$

The condition that determines the allocation of the searching workers between un_t^T and un_t^N depends on the value of being employed in each sector, E_t^s, and on the value of being unemployed in each sector, U_t^s.[8] This condition requires that the expected value of searching in one sector (whether the search ends in employment or in unemployment) is equal to the expected value of searching in the other sector:

$$(1 - p_t^{T,W}) U_t^T + p_t^{T,W} E_t^T = (1 - p_t^{N,W}) U_t^N + p_t^{N,W} E_t^N. \tag{18}$$

Equation 18 is called a directed search condition and it determines how many unemployed workers will search in each sector.

[8]See Appendix A for the definitions of these values.

3 Calibration

The model blocs are calibrated to Germany (Home country), the rest of the euro area (REA), US, and RW. The frequency of the model is quarterly.

Table 1 reports the great ratios that were matched (the sources are Eurostat, National accounts, and the IMF). Table 2 contains the matched trade matrix. Reported trade patterns show that both EA blocs trade mainly with each other and with the RW, while trade with the US is rather limited. In particular, the RW is a relevant trading partner for Home.

Table 3 contains the markups. The markups in the EA non-tradable sectors (a proxy for services) are higher than the corresponding values in the US and RW. The markup in the tradable sector (a proxy for manufacturing) is the same across regions.[9]

The implied calibration of preference and technology parameters is in Table 4. Discount factor is set to imply the annualised steady-state annual interest rate of 3%, habit formation, the intertemporal elasticity of substitution and the Frisch labour supply elasticity are set to 0.70, 1, and 0.50, respectively. The quarterly depreciation rate of capital is 0.025 (10% annual depreciation rate). The share of capital in the Cobb-Douglas production functions for tradable and non-tradable intermediate goods is 0.30. In the final goods baskets, elasticity of substitution between domestic and imported tradables is higher than that between tradables and non-tradables (0.6 and 0.5, respectively, see Bayoumi et al., 2004).[10] The quasi-shares of tradable goods in the consumption and investment baskets are set to 0.45 and 0.75, respectively, in each region of the EA and to 0.35 and 0.75 in the US and RW. The weight of domestic tradable goods in the consumption and investment tradable baskets is different among regions, and is set to match the multilateral import-to-GDP ratios. We set the weights of bilateral imports in the bundles to match the trade matrix reported in Table 2.

Table 4 also reports the elasticities of substitution between imports from different regions, elasticities of substitution between imports and home tradables, and elasticities of substitution between tradable and non-tradable goods. There is high uncertainty surrounding the estimates of this parameter. Given the extensive development of global value chains, in particular among

[9] The chosen values are consistent with the estimates from Martins et al. (1996), so that the degree of competition in the non-tradable sector is lower than in the tradable sector. Also, these values are in line with other studies, such as Bayoumi et al. (2004), Faruqee et al. (2007) and Everaert and Schule (2008).

[10] Short-run elasticity for imported goods is lower because of adjustment costs on imports.

countries of the EA, and the implied complementarity among traded goods and services, it cannot be excluded that the elasticity has a relatively low value. A low value would also be consistent with the positive (unconditional) correlation among the macroeconomic conditions of the EA and those of the other EA countries. Thus, we make consumption and investment imports from different regions complements by setting $\mu_{TI} = \mu_{TC} = 0.60$ and $\mu_{IMI} = \mu_{IMC} = 0.60$.[11] In this setting, all imports and all tradable goods are complementary (but still less complementary than tradable and non-tradable goods in the final consumption basket). The setting is important because it captures the property that when tariffs are imposed, imports from one region cannot simply be substituted with the imports from other regions if they are part of a value chain.

Table 5 reports nominal and real rigidities. We set Calvo price parameters in the domestic tradables and non-tradables sector to 0.92 (12.5 quarters) in the EA, consistent with the estimates by Christoffel et al. (2008) and Smets and Wouters (2003). The corresponding nominal rigidities outside the EA are set to 0.75, implying an average frequency of adjustment equal to 4 quarters, in line with Faruqee et al. (2007). Calvo parameters in the export sector are set to 0.75 in all the regions. The indexation parameters on prices are equal to 0.50. Adjustment costs on imports of consumption and investment goods are set to 2 and 1, respectively. We set adjustment costs on investment changes to 6 in the EA and to 4 in the US and RW. Wage rigidity parameter λ_w is set to 0.75 in all regions, implying that real wages adjust only 75% towards what the per-period Nash-bargained flexible wage would be.

Table 6 reports parameters in the monetary and fiscal rules. The interest rate reacts to its lagged value (inertial component of the monetary policy), annual inflation and quarterly output growth. The steady-state inflation target is set to 2% on an annual basis. In the EA, monetary policy reacts to the EA-wide variables. For fiscal rules, *lump-sum* taxes stabilize public debt. Steady-state ratios of government debt over (quarterly) GDP are equal to 2.40 in all the regions (0.6 in annual terms). Tax rates are set to be consistent with empirical evidence (see Coenen et al., 2008).

The details of the calibration of the labour market are reported in Table 7. We set the matching probability for firms on the basis of estimates for the US in den Haan et al. (2000),

[11] Corsetti et al. (2008) consider a range of the elasticity of substitution between domestic and imported goods between 0.5 and 1.5.

as better estimates for Europe and other countries are not available (similar values were used by Stähler and Thomas, 2012). The unemployment rate is set to 8% in Home and the REA, and to 6% in the US and the RW.

We calibrate some of the main labour market parameters using the estimates by Elsby et al. (2013), who estimate job finding rates for a number of the OECD economies. They also find that the separation rate between firms and workers is lower in the EA (and Home within the EA). We transform their monthly job finding rates into quarterly job finding probabilities, which we then use to calibrate the model. The main feature of the calibration is that labour markets differ substantially among the blocs in the model. The REA and Home labour markets are slow to react, while the US labour market is faster. The labour market in the RW is somewhere in between.[12] The US calibration follows den Haan et al. (2000), while the calibration of Germany follows Jung and Kuhn (2014). The latter find that the matching efficiency in Germany is low compared to the US and that this can explain the bulk of the cross-country labour market differences. We calibrate the break-up rate to match the level of unemployment in each bloc. The disutility of labour is calibrated so that, in the steady state, hours per worker are 1 (labour services in the steady state are equal to the level of employment). The setting of job finding rates, given job filling rates, gives us matching efficiency and vacancy posting costs. In this way, we obtain the matching efficiency of approximately 0.33 for Germany and 0.75 for the US.

We calibrate the matching elasticity to 0.5, which is in the middle of the range reported by Petrongolo and Pissarides (2001). The bargaining power of workers is set to 0.5, which is also in line with the literature.[13] Unemployment benefits are set as a proportion of the steady-state wage, where the proportion is the replacement ratio. Replacement ratios are broadly in line with the OECD estimates and are set to be higher for blocs in the EA, at 0.5, and lower in the US and the RW, at 0.2. The labour supply elasticity is set to 0.5 (implying its inverse, $\zeta = 2$) and follows Gomes et al. (2012).

[12] Elsby et al. (2013) report job finding rates only for a subset of the euro-area countries (France, Germany, Ireland, Italy, Portugal, and Spain), and only for a subset of the countries that comprise the RW in our model (Australia, Canada, Japan, New Zealand, Norway, Sweden, and U.K). We take the population-weighted averages of these estimates to obtain the estimates for the REA and the RW blocs.

[13] Moreover, the choice of the bargaining power equal to the matching elasticity satisfies the Hosios condition in flexible price models.

4 Results

In all scenarios we simulate an increase in US tariffs by 20 percentage points on both Home and RW tradables, which begins in the first period of simulations, lasts for ten years, is fully credible and, with the exception of the first period, fully anticipated by households and firms (perfect foresight).[14] In the benchmark scenario the ELB endogenously constrains the EA monetary policy rate. We assume that the ELB is only 10 (annualized) basis points below the steady-state level of the monetary policy rate, consistent with the current very low level of the monetary policy rate in the EA. We run the same scenario again, but this time assuming that the ELB does not hold in the EA. This allows us to disentangle its role in the transmission mechanism of the US tariff shock to the EA economy. The benchmark scenario is also simulated under alternative assumptions regarding wage flexibility in Home, cross-sector labour mobility *in all four blocs*, and the high long-run elasticity of substitution among tradable goods in all four blocs.

4.1 US tariff increase on imports of Home and RW goods

Figure 1 shows the responses of the main Home trade variables and US imports to a 20 percentage point-increase in US tariffs on all Home and RW tradables under the assumption that the ELB in the EA can be binding.

The top chart reports the multilateral and bilateral Home trade balances (each of them as a % of Home nominal GDP). Overall, the multilateral trade balance deteriorates. The deterioration is associated with the worsening of the bilateral trade balances vis-à-vis the US, due to the US tariffs, and vis-à-vis the RW. Instead, the Home trade balance vis-à-vis the REA improves.

Home exports and imports drop. Home exports to RW decrease persistently in the medium run, because of lower RW aggregate demand, associated with the negative effects of higher US tariffs on the RW economic activity (RW exports to US decrease) and, thus, on RW income and aggregate demand. Home exports to REA decrease as well, because the REA economy and, thus, REA aggregate demand is negatively affected by the decline in world economic activity.

Home imports widely decrease because of the lower Home aggregate demand (see below).

[14] Revenues from tariffs are part of the government budget constraint. The fiscal rule is specified in terms of lump-sum taxes that systematically change to stabilize the public debt. We choose lump-sum taxes because they are non-distortionary and thus do not affect main variables' responses to the tariff shock.

The drop in the Home imports limits the Home trade balance deterioration. The Home real exchange rate vis-à-vis the US dollar strongly and persistently depreciates, consistent with the lower US demand for Home goods and services. It depreciates to a lesser extent vis-à-vis the RW currency.

US imports of Home and RW products decrease, while US imports of REA products increase, because of the trade diversion effect of higher US tariffs on Home and RW exports, which is favourable for REA exports. Thus, US households and firms substitute REA goods and services for Home and RW goods and services, and the US trade balance improves in a relatively mild way (not reported to save space).

Figure 2 reports the responses of the main macroeconomic variables. GDP decreases in each bloc, including the US economy. US investment persistently decreases. Investment has a higher import content than consumption. Given the low elasticity of substitution, it is difficult to substitute US and REA goods for more expensive RW and Home goods. At the same time, households switch away from investment towards consumption, to smooth consumption over time. US consumption slightly increases, but by an amount which is not large enough to avoid the decrease in overall aggregate demand and, thus, GDP. The negative effect of lower US aggregate demand on US production is in absolute terms larger than the favourable price competitiveness effect on US goods from tariffs. Higher tariffs induce a small initial increase in US inflation. The US central bank raises the policy rate only by a small amount, consistent with the contained increase in inflation and taking into account the drop in US economic activity.

Similarly, RW production gradually decreases, given the higher US tariffs. Consistent with the lower income, RW consumption and investment in physical capital gradually decrease as well. Because the RW is not constrained by the ELB, a decline in monetary policy rate can mitigate much of the drop in consumption.

Crucially, the drops in GDP, its components, and inflation are more front-loaded and much larger for Home and the REA than for the US and the RW. Moreover, the Home and REA decreases are quite similar, even though the tariff was raised only on Home goods. The observed similarity in the Home and REA responses are due to the ELB constraining the response of the EA monetary policy rate. Thus, real interest rates rise in both Home and the REA. Absent the ELB, the policy rate would be reduced by the EA central bank to offset the deflationary effects of higher US tariffs. Also, Home and the REA are closely intertwined because of trade, so that the drop in Home activity and aggregate demand has negative spillovers to the REA economy.[15]

Consistent with the lower economic activity, labour market variables deteriorate in each bloc, as reported in Figure 3. Firms reduce their demand for labour, which shows in the decrease in employment (extensive margin), vacancies, job finding rates, and hours worked (intensive margin). Given lower labour demand, the real wage decreases as well. As for the main macroeconomic variables, the decrease is more front-loaded and much larger for Home and the REA, and the Home and REA responses are similar to each other.

The tariff imposition has negative effects on the US labour market variables, the relatively flexible labour market notwithstanding (matching efficiency and break-up rate are calibrated to relatively high values for the US case). All of them decrease, in a gradual way, following lower labour demand by firms.

Overall, our results suggest that the imposition of US tariffs on Home and RW goods has domestic and international recessionary effects. Moreover, Home and REA economic activity and aggregate demand face a similar large initial decline even if the shock is originally Home-specific, because of the ELB on the EA monetary policy rate and strong trade linkages.

4.2 The role of the ELB

We investigate the role of the ELB for the transmission of the US tariff increase to EA macroeconomic variables. To do so, we simulate again the scenario reported in the previous section (20 percentage point-increase in US tariffs on Home and RW tradables), this time assuming that the ELB does not constrain the reduction of the monetary policy rate implemented by the EA central bank to offset deteriorating macroeconomic conditions.

Figure 4 plots the bilateral Home-REA trade variables under the two alternative assumptions regarding the ELB. The improvement of the Home trade balance vis-à-vis the REA is slightly more front-loaded in the no-ELB case, because Home exports to the REA decrease at a slower rate.

[15]The ELB is long-lasting because, as said, we assume that the ELB is only 10 (annualized) basis points below the steady-state level of the monetary policy rate. Moreover, the tariff shock is long-lasting as well (10 years). Qualitatively, results do not greatly change if we consider a lower ELB or a tariff shock that lasts a lower number of periods.

The Home real exchange rate vis-à-vis the REA depreciates in both scenarios.[16] The depreciation is somewhat larger when the ELB holds, because the latter amplifies the negative effects of tariffs on Home aggregate demand and, thus, on Home prices.

Figure 5 shows the responses of main macroeconomic variables in the two cases. When the ELB is binding, both Home and REA aggregate demands for consumption and investment have similar responses, i.e., they both decrease by large amounts (much larger than in the no-ELB case). If the ELB holds, the decrease in REA aggregate demand is larger and, thus, has a larger negative effect on Home exports.

