Online appendix to "A single monetary policy for heterogeneous labour markets: the case of the euro area"

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A Expansionary demand shock

This appendix shows the responses to a *positive* demand shock, where the asymmetric unemployment targeting rule does not kick in (unemployment falls in the case of a positive demand shock).[1] Figures A-1 and A-2 show the euro area responses, and Figures A-3 to A-5 show the country-specific responses. Recall, however, that the ASUT rule only makes sense when $\phi_U > 0$ (if $\phi_U = 0$, it is identical to strict inflation targeting rule). Therefore, for a fair comparison of strict inflation targeting rule and an ASUT rule, one should compare the dashed red lines in the left column of the charts with the full black lines (for a moderate response to unemployment, $\phi_U = 2$) and the red dotted lines (for the more aggressive response to unemployment, $\phi_U = 3$) in the middle column of the charts. At the same time, one should keep in mind that in Figures **??** to **??** the performance of the ASUT rule is also identical to strict inflation targeting rule. This makes it clear that the the ASUT rule preserves the benefits of expansionary demand shocks for employment, while it mitigates the downturns in employment caused by contractionary demand shocks, as demonstrated in the main text.

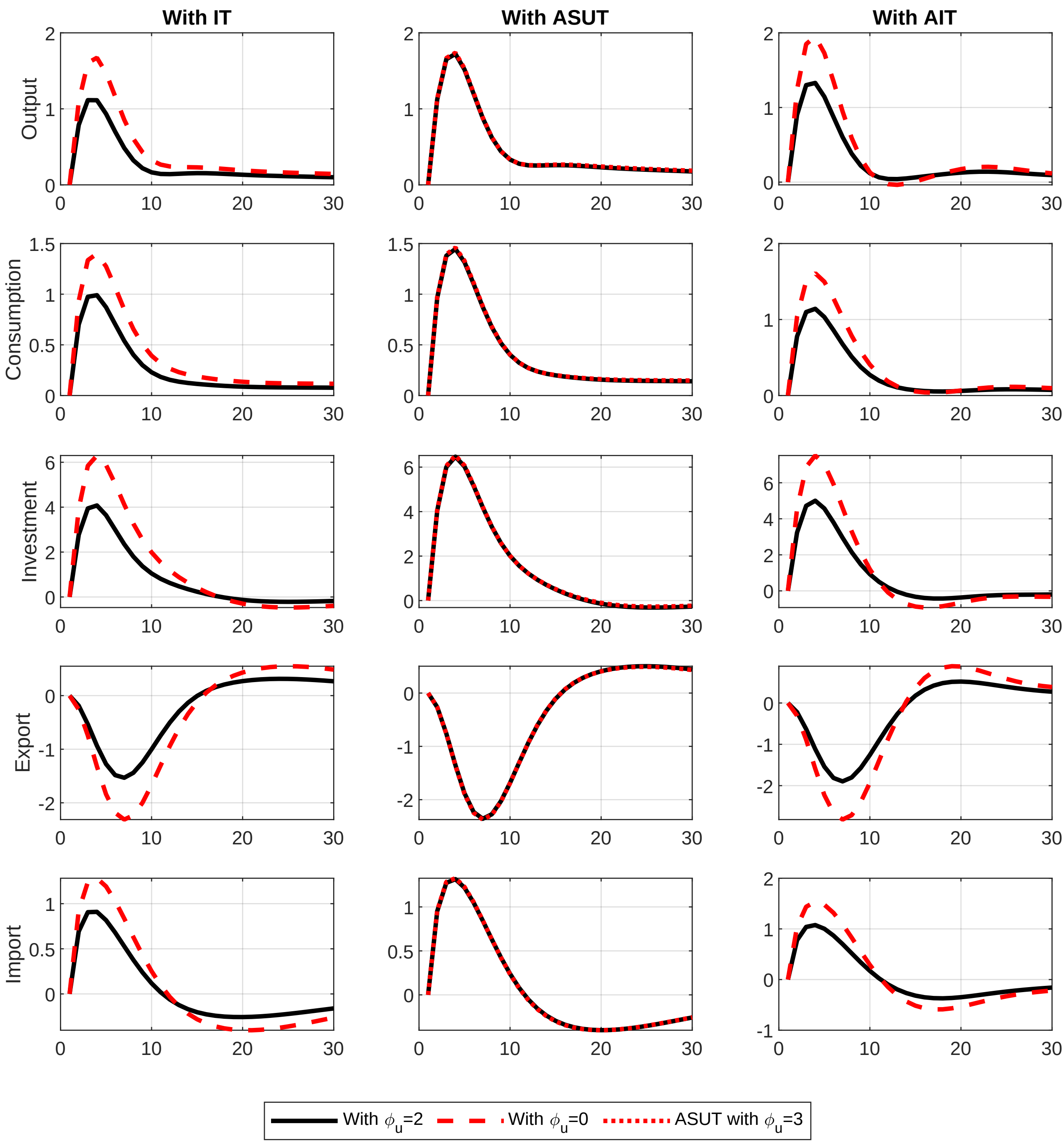
B Equalising labour markets only with respect to the replacement ratio

In the counterfactual reported in the main text, we set all targeted quantities in the calibration of the REA to be equal to those in Home. As explained in the main text, this involved many changes, but most of them were small and turned out not to be material for model dynamics. To demonstrate this, we report here the case where we set only the replacement ratio for the HtM households in the REA equal to that in Home, while keeping all other deep parameters unchanged.[2] The results are reported in Figures A-6, A-7 and A-8, and are not materially different from the figures reported in the main text. This indicates that it is indeed the case that the change in the replacement ratio of HtM households is the main driver of the differences

[1] The shock has been calibrated to achieve a 1 p.p. decrease in the euro-area-wide inflation rate at the trough.

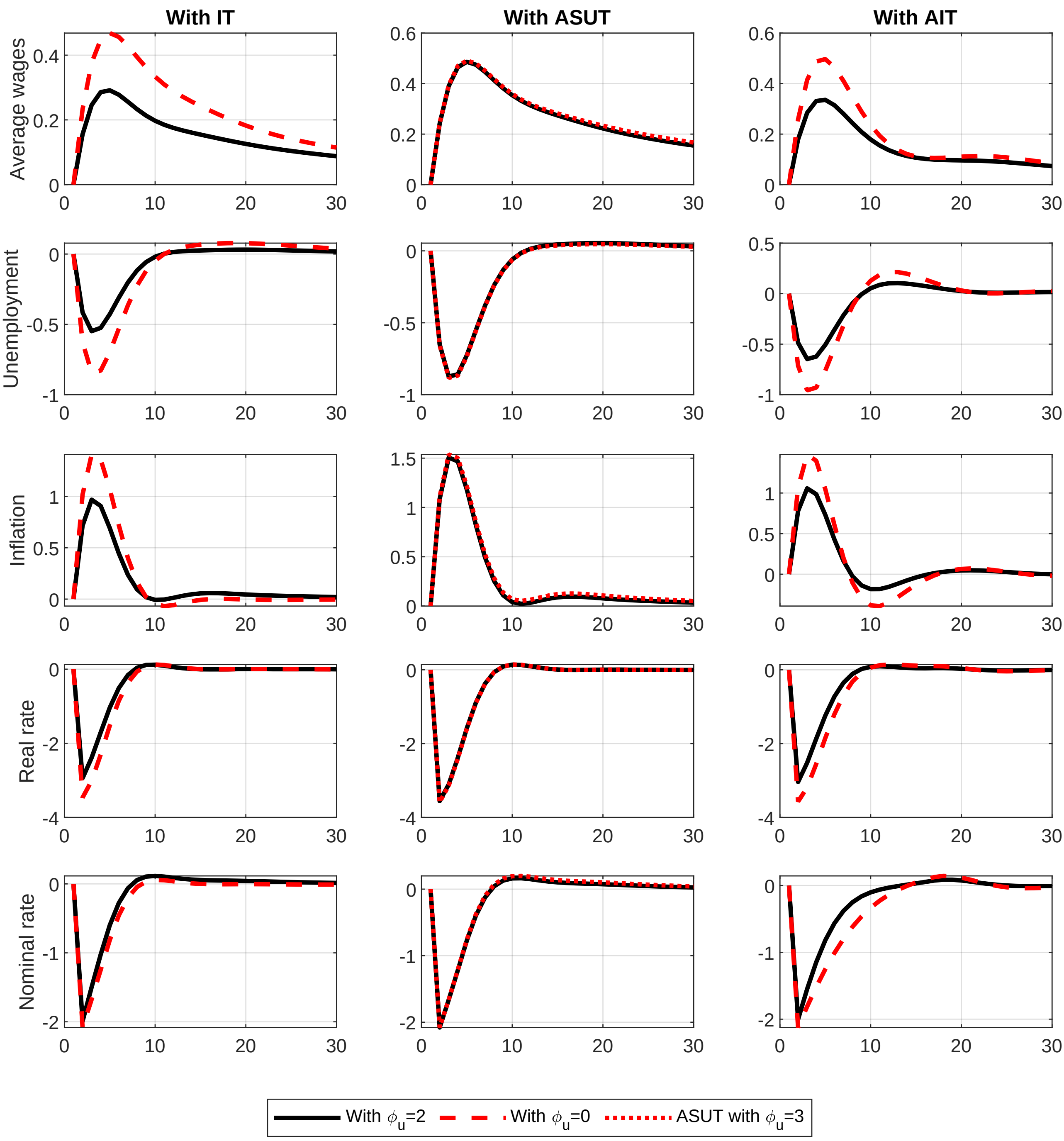
[2] Note that changing unemployment benefits in one country affects the steady state of all blocs in the model. This opens a question of what to do with the "deep" parameters that are calibrated to target a particular variable (e.g., steady-state unemployment rate, which is matched by adjusting the separation rate). To perform the counterfactual reported here, we first calibrated the model as in the benchmark case. We then collected all "deep" parameters, in particular the quasi-shares in trade aggregators, vacancy posting costs, matching efficiencies, bargaining powers and separation rates. We kept these at the same values as before the change in the replacement ratio, and re-computed the steady state with the new replacement ratio in the REA.

FIGURE A-1. Expansionary monetary policy shock: area-wide demand components



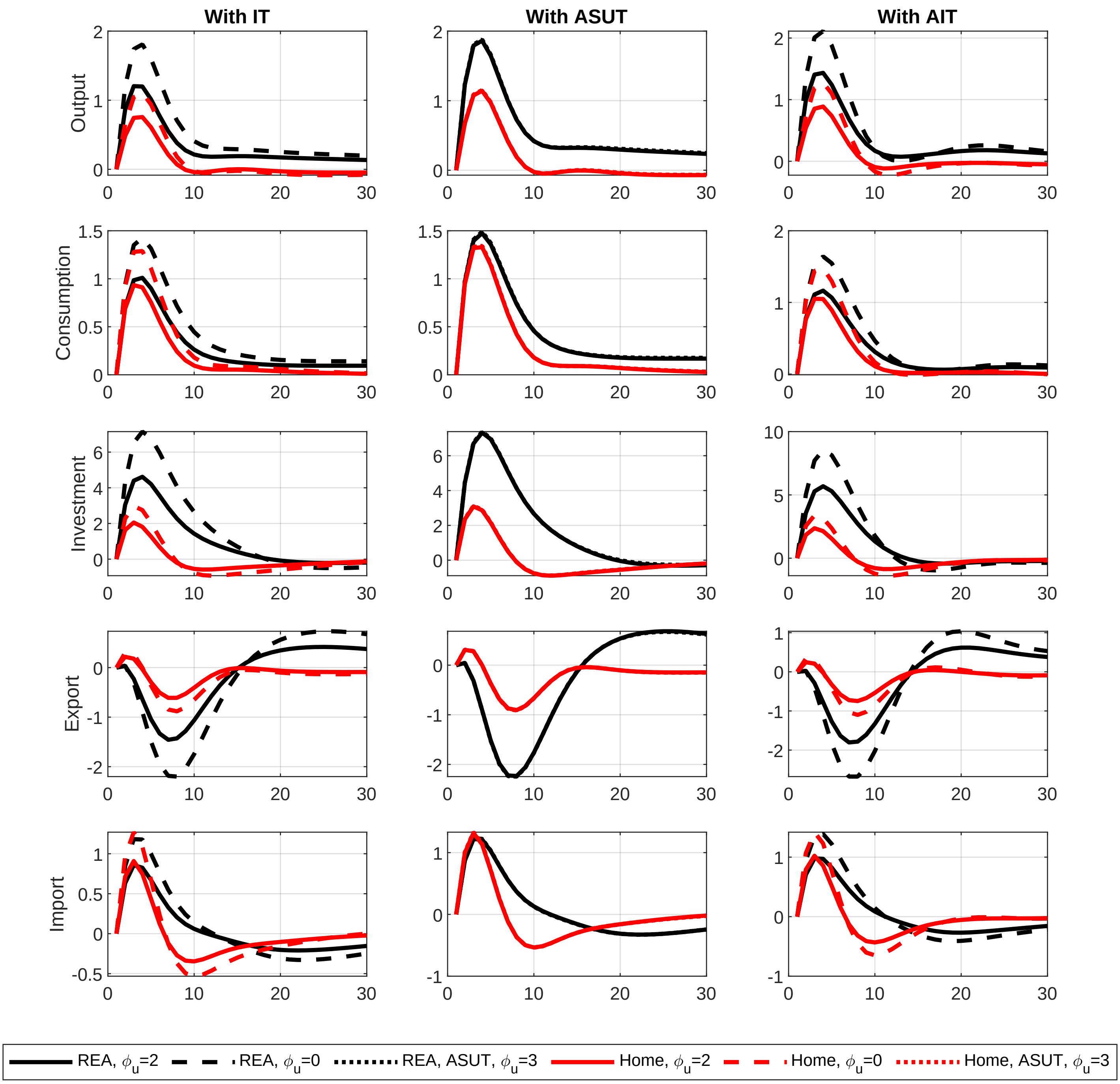
Horizontal axes: quarters; vertical axes: percent deviations from the steady state. All variables are in real terms.

Figure A-2. Expansionary monetary policy shock: area-wide variables



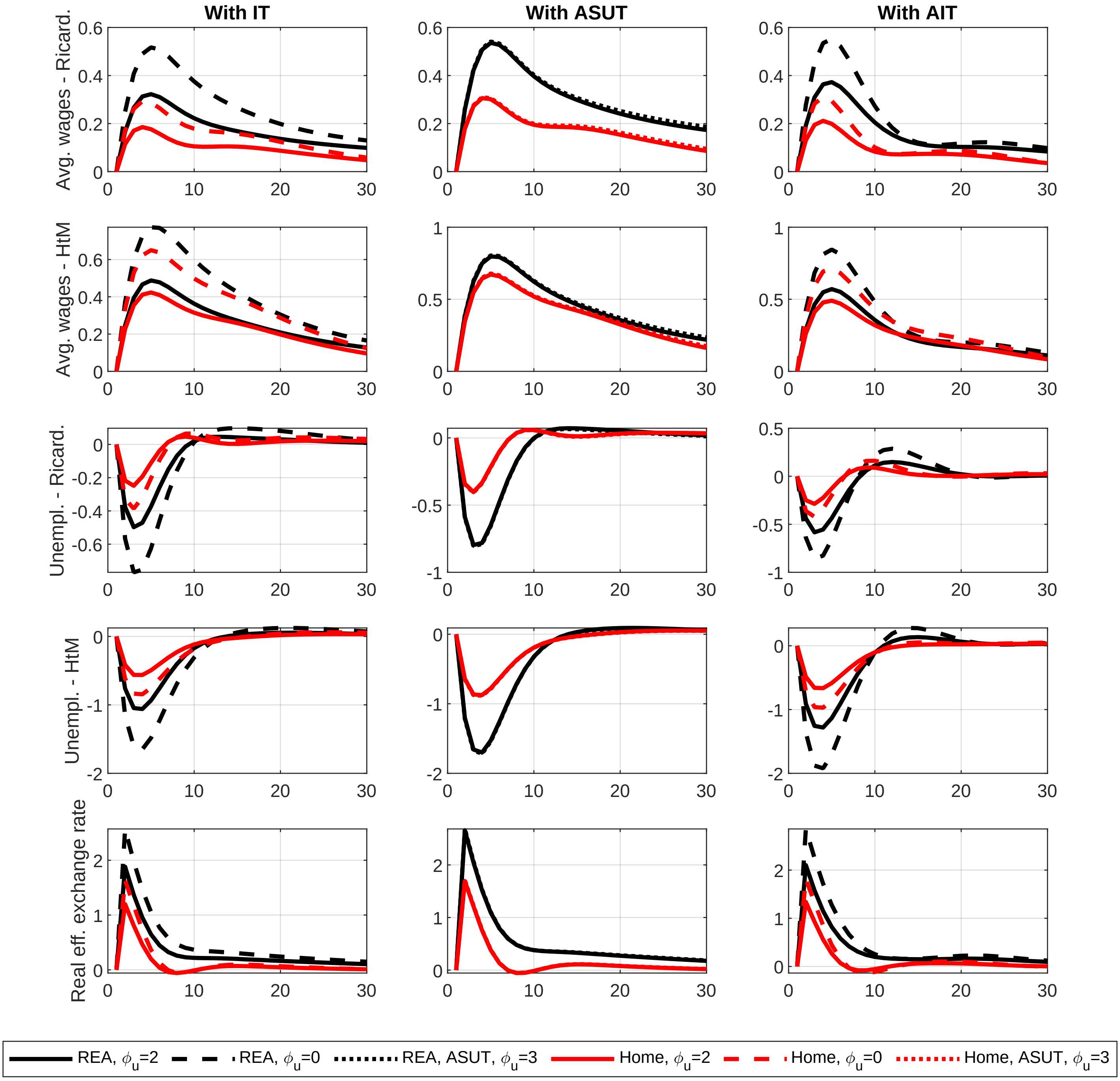
Horizontal axes: quarters; vertical axes: percentage point deviations from the steady state, except wages, which are in precent deviations. Interest rates and inflation are annualised.

FIGURE A-3. Expansionary monetary policy shock: country-specific demand components



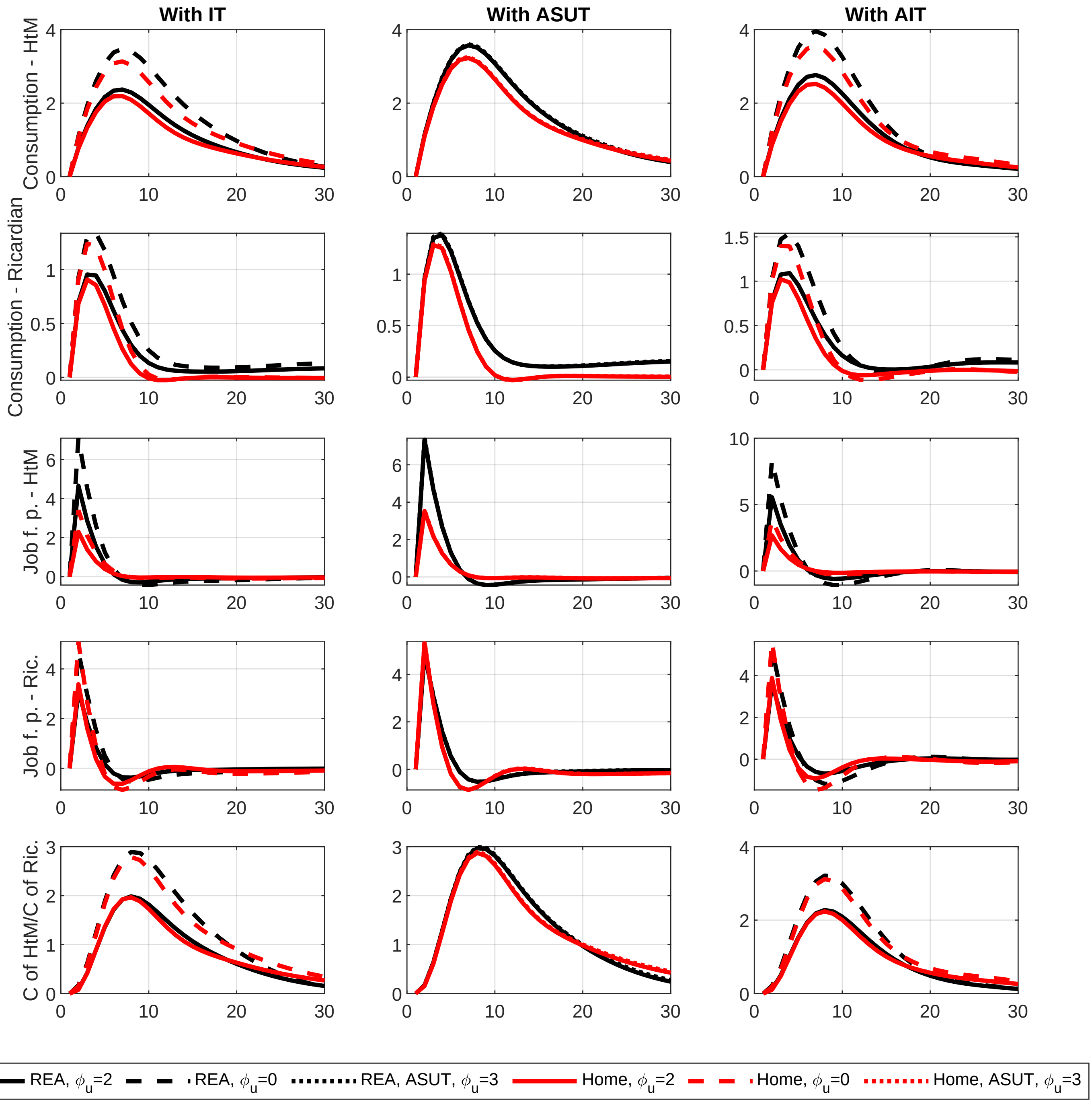
Horizontal axes: quarters; vertical axes: percent deviations from the steady state. All variables are in real terms.

Figure A-4. Expansionary monetary policy shock: country-specific variables



Horizontal axes: quarters; vertical axes: percent deviations from the steady state, except unemployment, which is in percentage point deviations. All variables are in real terms.

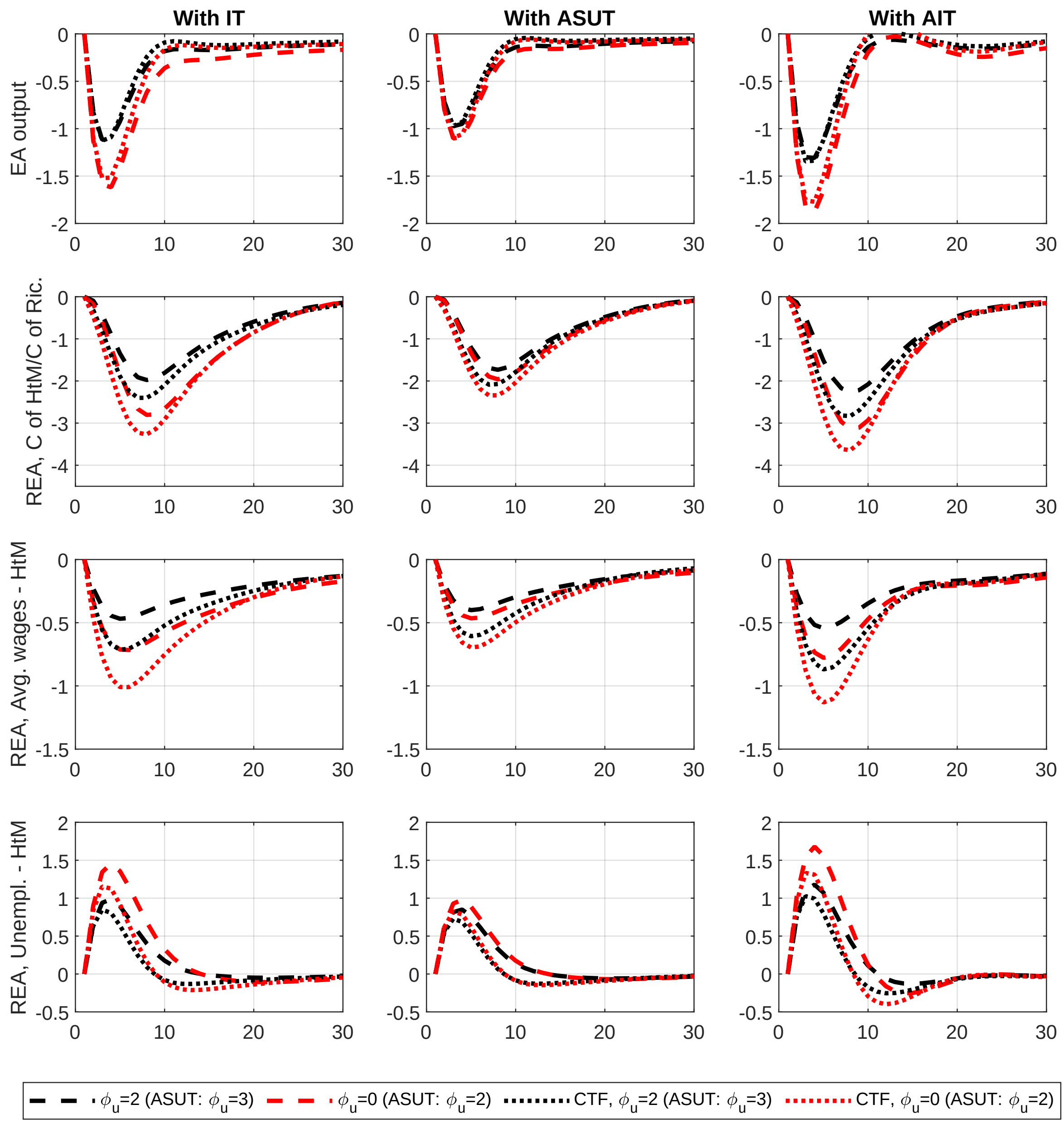
FIGURE A-5. Expansionary monetary policy shock: country-specific variables



Horizontal axes: quarters; vertical axes: percent deviations from the steady state, except job finding probabilities and relative consumption, which are in p.p. deviations. All variables are in real terms.