Relative to the ELB case, REA aggregate demand decreases less when the ELB does not bind. The smoother decrease in REA aggregate demand favours a slower decrease in Home exports. This explains why Home exports to REA decrease to a somewhat lesser extent if the ELB does not bind. In the short run the EA central bank raises the policy rate to counter the rising REA inflation (the REA bloc of the EA is bigger than Home, and therefore affects EA inflation and economic activity relatively more). However, in the medium and long run the EA central bank has to reduce the policy rate below the baseline level, as the initial inflation fades out, because US aggregate demand (and, thus, REA exports to the US), decreases. The medium- and long-run reduction of the EA policy rate is not possible under the ELB assumption. EA households and firms anticipate it, and thus reduce aggregate demand already in the short run, which immediately reduces inflation. The central bank responds by reducing the policy rate immediately, and the ELB becomes binding already in the short run. The implied increase in both Home and REA real interest rates depresses macroeconomic conditions in both regions in a synchronous way.

Figure 6 shows the responses of the main labour market variables. Their dynamics follows those of GDP and its components. When the monetary policy rate is not constrained by the ELB, REA labour market conditions deteriorate by much less than those in Home, because the central bank can provide some stimulus to the economy and because the REA is not directly affected by the adverse tariffs shock. Under the ELB assumption, both Home and REA labour variables follow large (in absolute terms) recessionary patterns, consistent with the amplification

[16]Home real exchange rate vis-à-vis the REA is equal to the difference between Home and REA and consumer price inflation rates, given that the nominal exchange rate is constant because they are both in the euro area.

effect of the ELB on the transmission of the adverse US tariff shock.

Overall, the reported results suggest that the increase in US tariffs on RW and Home exports has negative effects on both Home and REA economies. If the ELB constrained the EA central bank, the direct and indirect effects of the US tariff would affect both EA regions in a rather similar way, even if the US tariff is, in principle, a Home- and RW-specific shock.

4.3 Wage and labour market flexibility

4.3.1 Flexible wage in Home

In our benchmark case, we assume that real wages are somewhat rigid (average wages can adjust only a fraction towards the newly-bargained level in each period) and equally sticky in Home and in the REA. We simulate the US tariff increase on Home and the RW, this time assuming that wages are fully flexible in Home (and somewhat rigid in all other regions, in particular the REA). In both cases, we keep the ELB assumption.

The responses of the main macroeconomic variables are reported in Figure 7 and the responses of the main labour market variables are reported in Figure 8 as dashed lines, together with the main benchmark scenario (full lines). While the responses of real variables are qualitatively similar in both simulations, more flexibility of wages in Home implies that inflation drops by more, both in Home and in the REA (which imports Home products, whose inflation rate has decreased). The reason for the stronger drop in inflation is that when wages in Home are more flexible, they can adjust to account for part of the shock, which leads to lower marginal costs and therefore lower inflation. But, because of the ELB, lower inflation implies that real interest rates are higher. The result is that private consumption drops by somewhat more than when wages in the Home tradable sector are more rigid, resulting in somewhat stronger initial drop in GDP in Home and in the REA.

Because Home wages fall to a larger extent after the imposition of US tariffs, this induces Home firms to reduce employment less than they would otherwise (see Figure 8). Consistently, Home vacancies and the job finding probability decrease to a lower extent and recover faster. In the REA, vacancies and the job finding probability initially also fall almost as much as in the case where Home wages are sticky. However, more flexible wages in Home imply that a relatively large part of the EA adjusts more quickly to adverse circumstances. In the presence of the ELB this implies that the path of interest rates after the ELB stops binding is higher. This pushes, joint with the lower imported inflation associated with imports of Home products, the REA inflation down and also depresses the REA aggregate demand temporarily more than in the case with sticky wages. The intra-EA trade balance of Home therefore improves more slowly than otherwise.

Overall, results also show that greater Home wage flexibility reduces the negative effects of US tariffs on Home employment, output and, indirectly, on the corresponding REA variables.

The results of the same experiment for the case where there is no binding ELB are reported in Figures 9 and 10. When the ELB is not binding, the EA central bank can lower the policy rate to counter the negative effects caused by the tariff increase. While the EA central bank does not reduce interest rates immediately because of inflationary effects caused by the exchange rate depreciation, it does reduce interest rates persistently over the medium run.

Thus, consumption in Home does not drop as much, despite negative effects of tariffs on Home export demand (even though some of this is alleviated by exchange rate depreciation). Different from the case of binding ELB, consumption and investment in the REA region increase, favoured by the lower price of Home exports, that increase.

Home trade balance vis-à-vis the REA remains almost the same as in the benchmark case. The reason is that on the one hand the REA demand improves, which stimulates exports, while on the other hand the lower decline in domestic demand in Home when wages are flexible also lowers the decline in imports, offsetting higher exports due to the competitiveness improvement caused by the wage decrease.

Note that in the flexible-wage case Home wages adjust downwards almost as much as in the rigid-wage case (see Figure 10), despite much lower drop in aggregate demand. This induces labour firms to reduce vacancies by substantially less, in order to benefit from lower labour costs. The result is that the job finding probability for workers stays almost unchanged, which prevents most of the drop in Home employment. Despite lower wages this is sufficient to support private consumption, which drops by less than in the sticky-wage case. The lesser deterioration in Home economic activity and aggregate demand under flexible wages also favours REA production and, thus, the improvement in REA labour market conditions.

Overall, the US tariff imposed on one country of the EA and on the RW has recessionary and rather similar effects on both regions of the EA if the ELB is binding. These effects are magnified in the short run if wages are flexible in the region subject to the tariff. At the same time, flexible wages improve the labour market conditions in the medium run, leading to a somewhat quicker macroeconomic recovery.

4.3.2 Sector-specific matching functions

In this section we assume sticky wages and labour markets with two matching functions, one for the tradable and one for the non-tradable sector. Unemployed workers are allowed to decide in which sector they search for a job, i.e., there is directed search.[17] We compare this setting with the benchmark, featuring one matching function common to both sectors. First, we do the comparison for the case when the ELB in the EA is binding, and then for the case when the ELB in the EA is not binding.

For the case where the ELB in the EA is binding, Figure 11 reports the responses for macroeconomic variables and Figure 12 reports the responses of labour market variables. The tariff shock directly affects the tradable sector. However, the ELB implies that the tariff shock also causes a decrease in aggregate demand, because of the higher real interest rate. Thus, the non-tradable sector is also negatively affected by the shock. Overall, the responses are similar to those in the benchmark case. The short-run decreases of GDP and its components are more pronounced and the subsequent rebound faster under the assumption of sector-specific matching functions. Inflation decreases to a larger extent, consistent with the larger drop of aggregate demand.

Figure 12 reports the responses of the labour market variables. In the case of sector-specific matching functions it is easier for workers to substitute jobs in the non-tradable sector for jobs in the tradable sector in both EA regions. This also implies that the expected cost associated with hiring a worker falls by more in the sector where there are more unemployed. The reason is that even though the per-period cost of having a vacancy open is the same across sectors, under sector-specific matching functions firms fill a given vacancy faster in the sector with more

[17]Note that in this setting, unemployed workers and vacancies adjust so that labour market tightness is equalised across both labour market segments.

unemployed (everything else equal). Labour firms therefore respond by posting more vacancies in the sector where there are more unemployed. This is the reason why vacancies in the Home tradable sector in Figure 12 fall by less than in the benchmark case. For the same reason, vacancies in the non-tradable sector fall by more, which stimulates the unemployed in the non-tradable sector to search for work in the tradable sector.[18] Thus, unemployment in the tradable and non-tradable sectors respectively strongly increase and decrease on impact, while overall unemployment increases, consistent with the larger initial drop in GDP. Under the unique (i.e., economy-wide) matching function assumption, instead, unemployment is the same across both sectors, because there is just one economy-wide labour market and one unemployment rate.

In the case of sector-specific matching functions, consistent with the strong initial increase in unemployment in the tradable sector, real wages decrease relatively more in both EA regions, contributing, via lower marginal costs, to the additional initial decrease in inflation reported in Figure 11, exacerbating the recessionary effects of the ELB not only in Home but also in the REA region.

At the same time, firms in the REA observe more unemployed in the tradable sector and anticipate less waiting and hence lower costs associated with hiring. This to some extent mitigates the medium-run negative effects on employment and labour income, which benefits aggregate demand and, thus, a faster rebound of the economic activity. The rebound favours the REA macroeconomic and labour market conditions in the medium run.

To further understand the role of the ELB, the results of the same exercise for the case where there is no binding ELB are reported in Figures 13 and 14. The lower monetary policy rate, not constrained by the ELB, induces a stimulating effect that partially counterbalances the negative effects of the tariff shock. Interestingly, under the assumption of sector-specific matching functions, Home GDP decreases to a lower extent than under the assumption of the economy-wide matching function. As explained above, costs associated with hiring workers are lower in the sector with more unemployed under sector-specific matching functions, because firms can exploit different unemployment rates across sectors and post vacancies in the sector

[18] An increase in the number of unemployed in the tradable sector creates a positive externality for firms, by increasing the probability that a firm with a vacancy will find a worker. Firms therefore post more vacancies than they would do otherwise. This externality is amplified when unemployed can move between sectors, because they will be moving to the sector with relatively more vacancies, thus amplifying the positive externality for firms in that sector.

with more unemployed and, thus, fill a given vacancy in relatively shorter amount of time. This induces labour firms to post more vacancies than they otherwise would. Thus, labour market conditions deteriorate to a lesser extent and, in equilibrium, the Home real wage decreases by less.

The REA economy faces expansionary effects in the absence of the ELB. It benefits from cheaper Home products and the relative improvement in Home aggregate demand (compared to the binding ELB case). Thus, the REA labour market conditions also improve under the assumption of sector-specific matching functions.

Overall, in the presence of the ELB, the ability to relocate labour across sectors, combined with effectively cheaper vacancy posting makes wages fall by more. This exacerbates the short-run effects on both Home and REA of the tariff if the ELB holds in the EA. However, it also improves the Home and REA labour market conditions in the medium run, leading to a somewhat quicker recovery in the EA.

4.4 High elasticity of substitution

In the previous sections the (long-run) elasticity of substitution between domestic and imported tradables was set to 0.6, a relatively low value, to capture the high degree of complementarity among tradables that is likely to characterize global value chains, which are a relevant feature of the world economy. In this section we investigate the role of that assumption by setting the elasticity to a higher value, equal to 2.5. We run the benchmark scenario again, featuring sticky wages, under the alternative assumptions of binding and not binding ELB in the EA.

Figure 15 reports the responses of the main Home trade variables. Compared to Figure 1, now the Home trade balance deteriorates more, Home exports and imports decrease to a larger extent, and the Home real exchange rate depreciates less. This is consistent with the assumption of high elasticity, which implies that households and firms can easily substitute tradables among each other. Consistently, US imports of REA and RW tradables increase and decrease, respectively, to a larger extent. Home and REA GDP decrease to a larger extent in the short-term, but their recovery is quicker (Figure 16). Given the larger negative effects of US tariffs on Home exports, Home inflation decreases to a larger extent. The negative effects are thus amplified by the ELB.

Also the REA GDP decreases to a larger extent, because it is negatively affected by both the drop in Home aggregate demand and the ELB.

Figure 17 reports the labour market variables. Relative to the case of low elasticity (Figure 3) the short-run decreases of employment and other labour market variables do not greatly change. The corresponding medium-run returns to the baseline are consistent with the faster GDP recoveries.

The Home trade balance vis-vis-à-vis the REA improves more than under the benchmark calibration, because REA households increase imports of Home tradables to a larger extent (Fig. 18). This is true in particular if the ELB does not constrain the policy rate, because REA imports of Home goods and services persistently increase. The reason is that the REA economic activity benefits from higher exports to the US and from the response of the EA central bank, if it can decrease the policy rate without constraints. Thus, REA aggregate demand and GDP increase, instead of decreasing like the corresponding variables in Home (Figure 18) and like in the case of low elasticity (Figure 5). The higher REA economic activity in the absence of the ELB induces a favourable dynamics in REA labour market variables, reported in Figure (19), which displays an increase in employment in REA and a decrease in Home.

Overall, the effects of higher US tariffs on Home and RW products on the EA macroeconomic variables are negative and relatively large if the ELB holds in the EA. The effects on the REA variables can be expansionary if the ELB does not bind and the elasticity of substitution among tradables is sufficiently high.

5 Conclusions

We have assessed the impact of trade tariffs on the EA trade variables, macroeconomic conditions, and employment by developing and simulating a multi-country New Keynesian model featuring country-specific labour markets with search-and-matching frictions and the ELB constraining the response of the EA monetary policy.

According to our results, the tariffs produce recessionary effects in each country. If the ELB holds, then the trade tariff has recessionary effects on the whole EA even if it is imposed on only one EA country and on the RW. Moreover – if the ELB holds and, in the EA country subject to the tariff, the real wage is flexible or there are segmented labour markets with directed search within each country – then the recessionary effects on the whole EA are amplified in the short run. Finally, if the elasticity of substitution among tradables is low, then the tariff has recessionary effects on the whole EA also when the ELB does not hold.

Our work can be extended along several dimensions. Retaliation by the EA and the RW can be introduced. A global trade war, in which all blocs raise tariffs against each other, can also be considered. For the EA, we can assess to which extent region-specific fiscal policy or structural (pro-competition) reforms would be useful to counteract adverse trade shocks. Last, but not least, non-standard monetary policy measures could be considered. We leave all these interesting issues for future research.