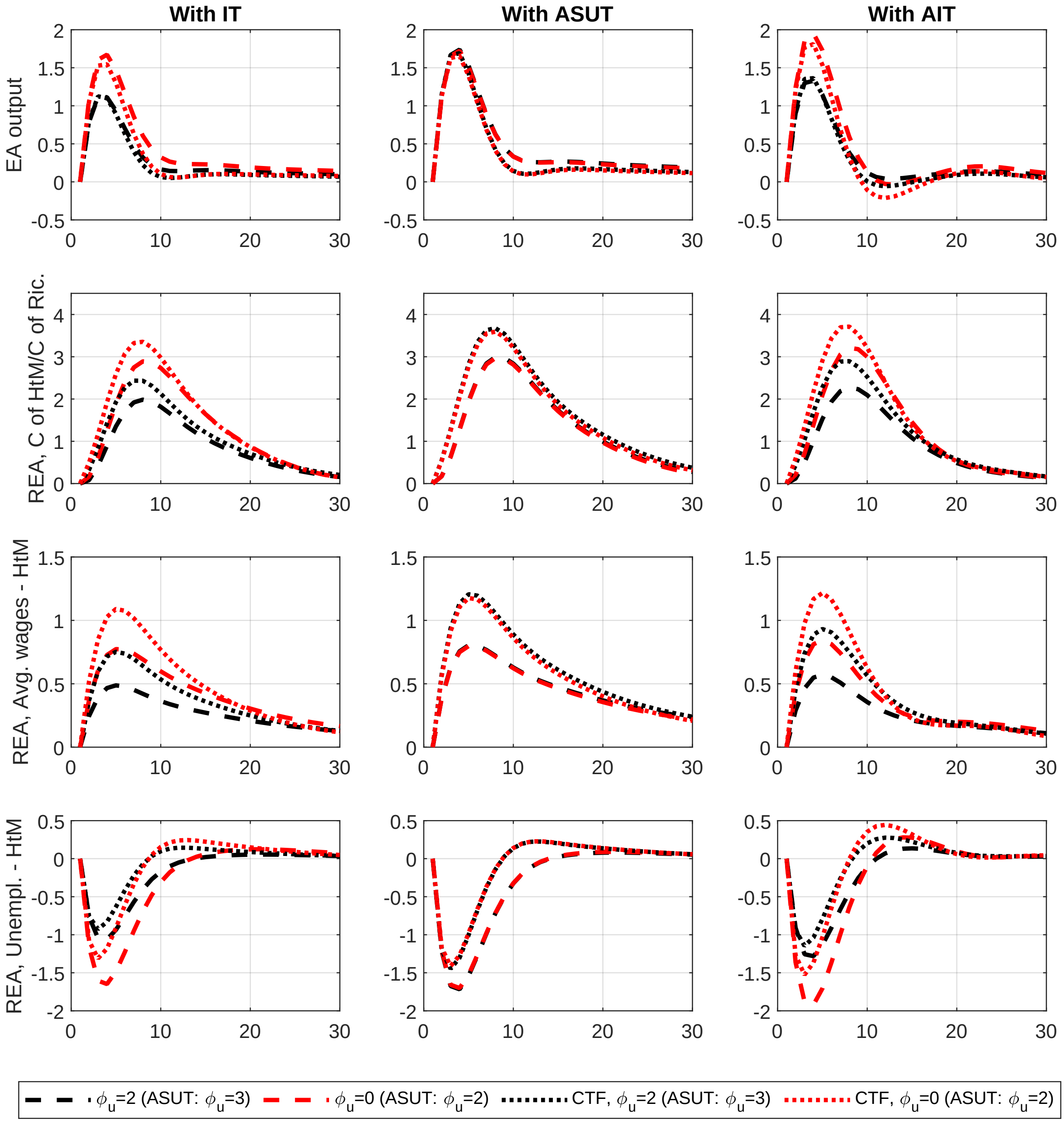
in the counterfactual experiment.

FIGURE A-8. Negative demand shock counterfact.: lower replacement rate in the REA



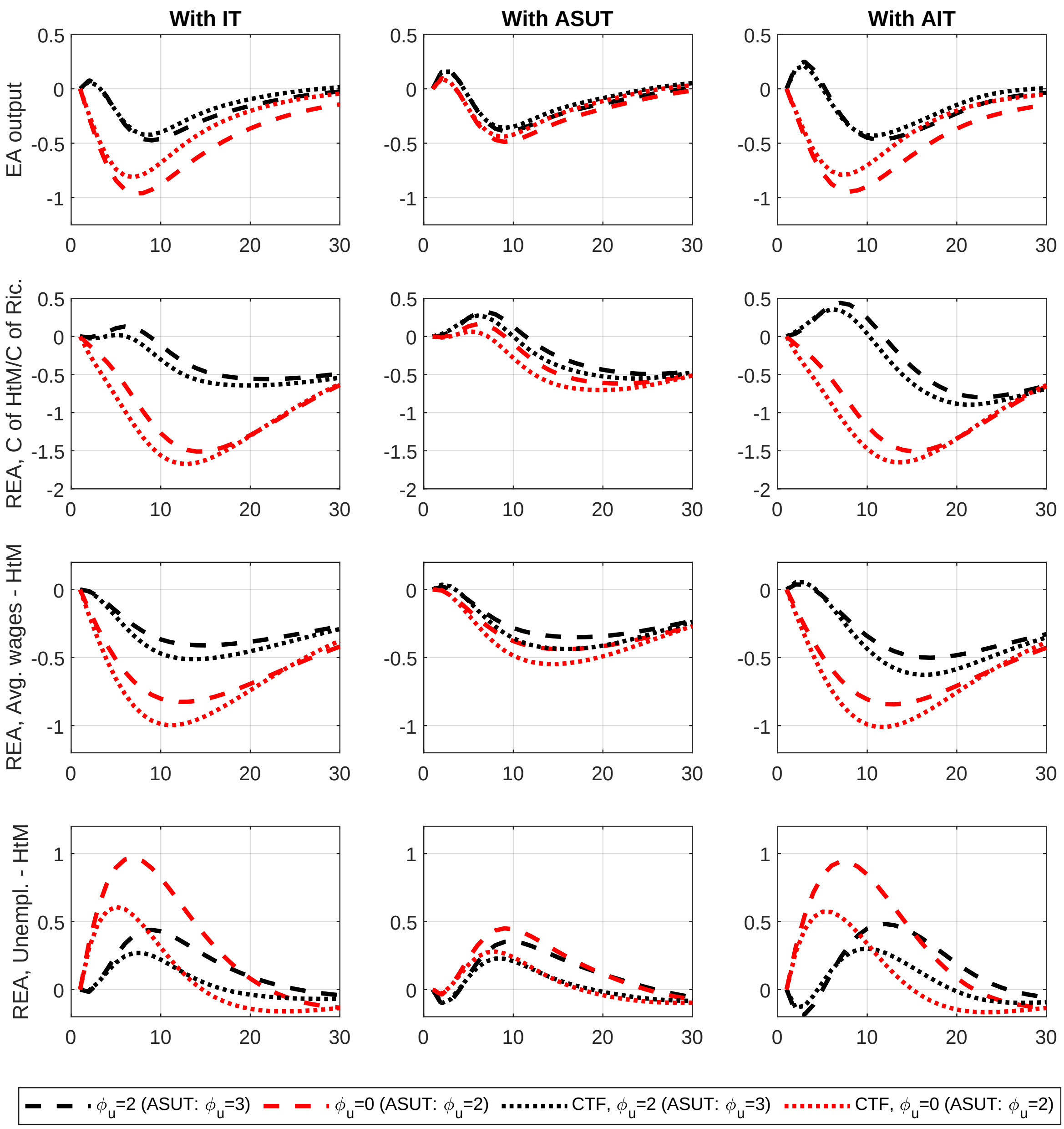
Dashed lines: benchmark. CTF stands for the counterfactual simulation with the REA replacement rate reduced to the level of replacement rate in Home. Horizontal axes: quarters; vertical axes: percent deviations from the steady state, except relative consumption and unemployment rate, which are in p.p. deviations. All variables are in real terms.

Figure A-6. Demand shock counterfactual: lower replacement rate in the REA



Dashed lines: benchmark. CTF stands for the counterfactual simulation with the REA replacement rate reduced to the level of replacement rate in Home. Horizontal axes: quarters; vertical axes: percent deviations from the steady state, except relative consumption and unemployment rate, which are in p.p. deviations. All variables are in real terms.

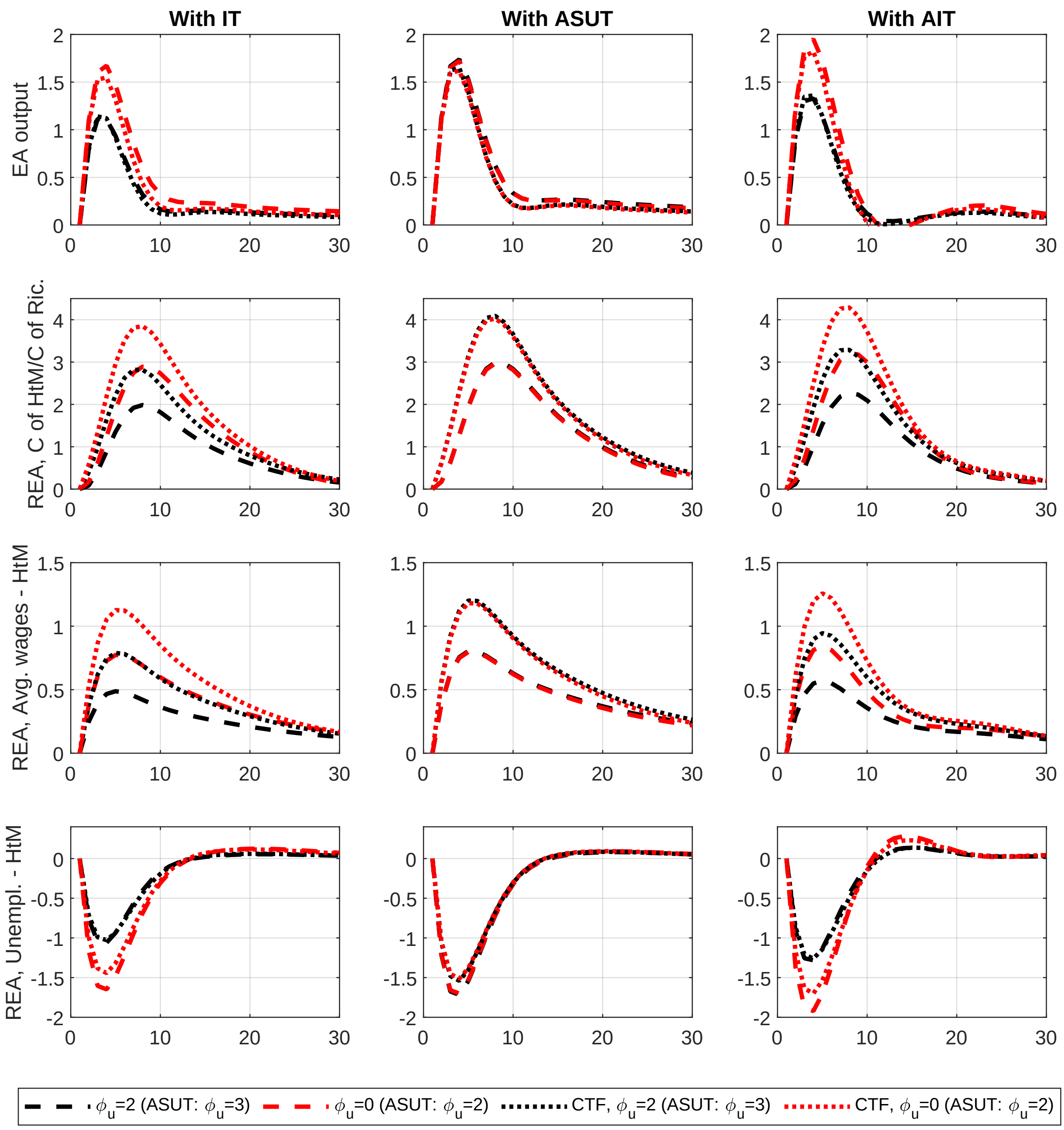
FIGURE A-7. Supply shock counterfactual: lower replacement rate in the REA



Dashed lines: benchmark. CTF stands for the counterfactual simulation with the REA replacement rate reduced to the level of replacement rate in Home. Horizontal axes: quarters; vertical axes: percent deviations from the steady state, except relative consumption and unemployment rate, which are in p.p. deviations. All variables are in real terms.

C Expansionary demand shock, Home and REA labour markets "equalised"

Figure A-9. Demand shock counterfactual: Home and REA labour markets "equalised"



Dashed lines: benchmark. CTF stands for the counterfactual simulation with all labour market parameters in the REA set to equal those in Home. Horizontal axes: quarters; vertical axes: percent deviations from the steady state, except relative consumption and unemployment rate, which are in p.p. deviations. All variables are in real terms.

D Wage Phillips curve and inflation-unemployment trade-off

Labour market frictions in the model affect the trade-off between inflation and unemployment. While the detailed investigation of the effects on Phillips curves is beyond the scope of this paper (note that there are three price Phillips curves in the model - one for tradable goods, one for non-tradable goods, and one for exports - there are also two wage Phillips curves - one for Ricardian and one for HtM households), we show here how the trade-off works for the new labour market features of the model. To do so, we consider the following experiment. Suppose that wages were more flexible than in the benchmark calibration (where they are quite rigid with the Calvo parameter at almost 0.9). We therefore lower wage rigidity for workers that renegotiate wages to 0.75 (average wage duration of four quarters) in both blocs of the euro area. This changes the slope of both wage Phillips curves (for Ricardian and HtM households).[3] We then re-run the inflationary supply shock with all three rules. The results for the euro area are shown in Figure A-10, with dashed lines showing the benchmark case with more rigid wages and dotted lines showing the case with more flexible wages.

More flexible wages change the inflation-unemployment trade-off, so that for the same shock, and for all the rules considered, both inflation and unemployment increase by less, with unemployment increasing much less than inflation. The reason is the fall in wages, which reduces inflation and at the same time shields unemployment, for the following reason. An inflationary markup shock causes a recession, but in the case of more flexible wages, the labour market can adjust better by lowering wages. The latter happens because in the recession, workers' probability of finding a job falls. This means that also their value of being unemployed - which in part depends on the probability of finding a job - falls. They are therefore willing to accept lower wage in the wage bargaining process. On the other hand, lower wages mean that firms reduce employment by less than they otherwise would, because labour is now cheaper. This mechanism changes the inflation-unemployment trade-off, so that with more flexible wages, the outcomes are more favourable both in terms of inflation and unemployment, under all monetary policy rules considered.

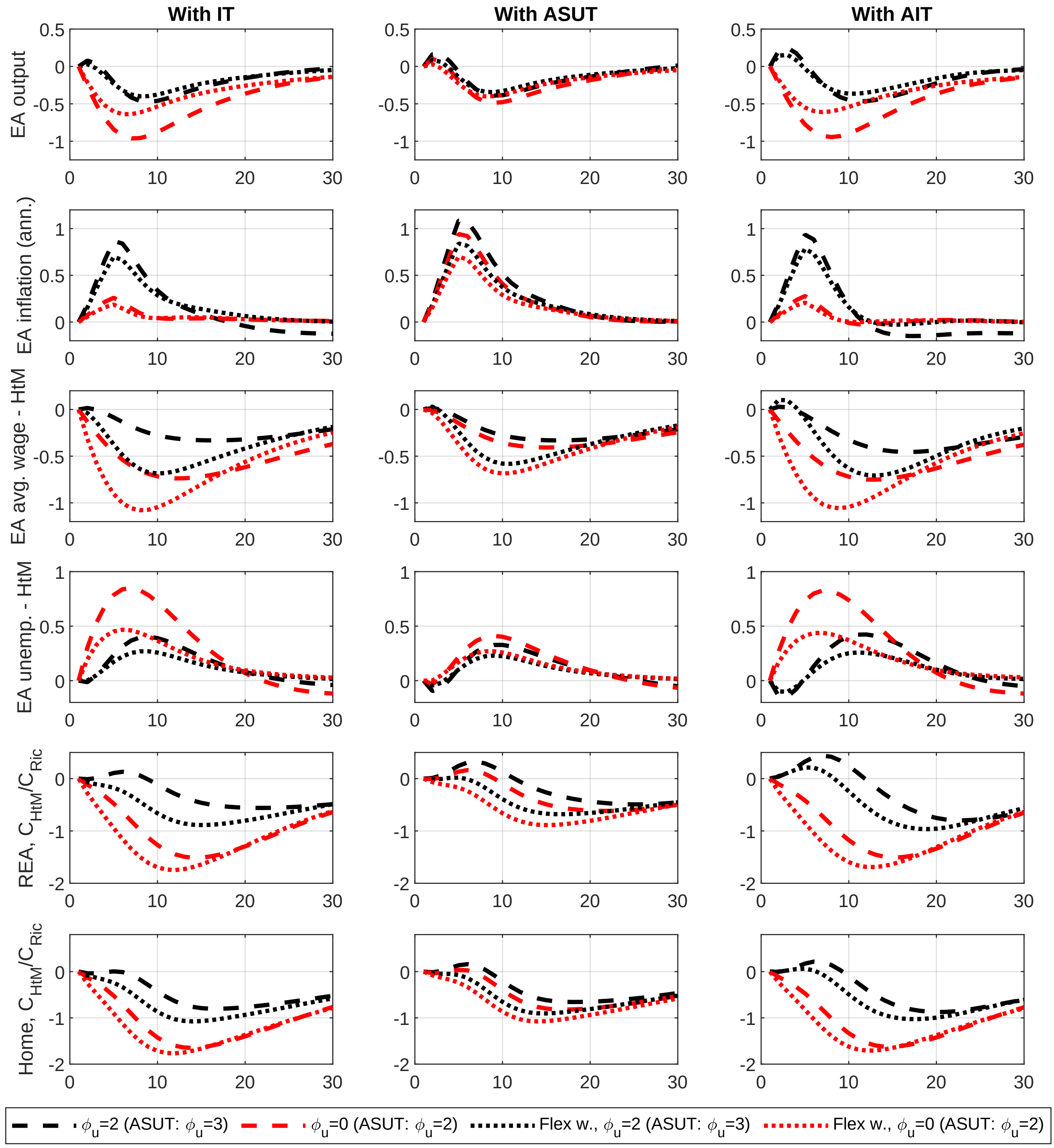
However, more flexible wages also imply that wages of HtM households fall by more, and this is not fully offset by the lower increase in unemployment of these households. Because HtM

[3] Note that we could also lower the rigidity of wages for newly-hired workers, which would have very similar qualitative implications as the experiment shown here. Because wages of new hires are already more flexible in the benchmark calibration, we focus on wages of existing workers.

households' consumption depends on their labour income, this means that their consumption also falls by more than consumption of Ricardian households, who can smooth consumption and therefore offset the temporary adverse shock. This can be seen in the last two rows of Figure A-10, where consumption inequality increases by more when wages are more flexible.[4] This holds for both blocs in the euro area and under all monetary policy rules considered.

[4] In Figure A-10 we only show wages and unemployment for HtM households, but the same applies for Ricardian households.

Figure A-10. Inflationary supply shock: The role of wage Phillips curve



Dashed lines: benchmark. Flex w. stands for the counterfactual with more flexible wages of existing workers. Horizontal axes: quarters; vertical axes: percent deviations from the steady state (output and wages), percentage point deviations from the steady state (unemployment rates and consumption ratios).

E Lower bargaining power of hand-to-mouth households

The difference in the bargaining power of Ricardian and HtM households is potentially an important issue, as it influences the heterogeneity of wage (and therefore unemployment) responses of the two types of households.[5] In the main body of the paper, we assumed the bargaining power is the same across the two types of households. The reason for this assumption was that the empirical evidence on the bargaining power of skilled and less-skilled workers is limited. The problem is that wages are rarely or almost never available by skill level, see e.g. Dumont et al. (2012). Bargaining power is usually related to the degree of unionisation, which has traditionally been higher in low-skilled professions, which would suggest these workers had higher bargaining power. However, this has been declining in recent years for many reasons, ranging from globalisation (for an early overview, see Rodrik (1997)) to skill-based technological change (Acemoglu et al. (2001)), among others. Given this evidence, it is likely that the bargaining power of more unionised low-skilled workers used to be higher than the bargaining power of less unionised high-skilled workers, but that it has since declined from the higher initial levels.

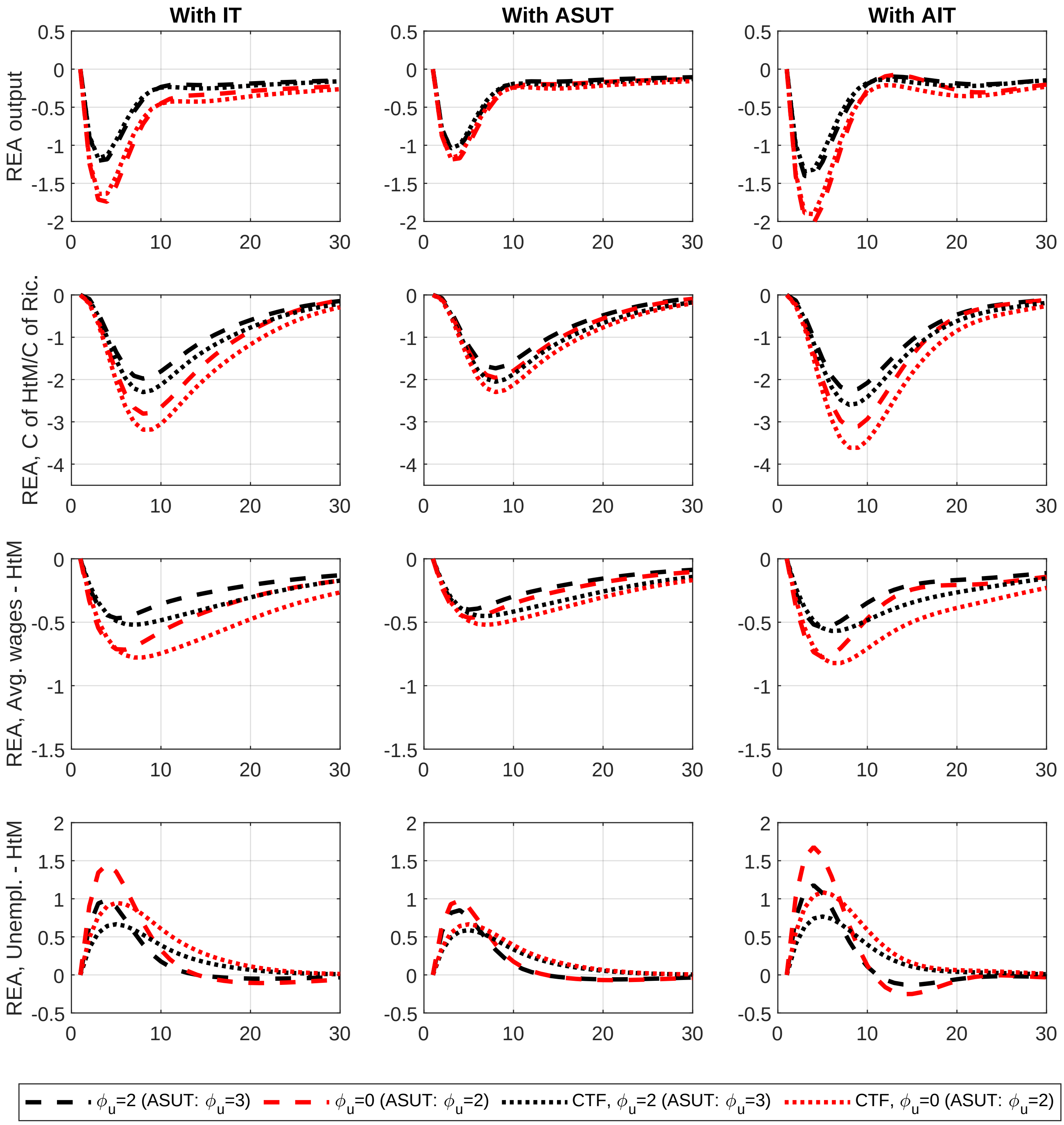
As a robustness check, we consider the case where the bargaining power of low-skilled workers may be lower than in our benchmark calibration. To investigate whether this affects our results, we recalibrate the bargaining power of HtM households to a lower level, $\eta_j = 0.2$, compared to the benchmark $\eta_j = 0.5$ and re-run the simulations. The results, compared to the benchmark, are reported in Figures A-11 (for the REA) and A-12 (for Home) for the contractionary monetary policy shock and in Figures A-13 (for the REA) and A-14 (for Home) for the inflationary supply shock.

Note that lowering the bargaining power of HtM households further lowers their steady-state levels income and consumption (which is already low because these households do not receive any income from capital and because their steady-state level of unemployment is higher). Moreover, it also changes the dynamics of their wages and employment. Specifically, after a contractionary demand shock (Figure A-11 for the REA and Figure A-12 for Home), their wages fall somewhat more and the fall is more persistent. This increases the value of such workers for firms, as they can pay lower wages for longer, and in response they keep more HtM workers employed, resulting in lower increase in unemployment, but at the price of lower wages and also more persistent unemployment (compared to the benchmark case, see the dotted lines in the last two

[5]We thank the anonymous reviewer for pointing this out.