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Appendix

A Structure of the labour market

A.1 Matching and labour market flows

The matching process is modelled using the Cobb-Douglas matching function:

$$M_t = \phi_{mat} un_t^{\mu_{mat}} vac_t^{1-\mu_{mat}}, \tag{19}$$

where M_t is the number of new matches per period, vac_t is the number of vacancies, un_t is the number of unemployed workers searching for a job, $\phi_{mat} > 0$ is the matching efficiency, and $0 < \mu_{mat} < 1$ is the elasticity of the matching function with respect to employment. The job finding probability, p_t^W, and job filling probability, p_t^F are, respectively:

$$p_t^W \equiv \frac{M_t}{un_t} = \phi_{mat} \left(\frac{vac_t}{un_t} \right)^{1-\mu_{mat}}. \tag{20}$$

$$p_t^F \equiv \frac{M_t}{vac_t} = \phi_{mat} \left(\frac{vac_t}{un_t} \right)^{-\mu_{mat}}. \tag{21}$$

Separations occur at the beginning of the period and newly matched workers become productive within the period. The number of employed workers in the current period t *after matching has been completed*, is nde_t. The number of employed workers *at the beginning of the period* t consists of workers who were employed in the previous period and have not been separated, $(1 - \delta_x)nde_{t-1}$, where $0 < \delta_x < 1$ is the exogenous separation rate. The law of motion for the number of employed workers is

$$\begin{aligned} nde_t &= (1 - \delta_x)nde_{t-1} + M_t \\ &= (1 - \delta_x)nde_{t-1} + p_t^F vac_t \\ &= (1 - \delta_x)nde_{t-1} + p_t^W un_t. \end{aligned} \tag{22}$$

Unemployed workers, un_t, who search for work at the beginning of the period t, are the unemployed at the end of the period $t-1$ after the $(t-1)$ matching has been completed, une_{t-1}, plus the newly separated workers, $\delta_x nde_{t-1}$:

$$un_t = une_{t-1} + \delta_x nde_{t-1}, \quad where \quad une_{t-1} = 1 - nde_{t-1}. \tag{23}$$

The number of unemployed at the end of the period t (after period t matching has been completed), une_t, is

$$une_t = 1 - nde_t. \tag{24}$$

A.2 Value functions

Household. An employed worker works h_t hours, receives a real hourly wage w_t (expressed in domestic consumption units), and is compensated for the foregone leisure. In case of a break-up in the beginning of the next period, she will be unemployed, conditional on not matching successfully in the next period. All unemployed workers search in the beginning of the next period, and can either find work with probability p^W_{t+1}, or remain unemployed. The value of being employed, E_t, is

$$E_t = (1-\tau^{wh}_t) w_t h_t - \frac{\chi}{\Lambda_t} \frac{h_t^{1+\zeta}}{1+\zeta} + \\ + \beta \frac{\Lambda_{t+1}}{\Lambda_t} \left(\delta_x (1-p^W_{t+1}) U_{t+1} + (1-\delta_x(1-p^W_{t+1})) E_{t+1} \right), \tag{25}$$

where $0 < \tau^{wh}_t < 1$ is the labour tax rate paid by the household, $1/\zeta$ is the Frisch labour supply elasticity, $\chi > 0$ is the weight of leisure in the utility function, $0 < \beta < 1$ is the time discount factor, and Λ_t is the marginal utility of household consumption. The value of being unemployed is

$$U_t = u_{ben,t} + \beta \frac{\Lambda_{t+1}}{\Lambda_t} \left((1-p^W_{t+1}) U_{t+1} + p^W_{t+1} E_{t+1} \right), \tag{26}$$

where unemployed workers receive unemployment benefits paid by the government, $u_{ben,t} \geq 0$. Unemployment benefits are assumed to be a fixed percentage $rrat > 0$ of the wage,

$$u_{ben,t} = rrat\ w_t. \tag{27}$$

When we consider sectors, then households have separate value functions for being employed and unemployed in each sector, with sector-specific wages (but we assume unemployment benefits are the same across sectors).

Labour firm. We assume a continuum of labour firms, each with one worker. Labour firms sell labour services to intermediate-goods firms at a price x_t and hire workers by posting vacancies, at a fixed per-period cost, $\psi > 0$. Once a worker is hired, she works h_t hours, which are transformed into labour services, y_t^h, as follows:

$$y_t^h = h_t^{\alpha_H},$$

where $\alpha_H > 0$. For every hour worked, a labour firm pays its worker a wage w_t. The value for a labour firm of having a worker, J_t, is

$$J_t = x_t h_t^{\alpha_H} - (1 + \tau_t^{wf}) w_t h_t + \beta \frac{\Lambda_{t+1}}{\Lambda_t} (1 - \delta_x) (J_{t+1}). \tag{28}$$

The value for a labour firm of having an open vacancy, V_t, is

$$V_t = -\psi + p_t^F J_t + \beta \frac{\Lambda_{t+1}}{\Lambda_t} \left((1 - p_{t+1}^F) V_{t+1} \right). \tag{29}$$

Labour firms post vacancies as long as the value of having a vacancy exceeds zero. In equilibrium, the value of having a vacancy is driven to zero and equation (29) can be simplified, resulting in the standard free-entry condition which determines the number of vacancies:

$$\psi = p_t^F J_t. \tag{30}$$

When we consider sectors, then labour firms in each sector have sector-specific value functions, analogously to the households.

A.3 Wages and hours worked

We assume that wages are determined by efficient Nash bargaining (Trigari, 2009) between labour firms and households that maximise the Nash surplus with respect to wages and hours worked. The outcome of bargaining is:

$$\eta(1-\tau_t^{wh})J_t = (1-\eta)(1+\tau_t^{wf})\left(E_t - U_t\right), \tag{31}$$

where $0 < \eta < 1$ is the bargaining power of households. Equation (31) implicitly determines wages. Hours worked are determined as

$$\alpha_H x_t h_t^{\alpha_H - 1} = \frac{\chi h_t^{\zeta}(1+\tau_t^{wf})}{\Lambda_t(1-\tau_t^{wh})}, \tag{32}$$

where the marginal product for a labour firm of an additional hour of labour services sold to intermediate goods firms is equated to the disutility of the household having its workers work an additional hour (measured in consumption units).

Table 1: Steady-State National Accounts (Ratio to GDP, %)

	Home	REA	US	RW
Domestic demand				
Private consumption	59	60	63	64
Private investment	20	20	20	20
Public consumption	20	20	16	16
Trade				
Imports (total)	28	24	11	15
Imports of consumption goods	18	20	7	9
Imports of investment goods	9	4	4	6
Net foreign assets (ratio to annual GDP)	40	-15	40	40
Production				
Tradables	40	39	37	37
Non-tradables	60	61	63	63
Labour	52	52	56	66
Share of world GDP	6	16	31	47

Note: REA=Rest of the euro area; US=United States; RW=Rest of world

Table 2: International Linkages (Trade Matrix, Share of Domestic GDP, %)

	Home	REA	US	RW
Consumption-good imports				
Total consumption good imports	18.4	20.1	7.3	8.7
From partner				
Home	-	3.1	0.3	1.1
REA	8.9	-	0.8	3.6
US	1.1	0.5	-	4.0
RW	8.4	16.5	6.2	-
Investment-good imports				
Total investment good imports	9.2	3.6	4.2	6.4
From partner				
Home	-	2.2	0.2	0.7
REA	4.4	-	0.4	2.3
US	0.6	0.6	-	3.4
RW	4.2	0.8	3.6	-

Note: REA=Rest of the euro area; US=United States; RW=Rest of world

Table 3: Price Markups (Implied Elasticities of Substitution)

	Tradables (θ_T)	Non-tradables (θ_N)
Home	1.20 (6.0)	1.50 (3.0)
REA	1.20 (6.0)	1.50 (3.0)
US	1.20 (6.0)	1.28 (4.6)
RW	1.20 (6.0)	1.28 (4.6)

Note: REA=Rest of the euro area; US=United States; RW=Rest of world

Table 4: Households, Entrepreneurs and Firms Behaviour

	Home	REA	US	RW
Households				
Discount factor (β)	$1.03^{-\frac{1}{4}}$	$1.03^{-\frac{1}{4}}$	$1.03^{-\frac{1}{4}}$	$1.03^{-\frac{1}{4}}$
Intertemporal elasticity of substitution (σ^{-1})	1.00	1.00	1.00	1.00
Inverse of the Frisch elasticity of labour supply (ζ)	2.00	2.00	2.00	2.00
Habit persistence (κ)	0.70	0.70	0.70	0.70
Capital depreciation rate(δ^K)	0.025	0.025	0.025	0.025
Intermediate-good firms (trad. and nontrad. sectors)				
Substitution btw. labour and capital	1.00	1.00	1.00	1.00
Bias towards capital - tradables (α_T)	0.30	0.30	0.30	0.30
Bias towards capital - non-tradables (α_N)	0.30	0.30	0.30	0.30
Production - labour services (α_H)	0.99	0.99	0.99	0.99
Final consumption-good firms				
Substitution btw. domestic and imported trad. goods (μ_{TC})	0.60	0.60	0.60	0.60
Bias towards domestic tradable goods (υ_{TC})	0.28	0.22	0.65	0.59
Substitution btw. tradables and non-tradables (μ_C)	0.50	0.50	0.50	0.50
Bias towards tradable goods (υ_C)	0.45	0.45	0.35	0.35
Substitution btw. consumption good imports (μ_{IMC})	0.60	0.60	0.60	0.60
Final investment-good firms				
Substitution btw. domestic and imported trad. goods (μ_{TI})	0.60	0.60	0.60	0.60
Bias towards domestic tradable goods (υ_{TI})	0.40	0.76	0.71	0.56
Substitution btw. tradables and non-tradables (μ_I)	0.50	0.50	0.50	0.50
Bias towards tradable goods (υ_I)	0.75	0.75	0.75	0.75
Substitution btw. investment good imports (μ_{IMI})	0.60	0.60	0.60	0.60

Note: REA=Rest of euro area; US=United States; RW=Rest of world

Table 5: Real and Nominal Rigidities

	Home	REA	US	RW
Adjustment costs				
Imports of consumption goods (γ_{IM^C})	2.00	2.00	2.00	2.00
Imports of investment goods (γ_{IM^I})	1.00	1.00	1.00	1.00
Capital utilization (γ_{u2})	2000	2000	2000	2000
Investment (γ_I)	6.00	6.00	4.00	4.00
Intermediation cost function - USD bond (γ_{B^*})	0.01	0.01	...	0.01
Intermediation cost function - Euro bond ($\gamma_{B^{EA}}$)	...	0.01	...	...
Calvo parameters				
Prices - domestic tradables (ξ_H) and non-tradables (ξ_N)	0.92	0.92	0.75	0.75
Prices - exports (ξ_X)	0.75	0.75	0.75	0.75
Real wage rigidity				
Real wage adjustment (λ_w)	0.75	0.75	0.75	0.75
Degree of indexation				
Prices - domestic tradables (χ_H) and non-tradables (χ_N)	0.50	0.50	0.50	0.50
Prices - exports (χ_X)	0.50	0.50	0.50	0.50

Note: REA=Rest of the euro area; US=United States; RW=Rest of world

Table 6: Monetary and Fiscal Policy

	Home	REA	US	RW
Monetary authority				
Inflation target ($\overline{\Pi}^4$)	1.02	1.02	1.02	1.02
Interest rate inertia (ϕ_R)	0.87	0.87	0.87	0.87
Interest rate sensitivity to inflation gap (ϕ_Π)	1.70	1.70	1.70	1.70
Interest rate sensitivity to output growth (ϕ_Y)	0.10	0.10	0.10	0.10
Fiscal authority				
Government debt-to-output ratio ($\overline{B_Y}$)	2.40	2.40	2.40	2.40
Sensitivity of lump-sum taxes to debt-to-output ratio (ϕ_{B_Y})	0.1	0.1	0.1	0.1
Consumption tax rate (τ_C)	0.183	0.183	0.077	0.077
Dividend tax rate (τ_D)	0.00	0.00	0.00	0.00
Capital income tax rate (τ_K)	0.189	0.192	0.164	0.160
Labour income tax rate (τ_N)	0.122	0.122	0.154	0.154
Rate of social security contribution by firms (τ^{wf})	0.219	0.219	0.071	0.071
Rate of social security contribution by households (τ^{wh})	0.118	0.118	0.071	0.071

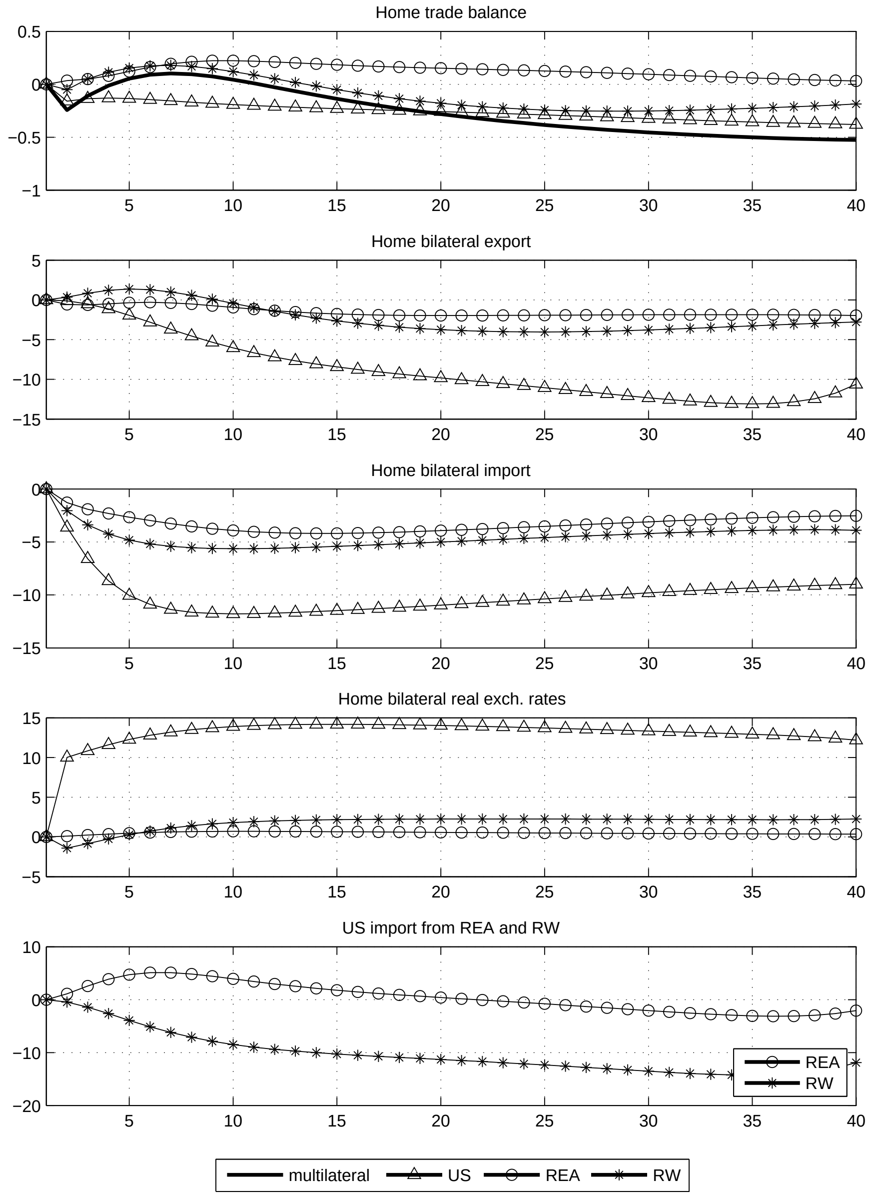
Note: REA=Rest of the euro area; US=United States; RW=Rest of world