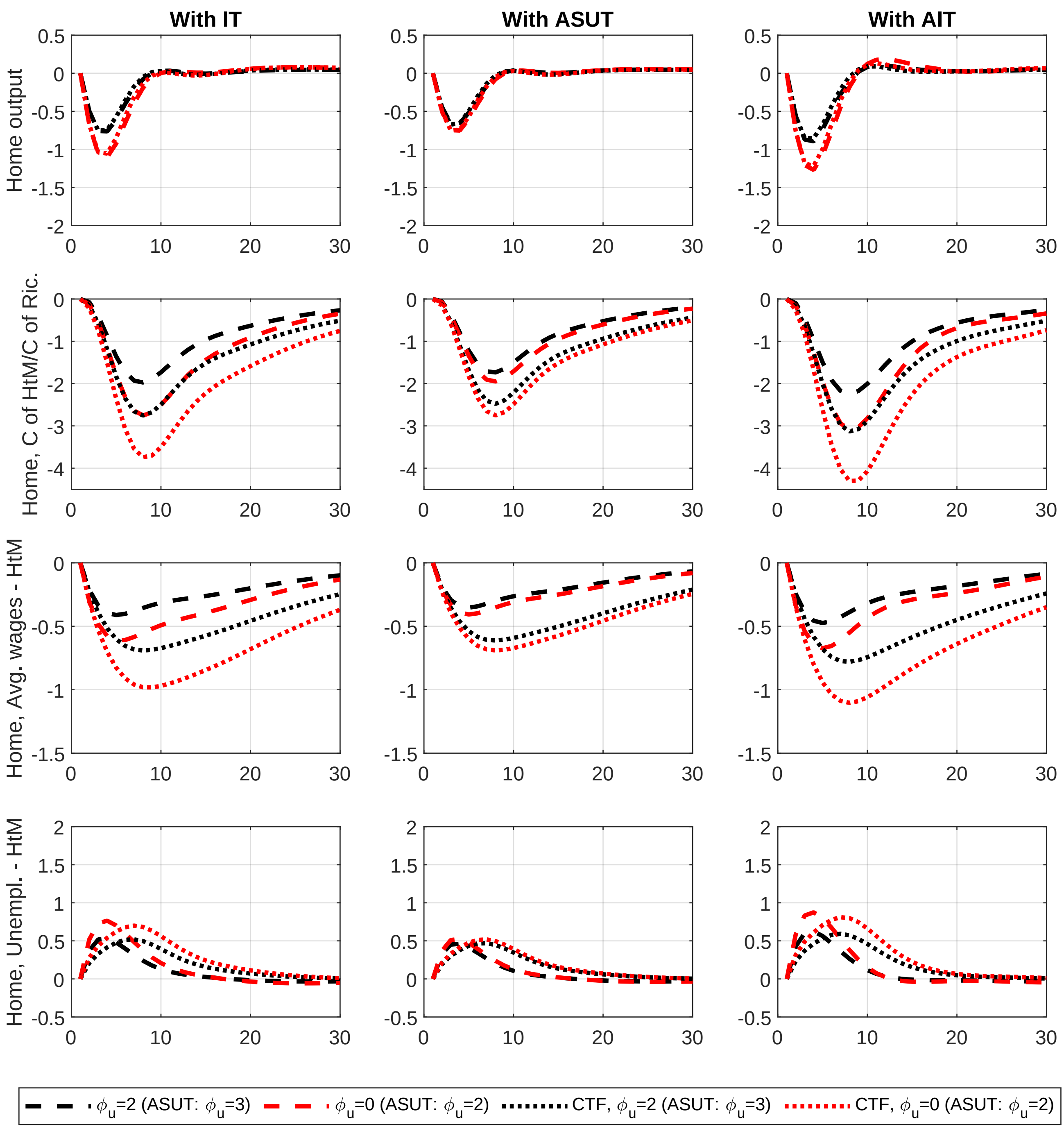
rows of Figures A-11 and A-12). Because lower wages and lower employment roughly offset each other, our main results are not materially affected - output follows a very similar path as in the benchmark case and the result regarding the disparity in consumption levels of Ricardian and HtM households is also confirmed. The same is the case when we examine inflationary markup shock, shown in Figures A-13 for the REA and A-14 for Home.

Figure A-11. REA, contractionary demand shock: Lower bargaining power of HtM households



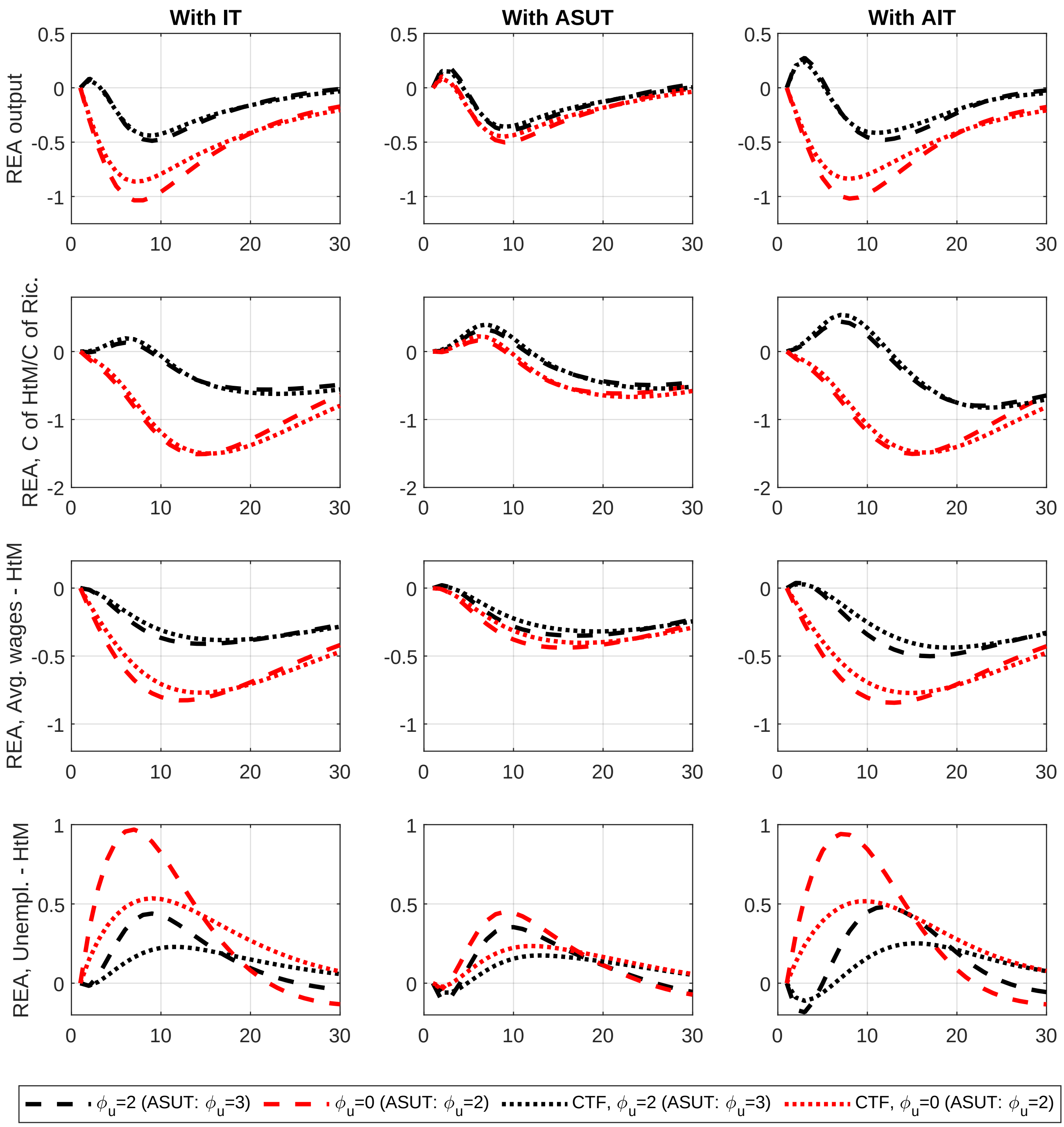
Dashed line is benchmark, dotted line is counterfactual with lower bargaining power of HtM households (labelled CTF in the legend). Horizontal axes: quarters; vertical axes: percent deviations from the steady state, except consumption ratio and unemployment rate, which are in percentage point deviations. All variables are in real terms.

FIGURE A-12. Home, contractionary demand shock: Lower bargaining power of HtM households



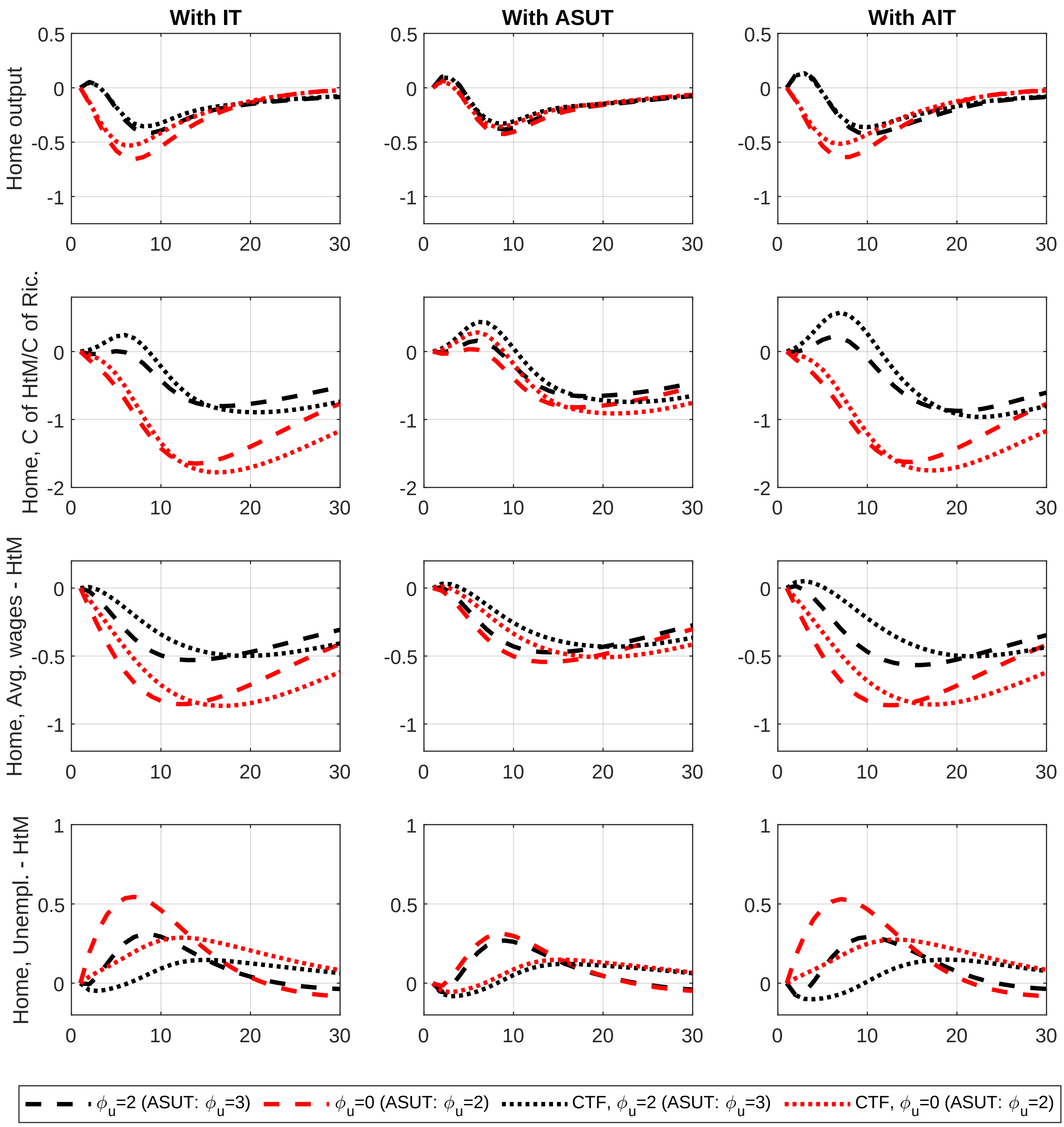
Dashed line is benchmark, dotted line is counterfactual with lower bargaining power of HtM households (labelled CTF in the legend). Horizontal axes: quarters; vertical axes: percent deviations from the steady state, except consumption ratio and unemployment rate, which are in percentage point deviations. All variables are in real terms.

Figure A-13. REA, inflationary markup shock: Lower bargaining power of HtM households



Dashed line is benchmark, dotted line is counterfactual with lower bargaining power of HtM households (labelled CTF in the legend). Horizontal axes: quarters; vertical axes: percent deviations from the steady state, except consumption ratio and unemployment rate, which are in percentage point deviations. All variables are in real terms.

FIGURE A-14. Home, inflationary markup shock: Lower bargaining power of HtM households



Dashed line is benchmark, dotted line is counterfactual with lower bargaining power of HtM households (labelled CTF in the legend). Horizontal axes: quarters; vertical axes: percent deviations from the steady state, except consumption ratio and unemployment rate, which are in percentage point deviations. All variables are in real terms.

F Main model equations

This section reports model equations that are important for understanding parts of the model not directly related to the labour market. It follows Gomes et al. (2010) and Gomes et al. (2012).

F.1 Households

Utility of two types of households in the model, Ricardian ($s = i$) and HtM ($s = j$) is:

$$E_t \left[\sum_{k=0}^{\infty} \beta^k \left(\frac{1-\kappa}{1-\sigma} \left(\frac{c_{s,t+k} - \kappa C_{s,t+k-1}}{1-\kappa} \right)^{1-\sigma} - \frac{1}{1+\zeta} h_{s,t+k}^{1+\zeta} \right) \right] \tag{1}$$

where $c_{s,t}$ is consumption, β is the discount rate, σ is the inverse of the intertemporal elasticity of substitution and ζ is the inverse of the elasticity of hours worked, $h_{s,t}$, with respect to the real wage. κ is the degree of habit formation in consumption of each type of households, where the habit depends on the aggregate consumption of the type, $C_{s,t}$.