Table 7: Labour market

	Home	REA	US	RW
Matching prob., workers, (p^W)	0.1647	0.1675	0.8164	0.4437
Matching prob., firms, (p^F)	0.70	0.70	0.70	0.70
Matching efficiency, (ϕ_{mat})	0.3347	0.3450	0.7576	0.5550
Vacancy posting cost, (ψ)	0.4775	0.4441	0.4725	0.8444
Break-up rate, (δ_x)	0.0137	0.0146	0.0497	0.0273
Disutility of labour, (χ)	2.3205	2.2758	2.6729	2.6798
Unemployment benefits, ($uben$)	0.5008	0.4929	0.2354	0.2332
Matching elasticity, (μ_{mat})	0.50	0.50	0.50	0.50
Bargaining power, (η)	0.50	0.50	0.50	0.50
Replacement ratio, ($rrat$)	0.50	0.50	0.20	0.20
Unemployment, un	0.08	0.08	0.06	0.06

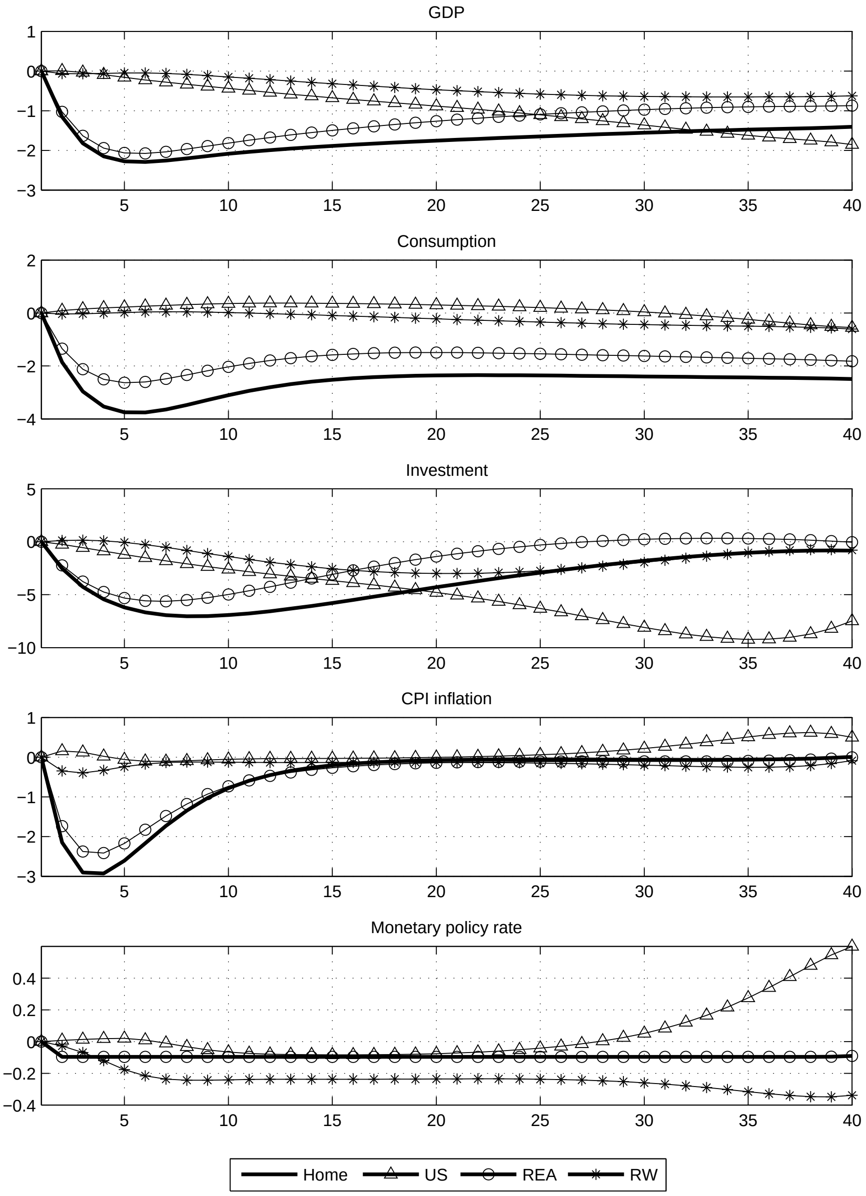
Note: REA=Rest of the euro area; US=United States; RW=Rest of world

Figure 1: US tariffs: Home trade



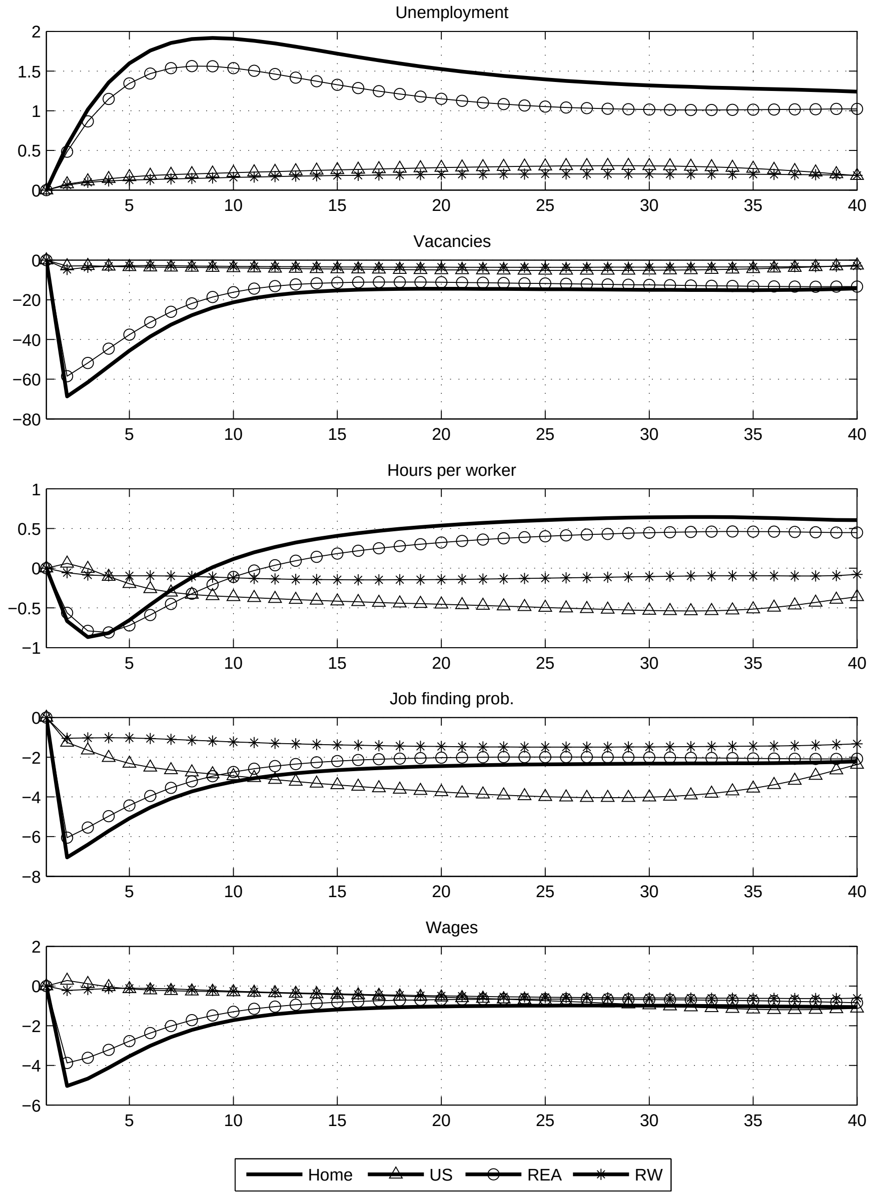
Note: Horizontal axis: quarters; vertical axis: trade balance: ratio to GDP, pp deviations from baseline; other variables: % deviations; exports and imports in real terms, i.e., at (constant) steady-state prices. Home bilateral real exchange rate: + is depreciation.

Figure 2: US tariffs: macroeconomic variables



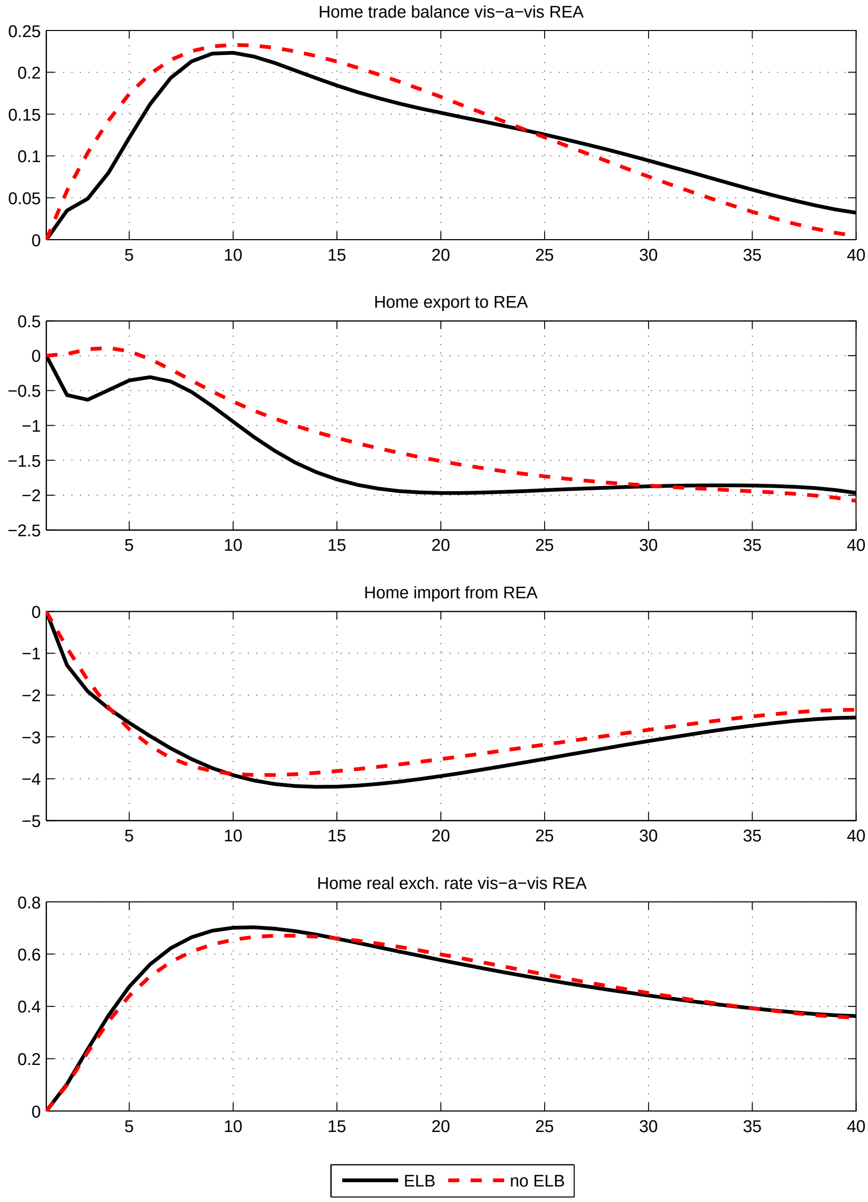
Note: Horizontal axis: quarters; vertical axis: % deviations from baseline; inflation and monetary policy rates: annualized pp deviations; GDP, consumption, and investment in real terms, i.e., at (constant) steady-state prices.

Figure 3: US tariffs: labour market



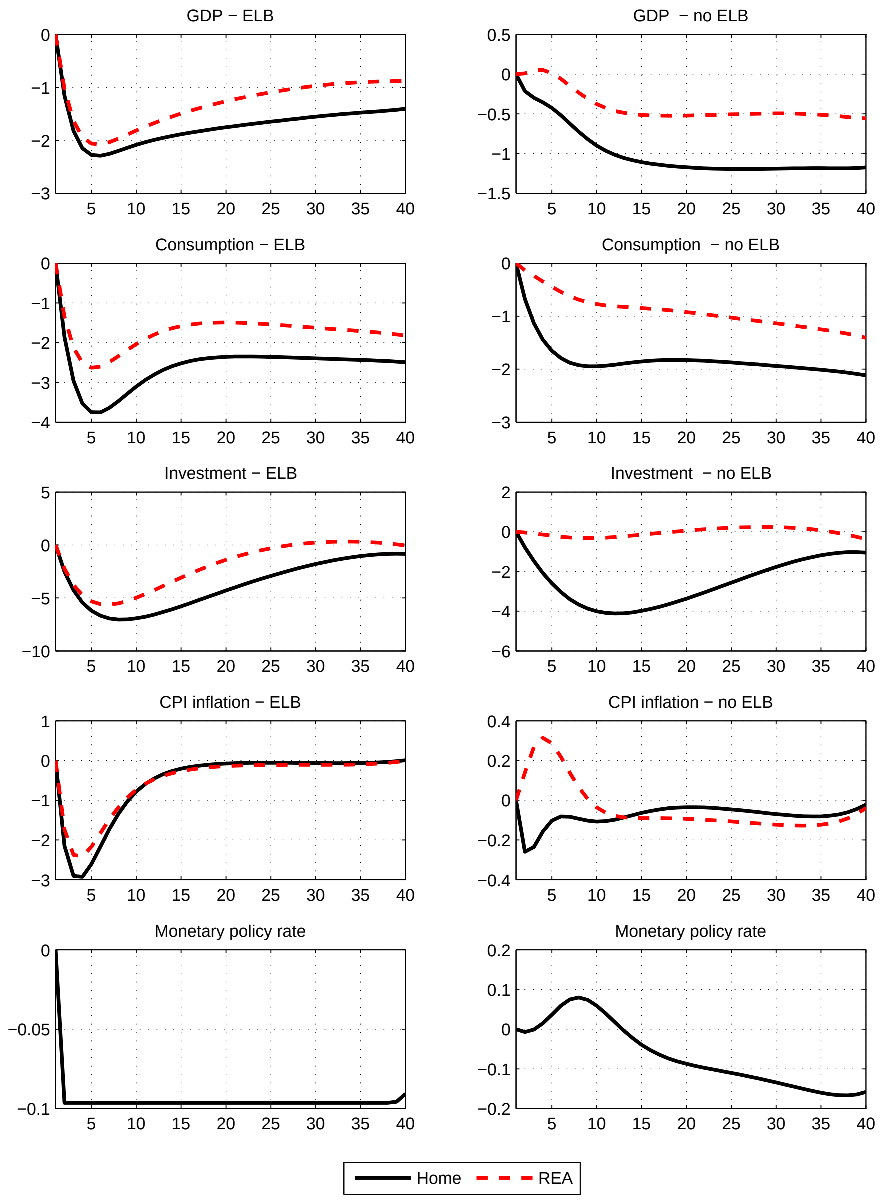
Note: Horizontal axis: quarters; vertical axis: % deviations from baseline, except job finding probability, which is in percentage point deviations from the baseline. Wages are real, i.e., deflated by the domestic consumption price level.