Ricardian households hold capital, domestic government bonds B_t, paying the rate R_t set by the central bank, and internationally traded bonds denominated in US dollars B_t^*, paying R_t^* set by the US central bank. Investment in capital is subject to investment-adjustment costs that give rise to the standard optimality condition (Tobin's marginal q). The Euler equation with respect to domestic government bonds is

$$u'(c_{s,t}) = \beta \left(u'(c_{s,t+1}) \frac{R_t(1-\Gamma_{B,t+1})}{\pi_{t+1}} \right), \tag{2}$$

where $\Gamma_{B,t+1}$ is the transaction cost for the euro area traded bonds, which depends on the intra-EA bond holdings.[6] There is an analogous Euler equation for internationally traded bonds:

$$u'(c_{s,t}) = \beta \left(u'(c_{s,t+1}) \frac{R_t^*(1-\Gamma_{B^*,t+1})}{\pi_{t+1}^*} \frac{rer_{t+1}}{rer_t} \right), \tag{3}$$

where rer_t is the real exchange rate and Γ_{B^*} is the international transaction premium for US-denominated bonds, where $S_t^{H,US}$ is the nominal exchange rate, expressed in terms of units of Home currency per unit of US dollars:

$$\Gamma_{B^*}\left(\frac{S_t^{H,US} B_{t+1}^*}{P_{Y,t} Y_t}; rp_t \right) \equiv \gamma_{B^*} \left(\exp\left(\frac{S_t^{H,US} B_{t+1}^*}{P_{Y,t} Y_t} - \overline{B_Y^*} \right) - 1 \right) - rp_t \tag{4}$$

[6] The bond traded in the union is in euros and the transaction cost is needed to stabilise the model.

where γ_{B^*} is a parameter, $\overline{B_Y^*}$ is the steady-state net foreign asset position, rp_t is a risk premium shock, $P_{Y,t}$ is the GDP deflator, Y_t is the GDP in real terms. The term $\Gamma_{B,t+1}$ in the Euler equation for euro area bonds is analogous and depends on the target for intra-EA bond holdings. For further details see the Appendix in Gomes et al. (2010).

F.2 Final goods

Final goods are consumption goods $Q_{C,t}$ and investment goods $Q_{I,t}$ (to save space, we list equations only for consumption goods, as the equations for investment goods are analogous). They are assembled from tradable goods, $TT_{C,t}$ and non-tradable goods, $NT_{C,t}$ using the constant elasticity of substitution technology:

$$Q_{C,t} = \left[\nu_C^{\frac{1}{\mu_C}} TT_{C,t}^{\frac{\mu_C - 1}{\mu_C}} + (1 - \nu_C)^{\frac{1}{\mu_C}} NT_{C,t}^{\frac{\mu_C - 1}{\mu_C}} \right]^{\frac{\mu_C}{\mu_C - 1}}, \tag{5}$$

where:

$$TT_{C,t} = \left[\nu_{TC}^{\frac{1}{\mu_{TC}}} HT_{C,t}^{\frac{\mu_{TC} - 1}{\mu_{TC}}} + (1 - \nu_{TC})^{\frac{1}{\mu_{TC}}} IM_{C,t}^{\frac{\mu_{TC} - 1}{\mu_{TC}}} \right]^{\frac{\mu_{TC}}{\mu_{TC} - 1}}. \tag{6}$$

Tradable goods are a composite bundle of of domestic tradable goods, $HT_{C,t}$, and imports, $IM_{C,t}$. Imports, in turn, are also a composite of imports from other regions CO, denoted by $IM_{C,CO,t}$, and H stands for the home country:

$$IM_{C,t} = \left[\sum_{CO \neq H} \left(\nu_{IM_C}^{H,CO}\right)^{\frac{1}{\mu_{IMC}}} \left(IM_{C,CO,t} \left(1 - \Gamma_{IM^C}^{H,CO} \left(\frac{IM_{C,CO,t}}{Q_{C,t}} \right) \right) \right)^{\frac{\mu_{IMC}-1}{\mu_{IMC}}} \right]^{\frac{\mu_{IMC}}{\mu_{IMC}-1}} \tag{7}$$

Parameters μ_C, μ_{TC}, and μ_{IMC} are intratemporal elasticities of substitution between the inputs in the production functions, while ν_C, ν_{TC}, and ν_{IM_C} are weights (quasi-shares) of the inputs into the production functions, with $\sum_{CO \neq H} \upsilon_{IM^C}^{H,CO} = 1$. The function $\Gamma_{IM^C}^{H,CO} \left(\frac{IM_{C,CO,t}}{Q_{C,t}^C} \right)$ is the adjustment cost for bilateral consumption imports of country H from country CO, where γ_{IM^C} determines the magnitude of the cost:

$$\Gamma_{IM^C}^{H,CO} \left(\frac{IM_{C,CO,t}}{Q_{C,t}} \right) \equiv \frac{\gamma_{IM^C}}{2} \left(\frac{IM_{C,CO,t}/Q_{C,t}}{IM_{C,CO,t-1}/Q_{C,t-1}} - 1 \right)^2. \tag{8}$$

A firm chooses the combination of the tradable and nontradable bundles that minimizes the expenditure $P_{HT,t}HT_{C,t} + P_{IM^C,t}IM_{C,t} + P_{NT,t}NT_{C,t}$ subject to technology constraints (5) and (6), taking the input prices as given, which yields the following demand functions:

$$\begin{aligned} HT_{C,t} &= \nu_{TC}\nu_C \left(\frac{P_{HT,t}}{P_{TT^C,t}}\right)^{-\mu_{TC}} \left(\frac{P_{TT^C,t}}{P_{C,t}}\right)^{-\mu_C} Q_{C,t} && (9) \\ IM_{C,t} &= (1-\nu_{TC})\,\nu_C \left(\frac{P_{IM^C,t}}{P_{TT^C,t}}\right)^{-\mu_{TC}} \left(\frac{P_{TT^C,t}}{P_{C,t}}\right)^{-\mu_C} Q_{C,t} && (10) \\ NT_{C,t} &= (1-\nu_C) \left(\frac{P_{NT,t}}{P_{C,t}}\right)^{-\mu_C} Q_{C,t} && (11) \\ IM_{C,CO,t} &= \nu_{IM^C}^{H,CO} \left(\frac{P_{IM,t}^{H,CO}}{P_{IM^C,t}\Gamma_{IM^C}^{H,CO\dagger}\left(IM_{C,CO,t}/Q_{C,t}\right)}\right)^{-\mu_{IMC}} \frac{IM_{C,t}}{1-\Gamma_{IM^C}^{H,CO}\left(IM_{C,CO,t}/Q_{C,t}\right)} && (12) \end{aligned}$$

The term $\Gamma_{IM^C}^{H,CO\dagger}\left(\frac{IM_{C,CO,t}}{Q_{C,t}}\right)$ in the bilateral import bundle is the derivative of the adjustment cost.

The corresponding cost-minimizing prices are:

$$\begin{aligned} P_{C,t} &= \left[\nu_C P_{TT^C,t}^{1-\mu_C} + (1-\nu_C)\,P_{NT,t}^{1-\mu_C}\right]^{\frac{1}{1-\mu_C}} && (13) \\ P_{TT^C,t} &= \left[\nu_{TC} P_{HT,t}^{1-\mu_{TC}} + (1-\nu_{TC})\,P_{IM^C,t}^{1-\mu_{TC}}\right]^{\frac{1}{1-\mu_{TC}}} && (14) \\ P_{IM^C,t} &= \left(\sum_{CO\neq H} \nu_{IM^C}^{H,CO} \left(\frac{P_{IM,t}^{H,CO}}{\Gamma_{IM^C}^{H,CO\dagger}\left(IM_t^{C,CO}(x)\,/Q_{C,t}(x)\right)}\right)^{1-\mu_{IMC}}\right)^{\frac{1}{1-\mu_{IMC}}}. && (15) \end{aligned}$$

F.3 Intermediate goods

Non-tradable ($Y_{N,t}$) and tradable ($Y_{T,t}$) intermediate goods are produced using a Cobb-Douglas technologies:

$$\begin{aligned} Y_{N,t} &= z_{N,t}K_{N,t}^{\alpha_N}N_{N,t}^{1-\alpha_N} - \psi_N && (16) \\ Y_{T,t} &= z_{T,t}K_{T,t}^{\alpha_T}N_{T,t}^{1-\alpha_T} - \psi_T && (17) \end{aligned}$$

where ψ_N and ψ_T are fixed costs. The inputs are homogenous capital services, $K_{N,t}$ and K_{NTt}, and labour services, $N_{N,t}$ and $N_{N,t}$. Capital services are supplied by domestic households under perfect competition, yielding that demand for capital is determined by its marginal product being equal to the rental rate, while labour demand is determined by the marginal product of labour at intermediate goods firm being equal to the cost of labour determined by labour packers, as described in the main text. $z_{N,t}$ and $z_{T,t}$ are sector-specific productivity shocks.

Note that the labour market clearing implies that the total labour services provided by the labour packer (see equation **??** in the main text) must equal to the labour demanded by intermediate goods firms:

$$n_t = N_{N,t} + N_{T,t}. \tag{18}$$

Goods markets for non-tradable and tradable goods clear by equating supply and demand. Demand for non-tradable goods comes from demands for non-tradable consumption and investment goods, ($NT_{C,t}$ and $NT_{I,t}$), and from government (G_t), which is fully biased towards non-tradable goods. Demand for tradable goods comes from demands for tradable consumption and investment goods ($HT_{C,t}$, $HT_{I,t}$) and from trading partners' imports ($IM_{CO,H,t}$). $s_{N,t}$, $s_{HT,t}$, and $s_{X,t}^{H,CO}$ are price dispersions in non-tradable, tradable, and export sectors:

$$Y_{N,t} = s_{N,t}\left(NT_{C,t} + NT_{I,t} + G_t\right) \tag{19}$$

$$Y_{T,t} = s_{HT,t}(HT_{C,t} + HT_{I,t}) + \sum_{CO \neq H} s_{X,t}^{H,CO} IM_{CO,H,t} \tag{20}$$

F.4 Price setting

Price setting follows the standard Calvo (1983) framework. Intermediate goods firms, however, set prices differently, depending on the market to which they are pricing their goods. This applies to non-tradable, home tradable and to export goods, in the latter case also for each export market separately (the so-called local currency pricing framework). Prices that are not reset are indexed to a composite of past inflation and inflation target.

Price setting for non-tradable goods. All non-tradable goods firms that are able to reset their prices, which happens with the probability $1-\xi_N$, choose the same price $\widetilde{P}_{NT,t}$. Firms that do not reset their prices index their prices according to $P_t = (\Pi_{NT,t-1})^{\chi_N}\, \overline{\Pi}^{1-\chi_N} P_{t-1}$, i.e., to a geometric average of past sector-specific inflation, $\Pi_{NT,t-1} \equiv P_{NT,t-1}/P_{NT,t-2}$ and the (constant) inflation target, $\overline{\Pi}$. The parameter χ_N measures the degree of indexation. Reoptimising firm maximizes the discounted sum of its expected nominal profits subject to the price-indexation scheme and taking as given the demand for its brand. The marginal costs $MC_{N,t}$ are symmetric across producers. $\Lambda_{i,t,t+k}$ is the stochastic discount factor of i-type households, who own firms.

The implied first-order condition is:

$$E_t\left[\sum_{k=0}^{\infty}(\xi_N)^k\,\Lambda_{i,t,t+k}\left(\prod_{s=1}^{k}\Pi_{NT,t+s-1}^{\chi_N}\overline{\Pi}^{1-\chi_N}\widetilde{P}_{NT,t}-\frac{\theta_N}{\theta_N-1}MC_{N,t+k}\right)NT_{t+k}\right]=0 \tag{21}$$

Firms whose price contracts are re-optimized set prices to equate the discounted sum of expected revenues to the discounted sum of expected marginal costs.

With price setting as described above, the sector-specific price index $P_{NT,t}$ is:

$$P_{NT,t}=\left[\xi_N\left(\Pi_{NT,t-1}^{\chi_N}\overline{\Pi}^{1-\chi_N}P_{NT,t-1}\right)^{1-\theta_N}+(1-\xi_N)\left(\widetilde{P}_{NT,t}\right)^{1-\theta_N}\right]^{\frac{1}{1-\theta_N}} \tag{22}$$

Price setting for home tradable goods. Price setting for home tradable goods is analogous to that of non-tradable goods. The probability of resetting the price is $(1-\xi_H)$. The sector-specific price index $P_{HT,t}$ evolves according to:

$$P_{HT,t}=\left[\xi_H\left(\Pi_{HT,t-1}^{\chi_H}\overline{\Pi}^{1-\chi_H}P_{HT,t-1}\right)^{1-\theta_T}+(1-\xi_H)\left(\widetilde{P}_{HT,t}\right)^{1-\theta_T}\right]^{\frac{1}{1-\theta_T}} \tag{23}$$

Price setting for export goods. Firms discriminates across countries, by invoicing and setting the price in the currency of the generic destination market CO (local currency pricing assumption). The probability of optimally resetting prices $(1-\xi_X)$, and all firms that reset their prices choose the same price, $\widetilde{P}_{X,t}^{H,CO}$, while the others index their prices to $P_{X,t}^{CO}=\left(\Pi_{X,t-1}^{H,CO}\right)^{\chi_X}\overline{\Pi}^{1-\chi_X}P_{X,t-1}^{CO}$, where $\Pi_{X,t-1}^{H,CO}\equiv P_{X,t-1}^{H,CO}/P_{X,t-2}^{H,CO}$ is the sector-specific inflation. Foreign inflation target is time invariant and equal to the Home inflation target, $\overline{\Pi}^{CO}=\overline{\Pi}$.