Figure 4: US tariffs and the ELB: intra-EA trade



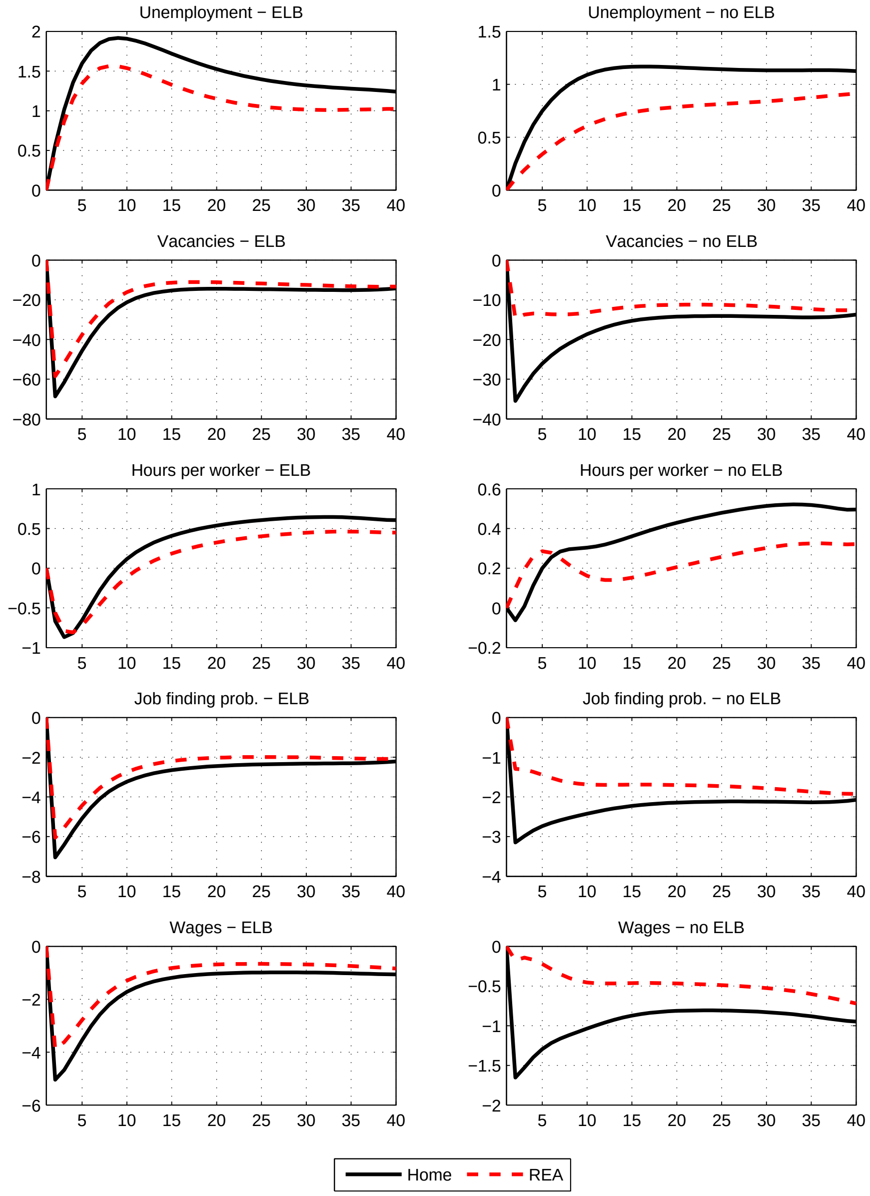
Note: Horizontal axis: quarters; vertical axis: trade balance: ratio to GDP, pp deviations from baseline; other variables: % deviations; exports and imports in real terms, i.e., at (constant) steady-state prices. Home bilateral real exchange rate: + is depreciation.

Figure 5: US tariffs and the ELB: EA macroeconomic variables



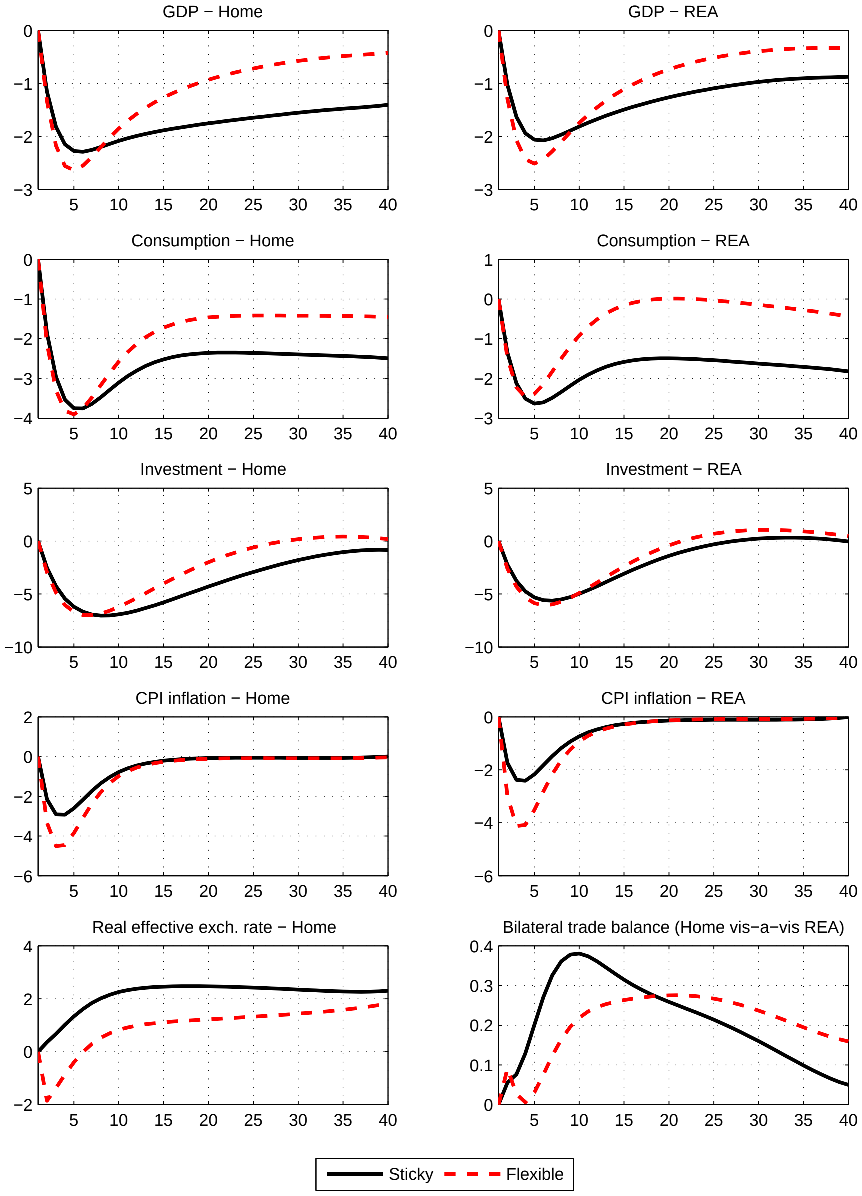
Note: Horizontal axis: quarters; vertical axis: % deviations from baseline; inflation and interest rates: annualized pp deviations; GDP and its components in real terms, i.e., at (constant) steady-state prices.

Figure 6: US tariffs and the ELB: EA labour market



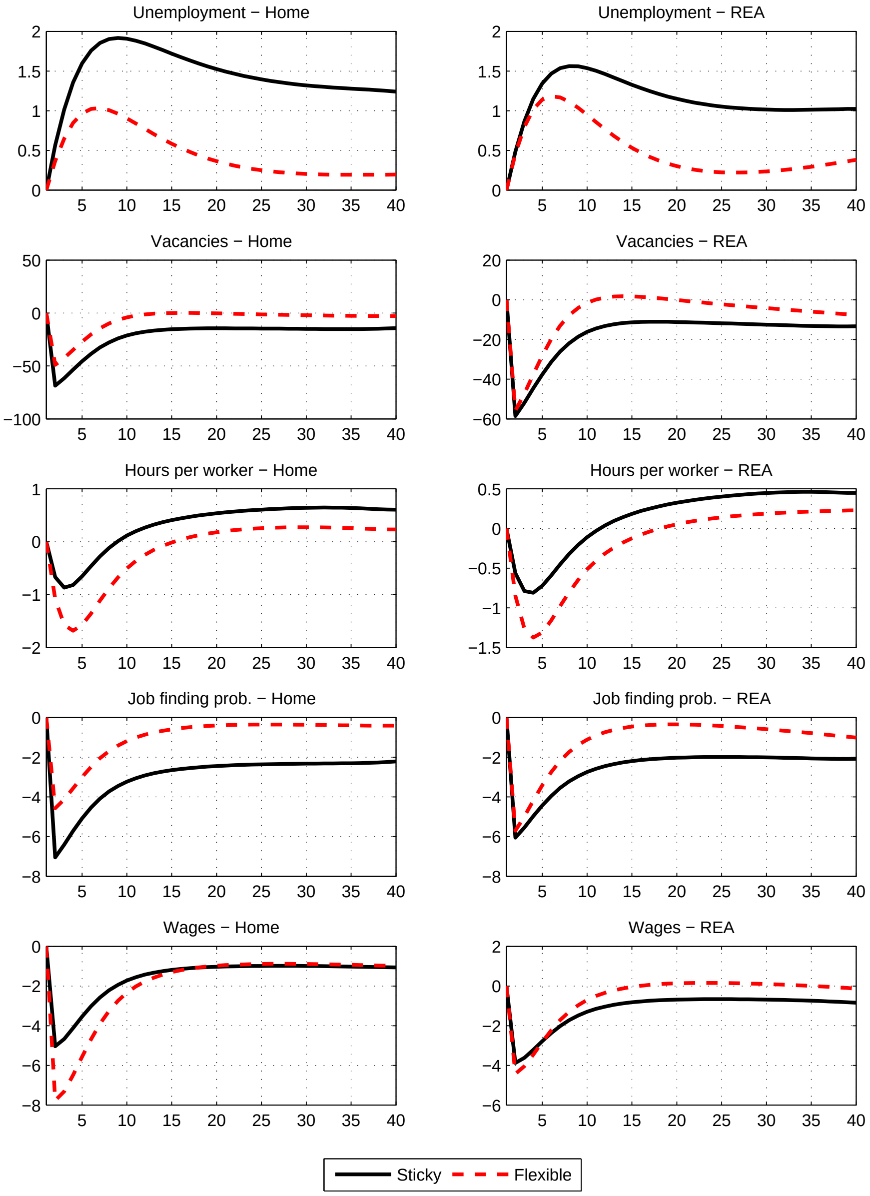
Note: Horizontal axis: quarters; vertical axis: % deviations from baseline, except job finding probabilities, which are in percentage point deviations from the baseline. Wages are real, i.e., deflated by the domestic consumption price level.

Figure 7: US tariffs, flexible real wages, and the ELB: EA macroeconomic variables



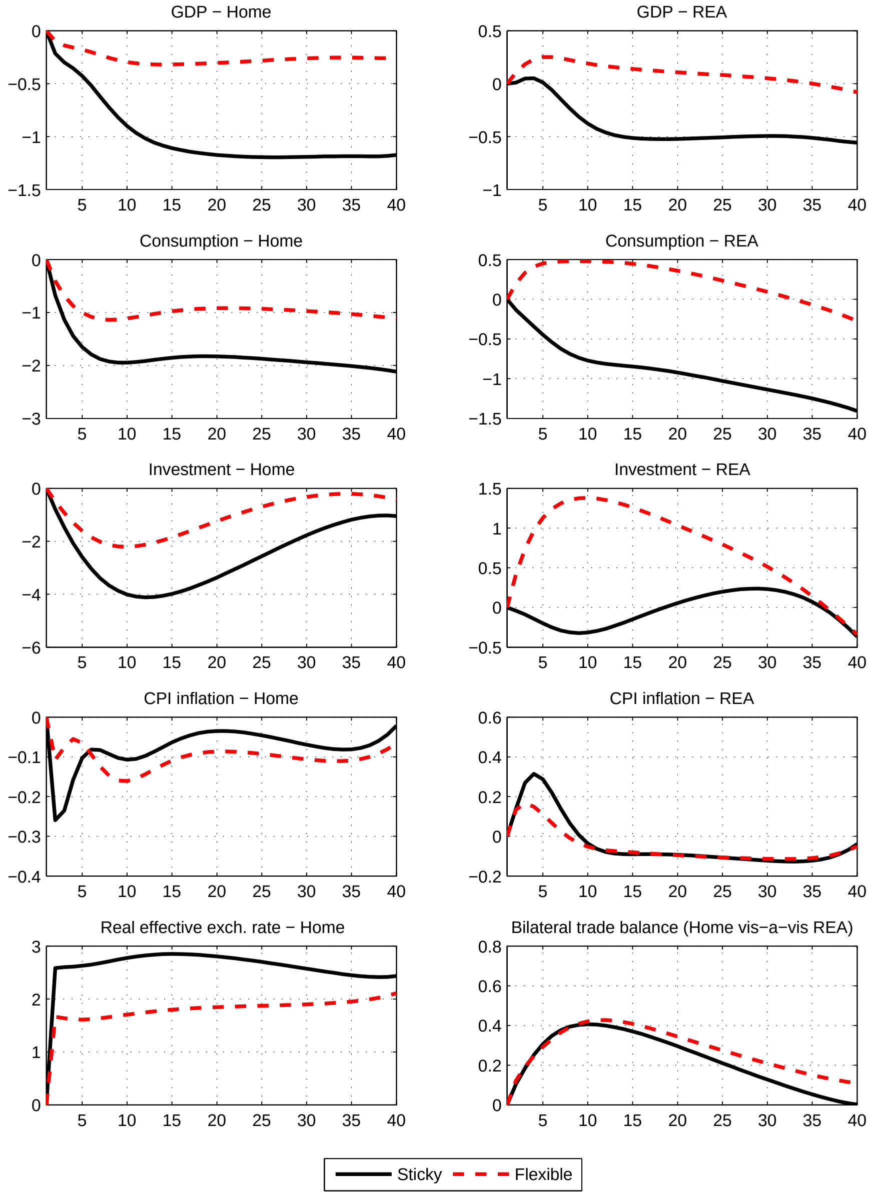
Note: Horizontal axis: quarters; vertical axis: % deviations from baseline, except inflation, which is in annualised percentage point deviations from the baseline, and the trade balance (ratio to GDP, percentage point deviations from the baseline). Real exchange rate: + is depreciation.

Figure 8: US tariffs, flexible real wages, and the ELB: EA labour market



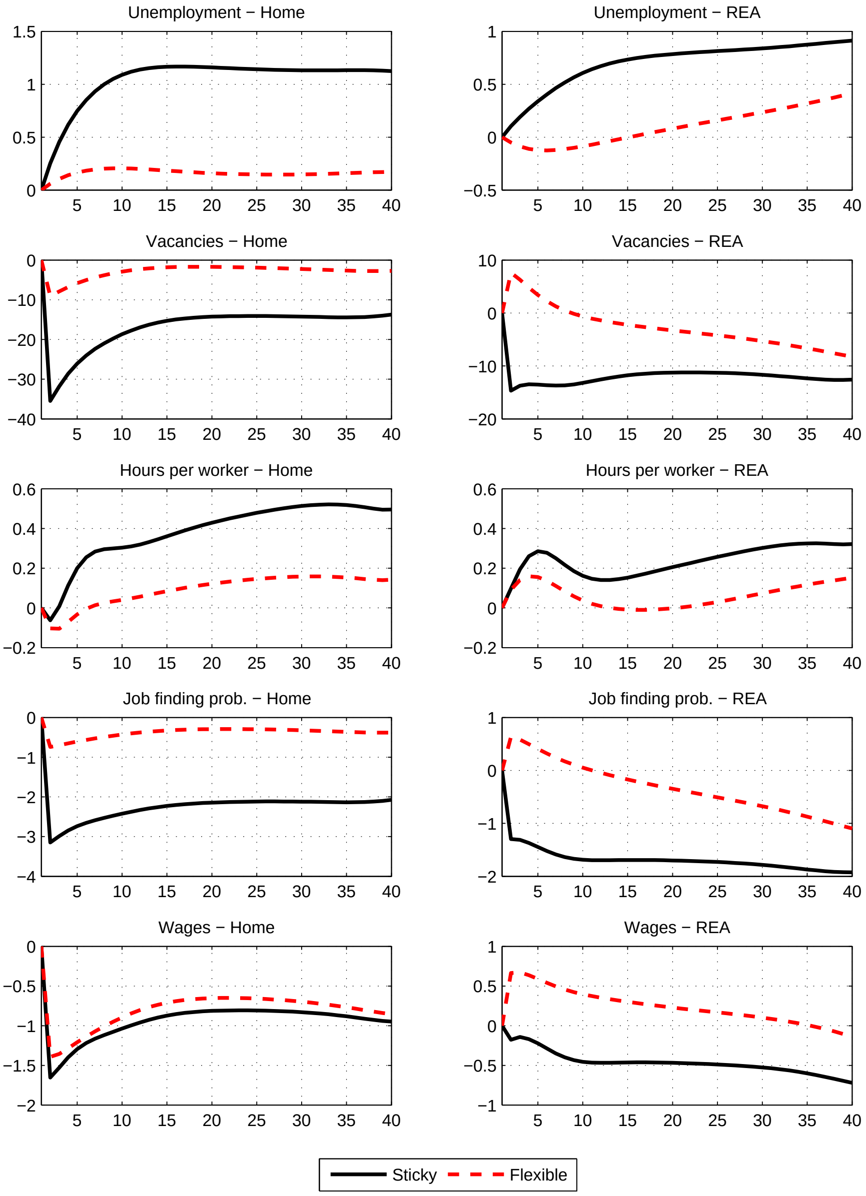
Note: Horizontal axis: quarters; vertical axis: % deviations from baseline, except job finding probabilities, which are in percentage point deviations from the baseline. Wages are real, i.e., deflated by the domestic consumption price level.

Figure 9: US tariffs, flexible real wages, and no ELB: EA macroeconomic variables



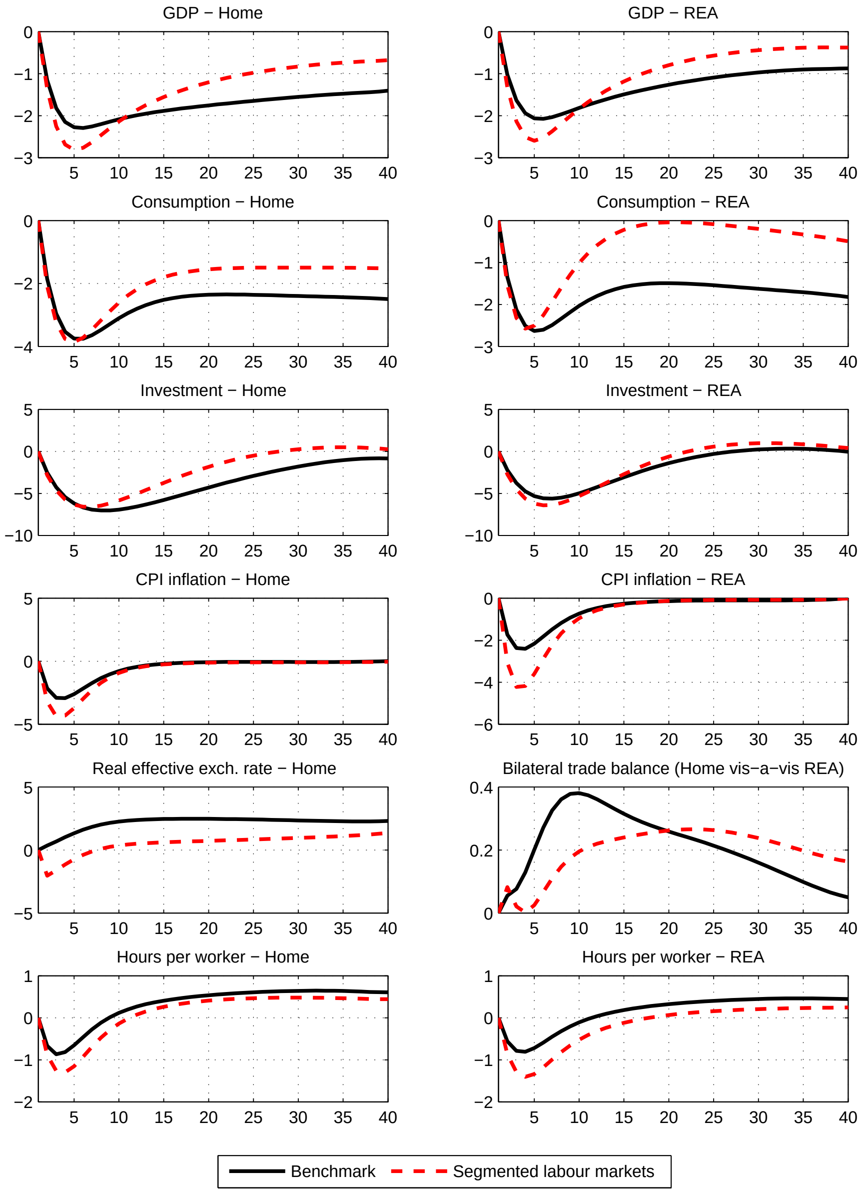
Note: Horizontal axis: quarters; vertical axis: % deviations from baseline, except inflation, which is in annualised percentage point deviations from the baseline, and the trade balance (ratio to GDP, percentage point deviations from the baseline). Real exchange rate: + is depreciation.

Figure 10: US tariffs, flexible wages, and no ELB: EA labour market



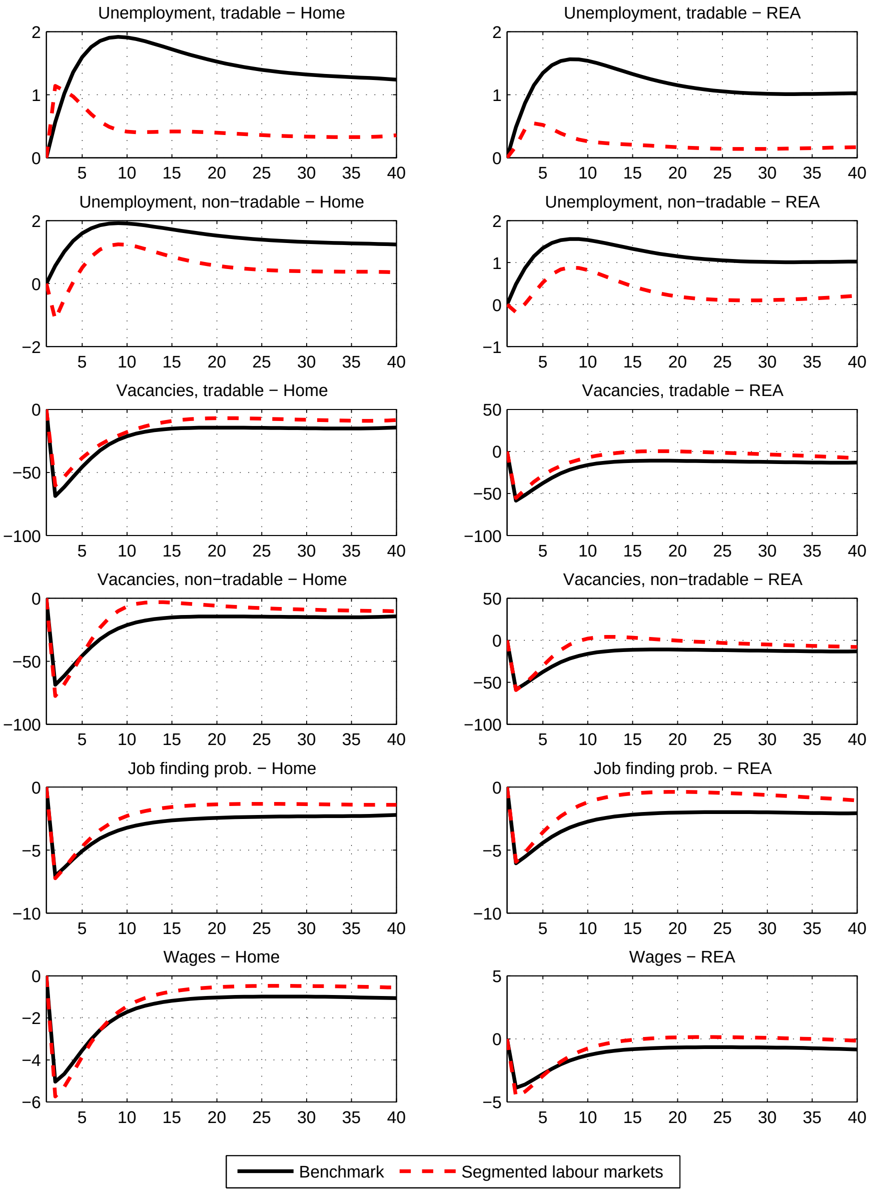
Note: Horizontal axis: quarters; vertical axis: % deviations from baseline, except job finding probabilities, which are in percentage point deviations from the baseline. Wages are real, i.e., deflated by the domestic consumption price level.