The bilateral exports price index (of country H to the generic country CO) is:

$$P_{X,t}^{H,CO}=\left[\xi_X\left(\left(\Pi_{X,t-1}^{H,CO}\right)^{\chi_X}\overline{\Pi}^{1-\chi_X}P_{X,t-1}^{H,CO}\right)^{1-\theta_T}+(1-\xi_X)\left(\widetilde{P}_{X,t}^{H,CO}\right)^{1-\theta_T}\right]^{\frac{1}{1-\theta_T}} \tag{24}$$

F.5 Labour market

We construct an enhanced labour market structure that we build onto the EAGLE model described above. The labour market features search frictions as in Mortensen and Pissarides (1999), but adds sticky wages by means of staggered wage setting, and a potential to distinguish wage stickiness of new hires and existing workers. This approach follows broadly Bodart et al. (2006) and de Walque et al. (2009). In addition, we distinguish between labour market segments for Ricardian and HtM households, each of which can have their own unemployment, hours worked, wage setting, and different wage rigidities for new hires and existing workers.

The aim of this relatively complex structure is to capture the labour market more realistically in an otherwise two-agent model, in particular the fact that it is likely that wages for new hires are more volatile than wages for existing workers (see e.g. Haefke et al. (2013) and Lydon and Lozej (2018)) and that it is likely that poorer households are often those for whom employment outcomes are more susceptible to business cycle fluctuations than for richer households. This is in line with the evidence for several countries (see Cairó and Cajner (2018) for the US, and Broer et al. (2022) for Germany).

More volatile employment outcomes for a particular segment of wealth distribution are not important in a representative-agent framework, where income fluctuations can be smoothed by risk sharing among the households. However, as outlined in the above papers, labour market at the bottom of the income distribution is different than at the top. This is why we need this relatively complex setup of the labour market to be able to capture the more volatile properties of the labour market at the bottom of the income distribution, i.e., the labour market for HtM households. This has broader implications, because the fluctuations in this labour market, due to the inability to smooth consumption, affect aggregate consumption and aggregate fluctuations.

There are two labour market segments, one for Ricardian and one for HtM households. There is a continuum of labour firms in each labour market segment, with each labour firm employing one worker. Labour firms pay labour taxes, bargain with households over wages, and post vacancies at a per-period fixed cost. If they find a worker, they sell homogeneous labour services to a labour packer, which aggregates labour from the Ricardian and HtM labour market segments and sells aggregated labour services to intermediate goods firms.

The flows on the labour market are as follows. The number of workers in segment s ($s = i$ for Ricardian and $s = j$ for HtM households) that are employed after the matching process has been completed, $nde_{s,t}$, evolves as follows:

$$nde_{s,t} = (1 - \delta_{x,s})\ nde_{s,t-1} + M_{s,t}, \tag{25}$$

where $M_{s,t}$ is the number of new matches formed in a period (with $M_{s,t} > 0$), and $\delta_{x,s}$ is the fraction of existing employment relationships that have (exogenously) separated in each period (i.e. it is the exogenous separation rate, $0 < \delta_{x,s} < 1$). The number of matches $M_{s,t}$ is defined according to the following matching function:

$$M_{s,t} = \phi_{s,M}(un_{s,t})^{\mu_s}(vac_{s,t})^{1-\mu_s} = p^W_{s,t}un_{s,t} = p^F_{s,t}vac_{s,t}, \tag{26}$$

where $\phi_{s,M}$ is matching efficiency, $un_{s,t}$ is the number of searching workers in each segment, $vac_{s,t}$ is the number of vacancies, $p^W_{s,t}$ is the matching probability for workers of each type, $p^F_{s,t}$ is the matching probability for firms, and μ_s, with $(0 < \mu_s < 1)$, is the elasticity of the matching function with respect to unemployment in each segment.

The probability for a searching worker to find a job is

$$p^W_{s,t} = \frac{M_t}{un_{s,t}} = \phi_{s,M}(\frac{vac_{s,t}}{un_{s,t}})^{1-\mu_s} \tag{27}$$

and the probability of a firm finding a worker is

$$p^F_{s,t} = \frac{M_{s,t}}{vac_{s,t}} = \phi_{s,M}(\frac{vac_{s,t}}{un_{s,t}})^{-\mu_s} \tag{28}$$

The number of unemployed workers who search for work at the beginning of period t (i.e., the number of workers who enter the matching process, $un_{s,t}$) is equal to those who were unemployed at the end of period $t-1$ after the $t-1$ matching has been completed (i.e., $une_{s,t-1}$), plus the newly separated workers (i.e., $\delta_{x,s}nde_{s,t-1}$):

$$un_{s,t} = une_{s,t-1} + \delta_{x,s}nde_{s,t-1}, \tag{29}$$

These workers are the ones who receive unemployment benefits. The population of each bloc in the model is standardised to 1, and so is the mass of households in each segment, so that the number of unemployed at the end of the period in a segment s is $une_{s,t} = 1 - nde_{s,t}$. Total unemployment in a bloc is a weighted unemployment across labour market segments, where ω is the share of HtM households: $une_t = \omega\ une_{j,t} + (1-\omega)une_{i,t}$.

F.5.1 Value functions

We will require two sets of value functions. One set of value functions is for wages that have been renegotiated in the current period, and one set for wages that have not been renegotiated.

We assume that wages that have not been renegotiated are indexed to inflation. The notation follows closely the notation used in Bodart et al. (2006) and de Walque et al. (2009).

Value functions for a labour firm Let $A^F(w^*_{s,t})$ denote the value of a job for a firm employing a worker from household type $s \in [i,\ j]$, where $w^*_{s,j}$ is the renegotiated wage, and i stands for a Ricardian and j for a HtM household. Following Bodart et al. (2006), it will be convenient to use this value in marginal utility terms, so we define $\mathcal{A}^F(w^*_{s,t}) \equiv u'(c_{s,t})A^F(w^*_{s,t})$, where $u'(c_{s,t})$ is the marginal utility of consumption of household s. The value of a job with a renegotiated wage for a labour firm can then be written as

$$\begin{aligned}\mathcal{A}^F_t(w^*_{s,t}) &= u'(c_{s,t})\left(h^{\alpha_H}_{s,t}x_{s,t} - h_{s,t}w^*_{s,t}(1+\tau^{wf}_t)\right) \\ &\quad + \beta(1-\delta_{x,s})\left[(1-\xi_{w,s})\mathcal{A}^F_{t+1}(w^*_{s,t+1}) + \xi_{w,s}\mathcal{A}^F_{t+1}(w^*_{s,t})\right]\end{aligned} \tag{30}$$

Here the term $h^{\alpha_H}_{s,t}$ denotes the effective hours that a labour firm produces from hours $h_{s,t}$ supplied by the worker from household s.[7] $x_{s,t}$ is what the labour packer pays for such unit of labour. The first term in equation 30 therefore measures earnings of the labour firm from selling hours worked. But for these hours it has to pay to the household hourly wage, which is in this case newly renegotiated, $w^*_{s,t}$. Because we assume that labour firms pay some labour taxes (social security contributions), the cost for the labour firm is increased by taxes paid, at the rate τ^{wf}_t. In the next period, if the firm and the worker do not separate, which occurs with probability $(1-\delta_{x,s})$, two cases can arise. In the first case, which occurs with the probability $(1-\xi_{w,s})$, wages are renegotiated and the value of the worker for the labour firm is again the value of a worker with a renegotiated wage, just in the next period, $\mathcal{A}^F_{t+1}(w^*_{s,t+1})$. With probability $\xi_{w,s}$ wages are not renegotiated and the firm is in next period stuck with the worker value at the current wage, $\mathcal{A}^F_{t+1}(w^*_{s,t})$.

The value at $t+1$ of the worker with renegotiated wage from time t is

$$\begin{aligned}\mathcal{A}^F_{t+1}(w^*_{s,t}) &= u'(c_{s,t+1})\left(h^{\alpha_H}_{s,t+1}x_{s,t+1} - h_{s,t+1}w^*_{s,t}\frac{(1+\overline{\pi})P_t}{P_{t+1}}(1+\tau^{wf}_{t+1})\right) \\ &\quad + \beta(1-\delta_{x,s})\left[(1-\xi_{w,s})\mathcal{A}^F_{t+2}(w^*_{s,t+2}) + \xi_{w,s}\mathcal{A}^F_{t+2}(w^*_{s,t})\right]\end{aligned} \tag{31}$$

[7] Note that α_H is very close to 1.

The wage from the previous period has been indexed by the ratio of trend inflation $\overline{\pi}$ and the price level growth, $P_t/P_{t+1} = (1+\pi_{t+1})$.[8]

If we substitute equation 31 into equation 30, and do this for every future period, we arrive at the following expression:

$$\begin{aligned}\mathcal{A}_t^F(w_{s,t}^*) = &\sum_{k=0}^{\infty}\left[\beta(1-\delta_{x,s})\xi_{w,s}\right]^k u'(c_{s,t+k})h_{s,t+k}^{\alpha_H}x_{s,t+k}\\ &- w_{s,t}^*\sum_{k=0}^{\infty}\left[\beta(1-\delta_{x,s})\xi_{w,s}\right]^k u'(c_{s,t+k})\frac{(1+\overline{\pi})^k P_t}{P_{t+k}}h_{s,t+k}(1+\tau_{t+k}^{wf})\\ &+\sum_{k=0}^{\infty}\beta(1-\delta_{x,s})(1-\xi_{w,s})\left[\beta(1-\delta_{x,s})\xi_{w,s}\right]^k\mathcal{A}_{t+k+1}^F(w_{s,t+k+1}^*)\end{aligned} \tag{32}$$

As in Bodart et al. (2006), we can define auxiliary variables and write the infinite sums in recursive form. For the first line in equation 32, define

$$S_{s,t}^x \equiv \sum_{k=0}^{\infty}\left[\beta(1-\delta_{x,s})\xi_{w,s}\right]^k u'(c_{s,t+k})h_{s,t+k}^{\alpha_H}x_{s,t+k} = u'(c_{s,t})h_{s,t}^{\alpha_H}x_{s,t} + \beta(1-\delta_{x,s})\xi_{w,s}S_{s,t+1}^x \tag{33}$$

Similarly, for the second line, define

$$\begin{aligned}S_{s,t}^{wf} &\equiv \sum_{k=0}^{\infty}\left[\beta(1-\delta_{x,s})\xi_{w,s}\right]^k u'(c_{s,t+k})h_{s,t}\frac{(1+\overline{\pi})^k P_t}{P_{t+k}}(1+\tau_t^{wf})\\ &= u'(c_{s,t})h_{s,t}(1+\tau_t^{wf}) + \beta(1-\delta_{x,s})\frac{(1+\overline{\pi})}{(1+\pi_{t+1})}\xi_{w,s}S_{s,t+1}^{wf}\end{aligned} \tag{34}$$

Using these definitions, we can simplify equation 32 to

[8]Indexation can be with respect to trend inflation or any other inflation rate that has the same trend growth as trend inflation. In the simulations we will assume that indexation is with respect to current inflation. The reason is that if nominal wages are indexed to trend inflation, real average wages fall when current inflation rises, even when newly negotiated wages rise. This makes only minor differences for the outcomes of our simulations, but would unnecessarily complicate the explanation.

$$\mathcal{A}_t^F(w^*_{s,t}) = \left(S^x_{s,t} - S^{wf}_{s,t} w^*_{s,t}\right) + \sum_{k=0}^{\infty} \beta(1-\delta_{x,s})(1-\xi_{w,s}) \left[\beta(1-\delta_{x,s})\xi_{w,s}\right]^k \mathcal{A}^F_{t+k+1}(w^*_{s,t+k+1})$$
$$= \left(S^x_{s,t} - S^{wf}_{s,t} w^*_{s,t}\right) - \beta(1-\delta_{x,s})\xi_{w,s}\left(S^x_{s,t+1} - S^{wf}_{s,t+1} w^*_{s,t+1}\right) + \beta(1-\delta_{x,s})\mathcal{A}^F_{t+1}(w^*_{s,t+1}) \tag{35}$$

To get rid of the infinite sum in the first line of equation 35 we used the fact that $\mathcal{A}_t^F(w^*_{s,t})$ can be multiplied by $\beta(1-\delta_{x,s})\xi_{w,s}$, forwarded by one period, and the result subtracted from both sides of the first line. After rearranging, we obtain the second line.