Figure 11: US tariffs, segmented labour markets, and the ELB: EA macroeconomic variables



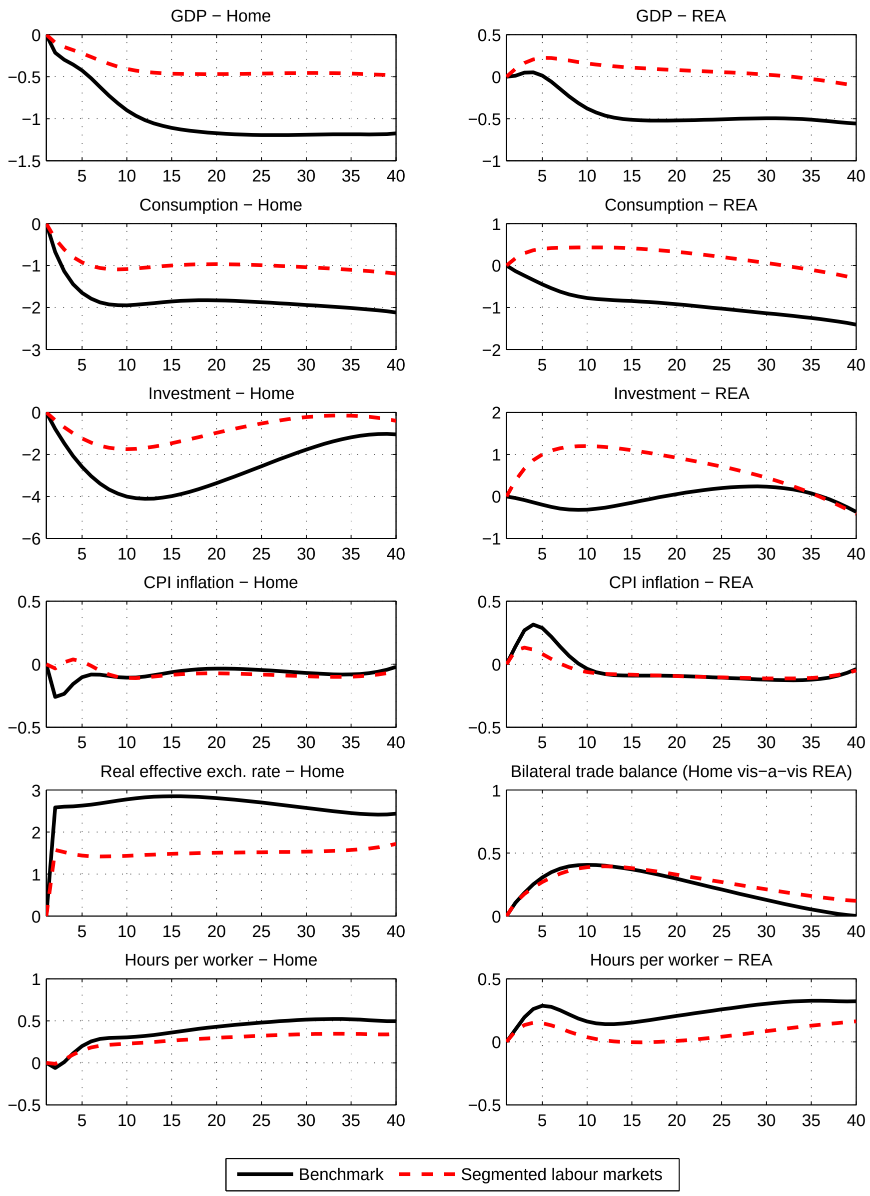
Note: Horizontal axis: quarters; vertical axis: % deviations from baseline, except inflation, which is in annualised percentage point deviations from the baseline, and the trade balance (ratio to GDP, percentage point deviations from the baseline). Real exchange rate: + is depreciation.

Figure 12: US tariffs, segmented labour markets, and the ELB: EA labour market



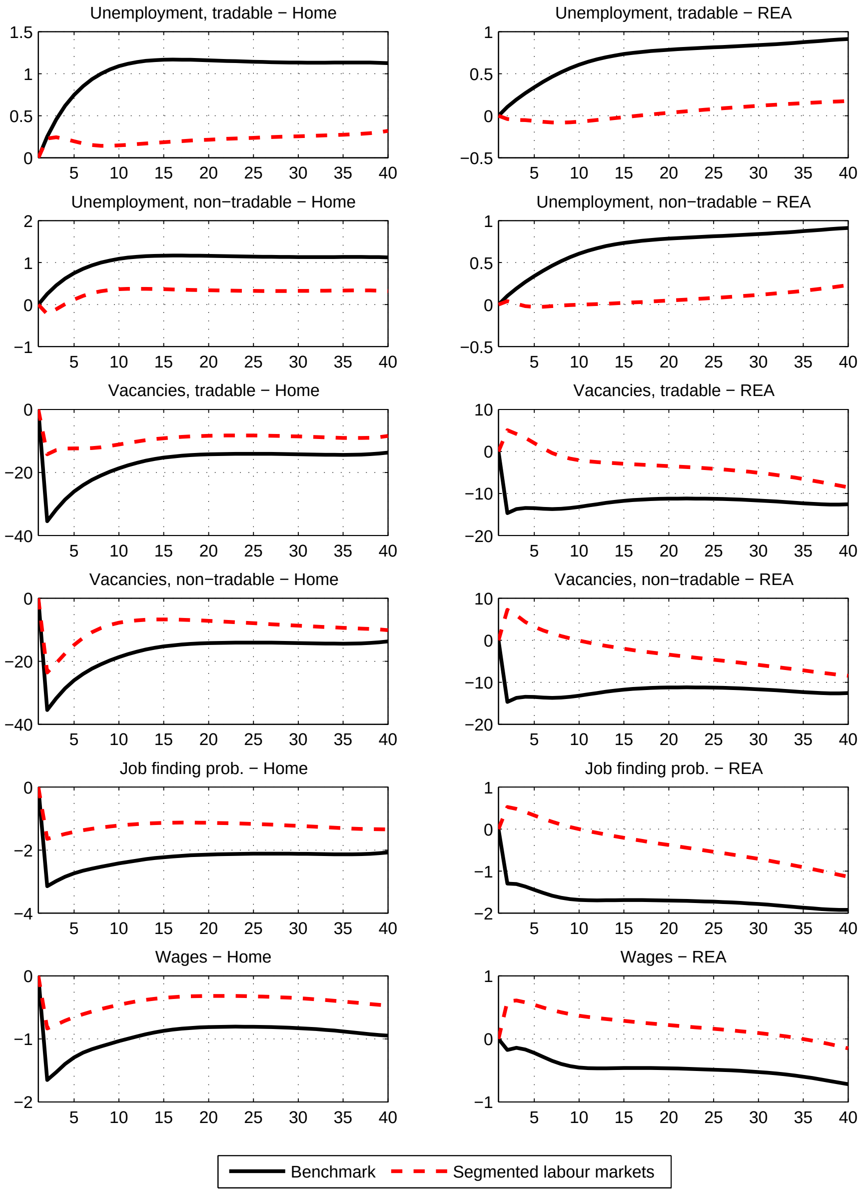
Note: Horizontal axis: quarters; vertical axis: % deviations from baseline, except job finding probabilities, which are in percentage point deviations from the baseline. Wages are real, i.e., deflated by the domestic consumption price level. Note that wages and job finding probabilities are equalised across sectors.

Figure 13: US tariffs, segmented labour markets, and no ELB: EA macroeconomic variables



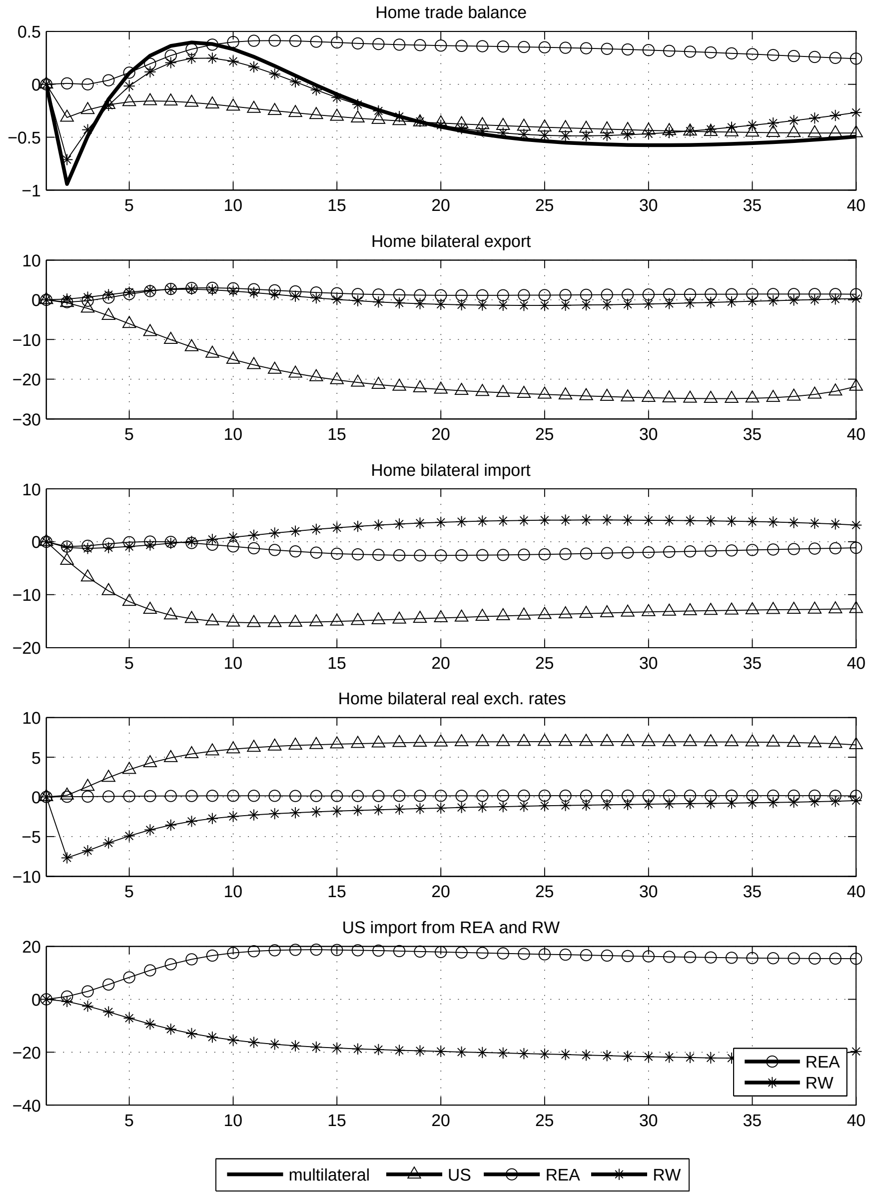
Note: Horizontal axis: quarters; vertical axis: % deviations from baseline, except inflation, which is in annualised percentage point deviations from the baseline, and the trade balance (ratio to GDP, percentage point deviations from the baseline). Real exchange rate: + is depreciation.

Figure 14: US tariffs, segmented labour markets, and no ELB: EA labour market



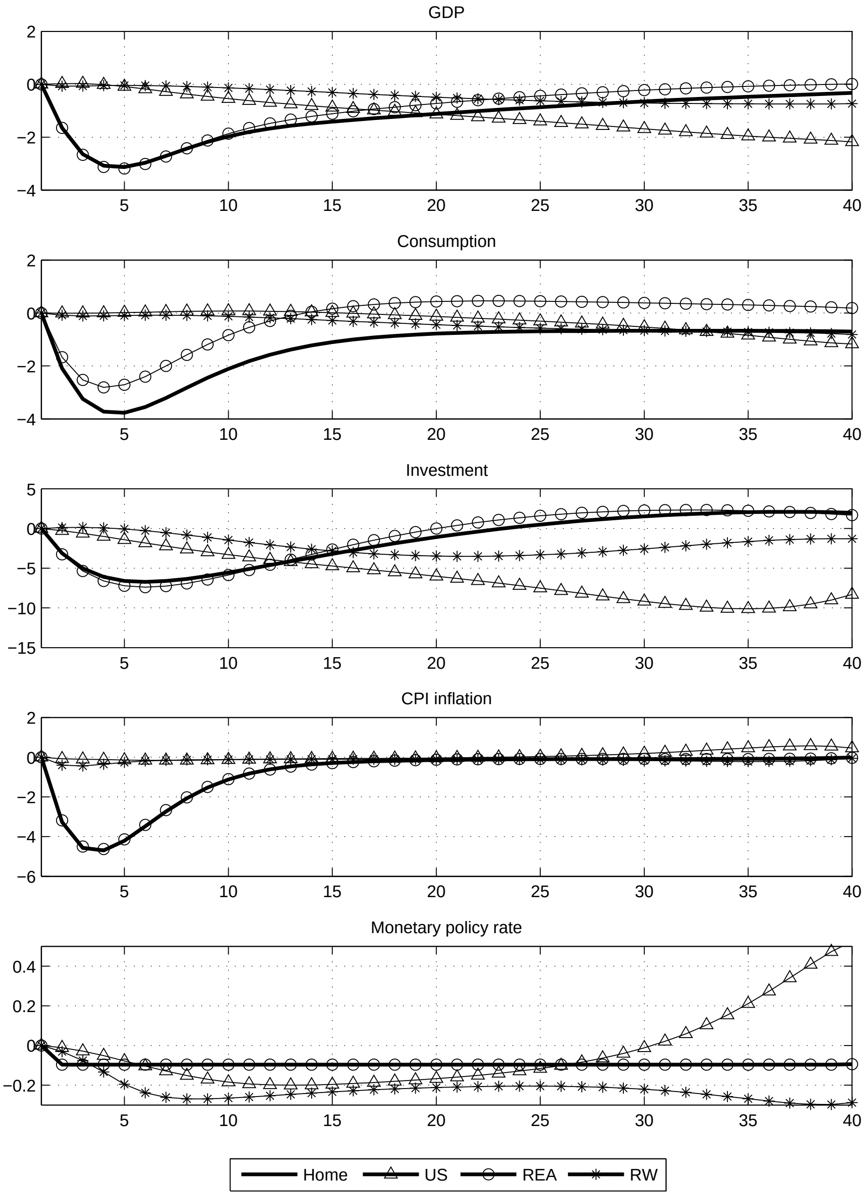
Note: Horizontal axis: quarters; vertical axis: % deviations from baseline, except job finding probabilities, which are in percentage point deviations from the baseline. Wages are real, i.e., deflated by the domestic consumption price level. Note that wages and job finding probabilities are equalised across sectors.

Figure 15: US tariffs and high elasticity: Home trade



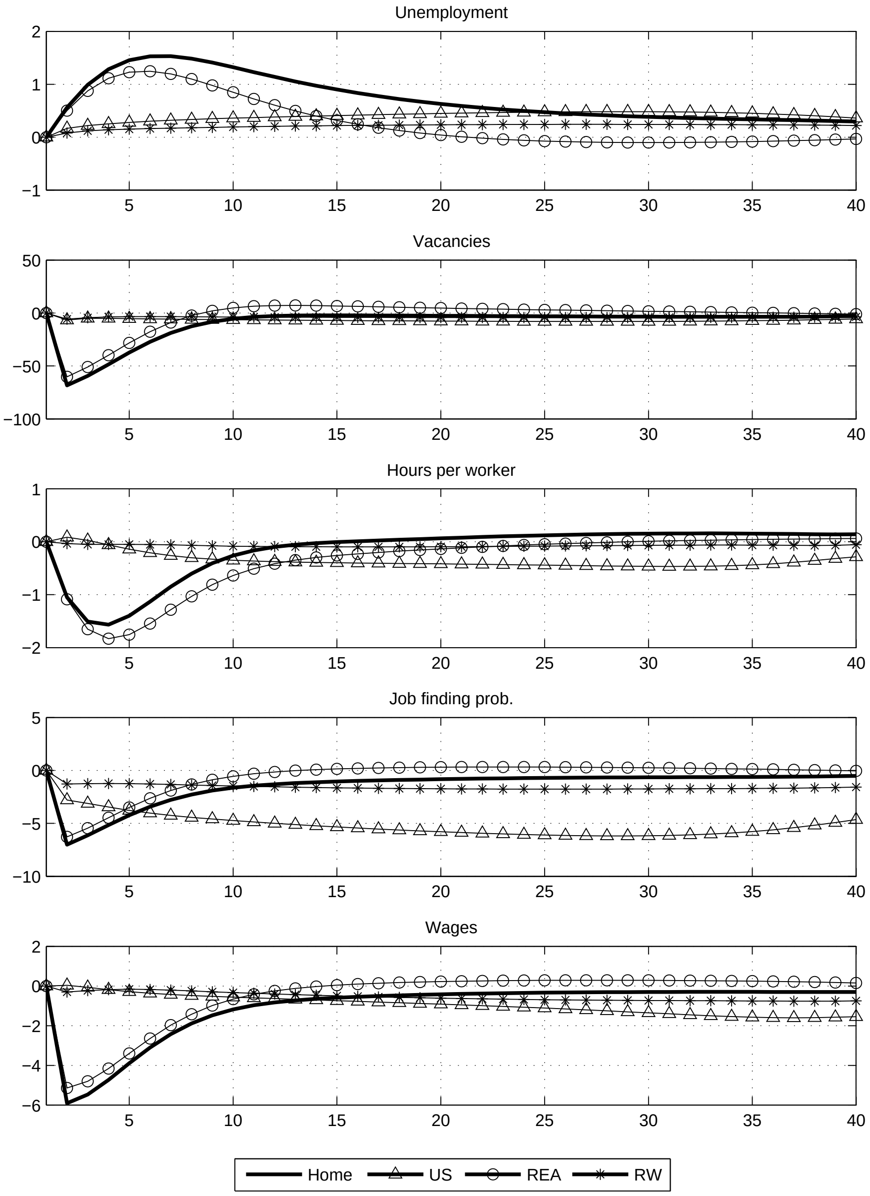
Note: Horizontal axis: quarters; vertical axis: trade balance: ratio to GDP, pp deviations from baseline; other variables: % deviations; exports and imports in real terms, i.e., at (constant) steady-state prices. Home real exchange rate: + is depreciation.

Figure 16: US tariffs and high elasticity: EA macroeconomic variables



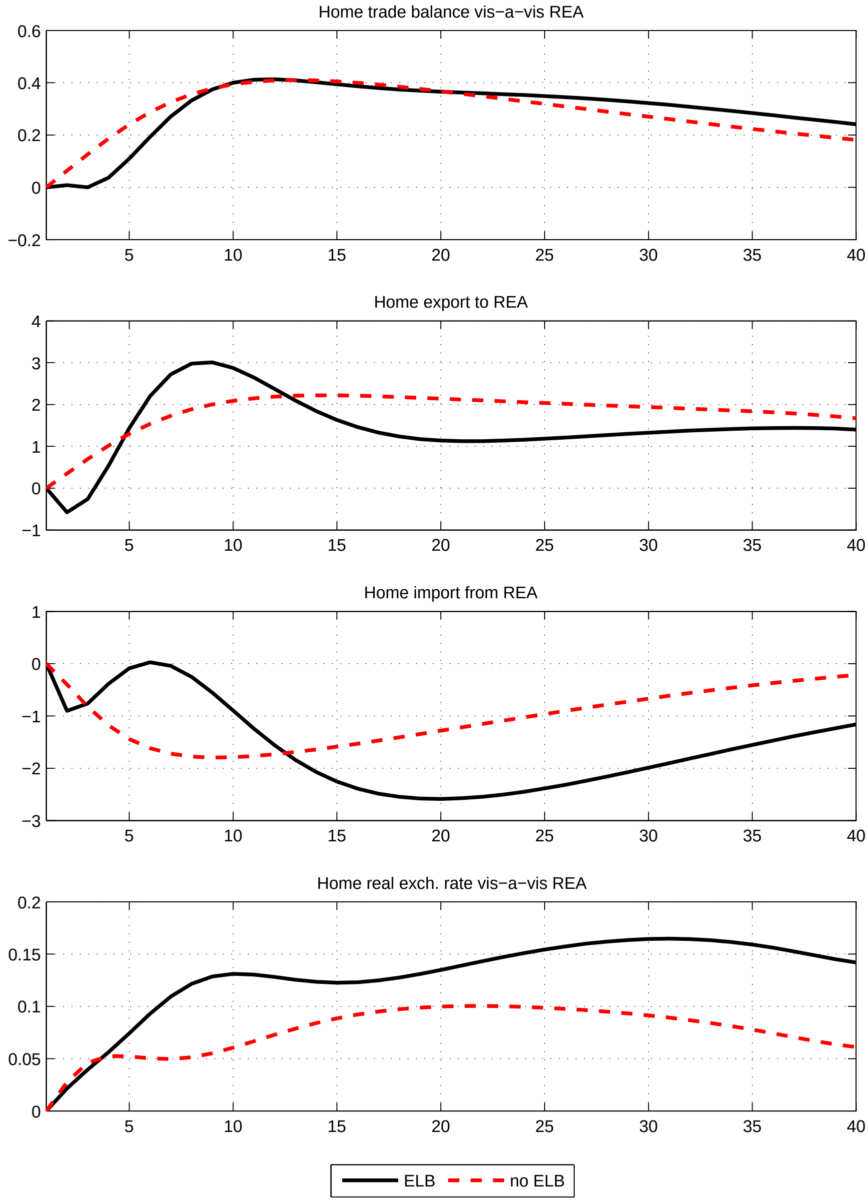
Note: Horizontal axis: quarters; vertical axis: % deviations from baseline; inflation and monetary policy rates: annualized pp deviations; GDP, consumption, and investment in real terms, i.e., at (constant) steady-state prices.

Figure 17: US tariffs and high elasticity: EA labour market



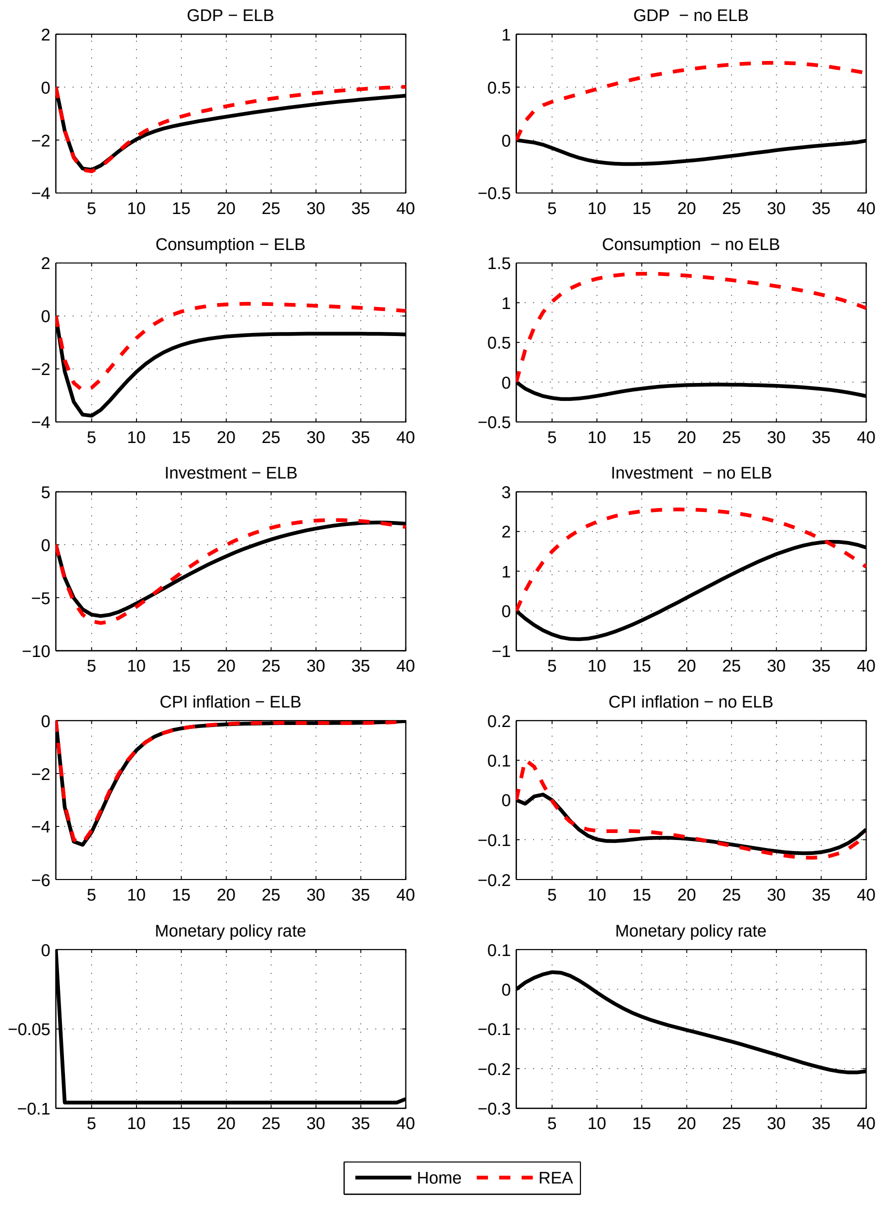
Note: Horizontal axis: quarters; vertical axis: % deviations from baseline, except job finding probability, which is in percentage point deviations from the baseline. Wages are real, i.e., deflated by the domestic consumption price level.

Figure 18: US tariffs, high elasticity, and the ELB: intra-EA trade



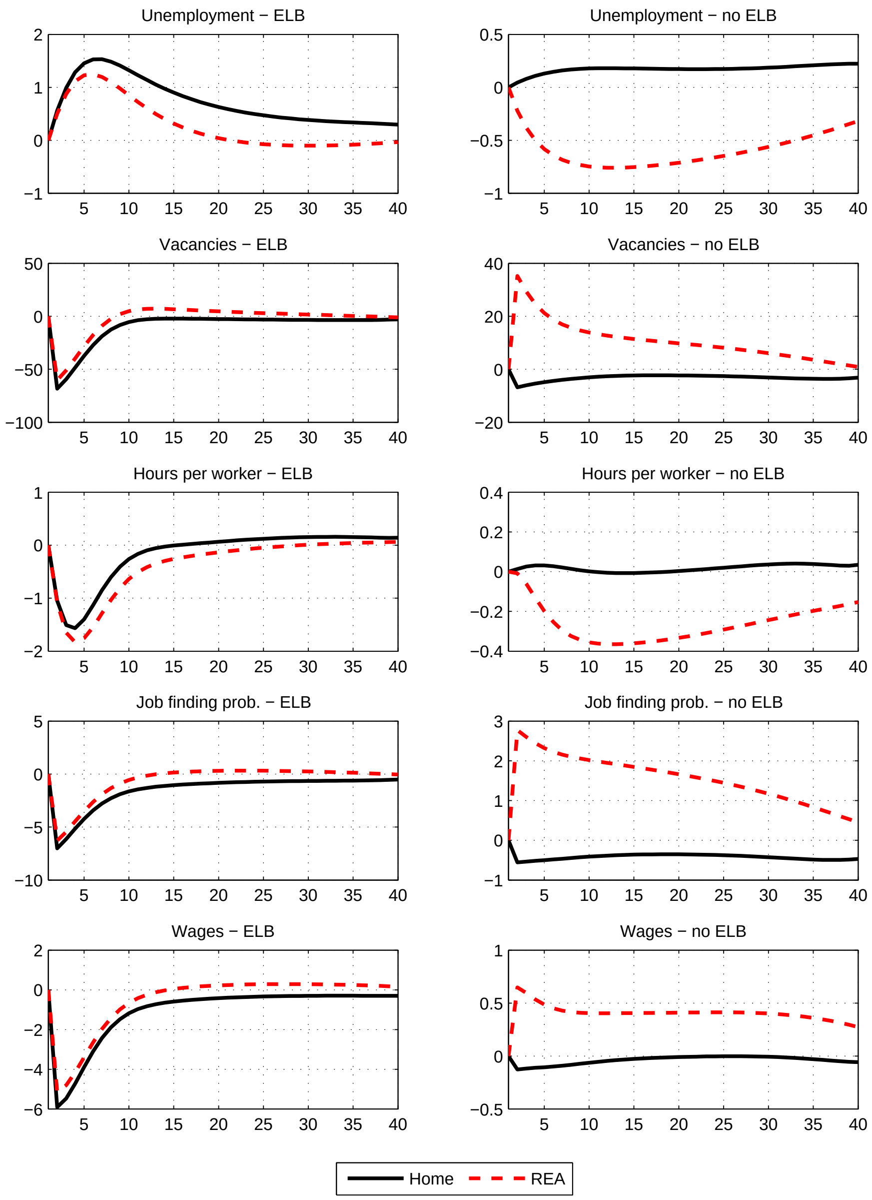
Note: Horizontal axis: quarters; vertical axis: trade balance: ratio to GDP, pp deviations from baseline; other variables: % deviations; exports and imports in real terms, i.e., at (constant) steady-state prices. Home real exchange rate: + is depreciation.

Figure 19: US tariffs, high elasticity, and the ELB: EA macroeconomic variables



Note: Horizontal axis: quarters; vertical axis: % deviations from baseline; inflation and interest rates: annualized pp deviations; GDP and its components in real terms, i.e., at (constant) steady-state prices.

Figure 20: US tariffs, high elasticity, and the ELB: EA labour market



Note: Horizontal axis: quarters; vertical axis: % deviations from baseline, except job finding probabilities, which are in percentage point deviations from the baseline. Wages are real, i.e., deflated by the domestic consumption price level.

Acknowledgements

The opinions expressed are those of the authors and do not reflect views of the Bank of Italy, Central Bank of Ireland or the European Central Bank. We are grateful to Daragh Clancy and the participants of the 2019 Computing in Economics and Finance (CEF) Conference, the 2019 International Network for Economic Research (INFER) Workshop, the 2018 Public Finance Workshop at the Bank of Slovenia, and the 2018 EAGLE Network. Any remaining errors are the sole responsibility of the authors.

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PDF ISBN 978-92-899-4077-1 ISSN 1725-2806 doi:10.2866/70884 QB-AR-20-086-EN-N