We can then similarly define the value of a worker with an average wage for a labour firm:

$$\begin{aligned} \mathcal{A}_t^F(w_{s,t}) = u'(c_{s,t}) \left(h^{\alpha_H}_{s,t} x_{s,t} - h_{s,t} w_{s,t}(1+\tau^{wf}_t)\right) \\ + \beta(1-\delta_{x,s}) \left[(1-\xi_{w,s})\mathcal{A}^F_{t+1}(w^*_{s,t+1}) + \xi_{w,s}\mathcal{A}^F_{t+1}(w_{s,t})\right] \end{aligned} \tag{36}$$

Following the same steps as above, we obtain, after some algebra

$$\mathcal{A}_t^F(w_{s,t}) = \left(S^x_{s,t} - S^{wf}_{s,t} w_{s,t}\right) - \beta(1-\delta_{x,s})\xi_{w,s}\left(S^x_{s,t+1} - S^{wf}_{s,t+1} w_{s,t+1}\right) + \beta(1-\delta_{x,s})\mathcal{A}^F_{t+1}(w_{s,t+1}) \tag{37}$$

Free entry condition A firm posting a vacancy for household type s must pay a per-period constant cost ψ_s for having a vacancy open. If $\kappa_{w,s}$ denotes the probability that a firm cannot renegotiate the wage for a newly hired worker from household type s, then the value of employing a new worker is, in monetary terms (recall, $\mathcal{A}^F(w^*_{s,t}) \equiv u'(c_{s,t})A^F(w^*_{s,t})$, and the same for the value at average wage), equal to the weighted average of the value of a worker at a newly-renegotiated job and the value of a worker hired at average wage. The free-entry condition is therefore:

$$\psi_s = p^F_t \beta \frac{u'(c_{s,t+1})}{u'(c_{s,t})} \left[(1-\kappa_{w,s})\mathcal{A}^F_t(w^*_{s,t+1}) + \kappa_{w,s}\mathcal{A}^F_t(w_{s,t+1})\right]. \tag{38}$$

Value functions for a worker Similarly as for labour firms, we can define value functions for workers. Again we have two types of value functions, one for a newly-renegotiated wage and one for the average wage, for each type of household. The value of a job, net of the value of unemployment, for a worker with newly-renegotiated wage is

$$
\begin{aligned}
\mathcal{A}_t^H(w_{s,t}^*) &= u'(c_{s,t})\left(h_{s,t}w_{s,t}^*(1-\tau_t^{wh}) - b_{s,t}\right) - \chi\frac{h_{s,t}^{1+\varphi}}{1+\varphi} \\
&+ \beta(1-\delta_{x,s})\left[(1-\xi_{w,s})\mathcal{A}_{t+1}^H(w_{s,t+1}^*) + \xi_{w,s}\mathcal{A}_{t+1}^H(w_{s,t}^*)\right] \\
&- \beta p_{s,t}^W\left[(1-\kappa_{w,s})\mathcal{A}_{t+1}^H(w_{s,t+1}^*) + \kappa_{w,s}\mathcal{A}_{t+1}^H(w_{s,t+1})\right]
\end{aligned} \tag{39}
$$

The first line of equation 39 denotes, in utility terms, first the net gain of having a job, which is hours worked times wage net of taxes paid by the household, at a rate τ_t^{wh} and net of opportunity cost of having a job, which are unemployment benefits, $b_{s,t}$.[9] The second term in the first line is the disutility of hours worked.[10] The second line represents the value of having a job in the next period, which occurs with the probability $(1-\delta_{x,s})$. This job can be either at the newly renegotiated wage or at the current wage. The last row of equation 39 is the value of the opportunity cost of having a job, which is the value of being unemployed. If a worker is unemployed, then there is a probability $p_{s,t}^W$ to find a job, which can be either at a newly-renegotiated wage with probability $(1-\kappa_{w,s})$, or at an average wage, with probability $\kappa_{w,s}$.

If we follow the same sequence of steps as we did for the firm and define additional auxiliary variables to sum the utility obtained from wages, unemployment benefits, and the disutility of labour terms,

$$
\begin{aligned}
S_{s,t}^{wh} &\equiv \sum_{k=0}^{\infty}\left[\beta(1-\delta_{x,s})\xi_{w,s}\right]^k u'(c_{s,t+k})h_{s,t}\frac{(1+\overline{\pi})^k P_t}{P_{t+k}}(1-\tau_t^{wh}) \\
&= u'(c_{s,t})h_{s,t}(1-\tau_t^{wh}) + \beta(1-\delta_{x,s})\frac{(1+\overline{\pi})}{(1+\pi_{t+1})}\xi_{w,s}S_{s,t+1}^{wh},
\end{aligned} \tag{40}
$$

$$
S_{s,t}^b = u'(c_{s,t+k})b_{s,t} + \beta(1-\delta_{x,s})\xi_{w,s}\frac{(1+\overline{\pi})}{(1+\pi_{t+1})}S_{s,t+1}^b, \tag{41}
$$

[9] We assume that unemployment benefits are a fraction (replacement ratio) of average wage and are indexed in the same way as the average wage.

[10] We assume that the household as a whole sends its members to work, so that the marginal disutility for the household is the disutility for the worker.

$$S^h_{s,t} = \chi \frac{h^{1+\varphi}_{s,t}}{1+\varphi} + \beta(1-\delta_{x,s})\xi_{w,s} S^h_{s,t+1}, \tag{42}$$

then we can write the net value of a job for a new wage for the household:[11]

$$\begin{aligned}
\mathcal{A}^H_t(w^*_{s,t}) = {} & S^w_{s,t} w^*_{s,t} - S^b_{s,t} - \beta(1-\delta_{x,s})\xi_{w,s} \left(S^w_{t+1} w^*_{s,t+1} - S^b_{s,t+1} \right) \\
& - S^h_{s,t} + \beta(1-\delta_{x,s})\xi_{w,s} S^h_{s,t+1} \\
& + \beta \left[1 - \delta_{x,s} - (1-\kappa_{w,s}) p^W_{s,t} \right] \mathcal{A}^H_{t+1}(w^*_{s,t+1}) - \beta \kappa_{w,s} p^W_{s,t} \mathcal{A}^H_{t+1}(w_{s,t+1})
\end{aligned} \tag{43}$$

In a similar fashion, we can obtain the value of a job for an average wage for the household:

$$\begin{aligned}
\mathcal{A}^H_t(w_{s,t}) = {} & S^w_{s,t} w_{s,t} - S^b_{s,t} - \beta(1-\delta_{x,s})\xi_{w,s} \left(S^w_{s,t+1} w_{s,t+1} - S^b_{s,t+1} \right) \\
& - S^h_{s,t} + \beta(1-\delta_{x,s})\xi_{w,s} S^h_{s,t+1} \\
& + \beta \left[(1-\delta_{x,s})(1-\xi_{w,s}) - (1-\kappa_{w,s}) p^W_{s,t} \right] \mathcal{A}^H_{t+1}(w^*_{s,t+1}) \\
& + \beta \left[(1-\delta_{x,s})\xi_{w,s} - \kappa_{w,s} p^W_{s,t} \right] \mathcal{A}^H_{t+1}(w_{s,t+1})
\end{aligned} \tag{44}$$

F.5.2 Wages and hours

We assume that wages and hours are determined using Nash bargaining. Assuming standard (efficient) Nash bargaining between households and labour firms, every period, wages and hours worked are determined by maximising the following expression, where $0 < \eta_s < 1$ measures the bargaining power of workers of type s:

$$\max_{w^*_{s,t}, h_{s,t}} \left(A^H_t(w^*_{s,t}) \right)^{\eta_s} \left(A^F_t(w^*_{s,t}) \right)^{1-\eta_s}. \tag{45}$$

The result is that wages are split according to the Nash sharing rule:

$$\eta_s(1-\tau^{wh}_t) A^F_t(w^*_{s,t}) = (1-\eta_s)(1+\tau^{wf}_t) A^H_t(w^*_{s,t}). \tag{46}$$

The intuition for the above rule is that households and labour firms bargain over each other's matching surpluses, where the surplus of the firm is the value of the worker (because in equilib-

[11] Note that the only difference between $S^{wf}_{s,t}$ of the firm and $S^{wh}_{s,t}$ of the household is with respect to the relevant tax rates and the fact that the labour tax increases costs for the firm, while it decreases wage revenues for the household.

rium the value of the vacancy is zero), and for the household the value of the match is the net gain from being employed (relative to being unemployed), both evaluated at the currently-negotiated wage. The above equation thus determines $w^*_{t,s}$.

The average wage is a weighted average of the average wage from the previous period and the wages of new hires, where the weights are the share of workers who have kept their employment and wage from the previous period in total current employment, $\frac{(1-\delta_{x,s})nde_{s,t-1}}{nde_{s,t}}$, and the share of newly hired workers at the new wage, $\frac{M_{s,t}}{nde_{s,t}}$. Note that only a fraction $\xi_{w,s}$ of workers that have kept their jobs are able to index wages to trend inflation. The average hourly wage is therefore determined as follows:

$$
\begin{aligned}
w_{s,t} = {} & \frac{(1-\delta_{x,s})nde_{s,t-1}}{nde_{s,t}} \left[\xi_{w,s} \frac{1+\overline{\pi}}{1+\pi_{t-1}} w_{s,t-1} + (1-\xi_{w,s}) w^*_{s,t} \right] \\
& + \frac{M_{s,t}}{nde_{s,t}} \left[\kappa_{w,s} w_{s,t} + (1-\kappa_{w,s}) w^*_{s,t} \right],
\end{aligned}
\tag{47}
$$

where the first row is the average wage of existing workers and the second row is the average wage of new hires, with the number of new matches $M_{s,t}$ counting the number of new hires.[12]

Similarly, hours worked are determined by per-period Nash bargaining, and after taking into account the wage decision (equation 46), hours worked expression is:

$$
\alpha_H x_{s,t} (h_{s,t})^{\alpha_H - 1} = \frac{\chi}{u'(c_{s,t})} \frac{(1+\tau^{wf}_t)}{(1-\tau^{wh}_t)} (h_{s,t})^{\varphi}. \tag{48}
$$

The term on the left is the marginal revenue from labour services brought about by an additional hour worked and the term on the right is the marginal disutility of having to work an additional hour, in after-tax consumption terms.

Note that throughout our notation we have assumed that hours worked do not depend on wages. Equation (48) shows that under the assumption of efficient Nash bargaining, this is indeed the case.[13]

[12] If indexation is with respect to current-period inflation, the ratio of inflation rates that multiplies the previous-period wage drops out, because previous-period wage is indexed to previous-period inflation.

[13] There are other cases, which change the relation between hours and wages and open the so-called wage channel, see Christoffel and Linzert (2010) and the application in Bodart et al. (2006) and de Walque et al. (2009).

F.5.3 Labour packer

Labour from Ricardian and HtM households is aggregated by a labour packer using a CES technology, as follows:

$$n_t^{1-\frac{1}{\eta_L}} = \left[(1-\omega)^{\frac{1}{\eta_L}} \left(nde_{i,t} h_{i,t}^{\alpha_H}\right)^{1-\frac{1}{\eta_L}} + \omega^{\frac{1}{\eta_L}} \left(nde_{j,t} h_{j,t}^{\alpha_H}\right)^{1-\frac{1}{\eta_L}}\right], \tag{49}$$

where n_t are aggregate labour services and $nde_{s,t} h_{s,t}^{\alpha_H}$ are total labour services provided by labour firms in household segment s. Parameter ω measures the share of HtM households in the economy and η_L the degree of substitution between Ricardian and HtM households.

G Monetary policy rules

We consider three different types of monetary policy rules in the euro area.

Benchmark Taylor rule

$$r_t = \varphi_r \; r_{t-1} + (1-\varphi_r)\left(r^* + \pi^* + \varphi_\pi \left(\pi_t - \pi^*\right) + \varphi_u \; \hat{u}_t\right) + \epsilon_t^R \tag{50}$$

where r_t is the annualised nominal interest rate, r^* is the annualised long-run equilibrium real interest rate, π_t is the annual price inflation rate, π^* is the annual inflation target, and $\hat{u}_t$ is the unemployment gap, i.e. the gap between the unemployment rate une_t and its steady-state level, $\overline{une}$.[14] ϵ_t^R is a shock.

Taylor rule with an asymmetric response to unemployment

$$r_t = \varphi_r \; r_{t-1} + (1-\varphi_r)\left(r^* + \pi^* + \varphi_\pi \left(\pi_t - \pi^*\right) + I_{u>u^*}\varphi_U \; \hat{u}_t\right) + \epsilon_t^R \tag{51}$$

where $I_{u>u^*}\varphi_U$ is an indicator function that takes the value 1 if the unemployment rate is above its steady-state value u^* and 0 otherwise. This rule follows Board of Governors of the Federal Reserve System (2022) and Bundick and Petrosky-Nadeau (2021).

[14]The monetary policy increases (decreases) interest rates when the unemployment rate is below (above) its steady state value. For convenience purposes, the gap is defined such that the parameter φ_u is positive.

Average inflation targeting rule

$$r_t = \varphi_r \; r_{t-1} + (1-\varphi_r) \left(r^* + \pi^* + \varphi_\pi \left(\bar{\pi}_t^T - \pi^* \right) + \varphi_u \; \hat{u}_t \right) + \epsilon_t^R \tag{52}$$

where $\bar{\pi}_t^T$ is the annualised average inflation rate over the past T years (T is the averaging window, which we set to be equal to 4 years).

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