DREAM
Danish Research Institute for
Economic Analysis and Modelling

MAKRO

Matching inter-temporal marginal propensities to consume

With hand-to-mouth reference consumption and habits

Emil Holst Partsch

Economic memo
19 December 2024

www.dreamgruppen.dk

Matching inter-temporal marginal propensities to consume with hand-to-mouth reference consumption and habits

Emil Holst Partsch

Working paper
December 2024

www.dreamgruppen.dk

1 Introduction

Frontier evidence on inter-temporal consumption behavior shows that following a one-time transfer, consumption rises for several periods with a mean on-impact yearly marginal propensity to consume (MPC) of roughly 50 percent, see Fagereng et al. (2021). This is inconsistent with the typical business cycle models; the standard way to match high on-impact MPC's has been to combine a share of Ricardian agents with a share of hand-to-mouth agents (Keynesian consumers) who consume all income in every period (e.g. Bilbiie et al., 2008).This, however, only generates high on-impact marginal propensities to consume but no effects in the following periods (as the Ricardian agents have close to zero MPC's for transitory shocks), and is thus contrary to empirical evidence showing significant year $t+1$ effects. Recent business cycle literature has solved this by introducing microeconomic stochasticity and incomplete markets (Heterogeneous-Agent New-Keynesian, HANK, models), in which agents close to but not at their borrowing constraint will have high MPC's and smooth consumption.[1] In the present note, I present a solution that does not rely on stochasticity.[2] In particular, I combine a representative agent model with consumption habits, as is typical in the Dynamic Stochastic General Equilibrium (DSGE) literature, with a so-called splurge factor. In MAKRO, we call this a "hand-to-mouth" (HtM) factor. The HtM factor is a fraction of income spent in each period following Carroll et al. (2023), and therefore generates a high on-impact MPC. The existence of habits spreads this high on-impact MPC out over several periods, consistent with data.

In general, the model with the splurge-factor has two advantages over the model with hand-to-mouth households: Firstly, we replace the ad-hoc backward-looking friction in hand-to-mouth consumption such that the persistence in the inter-temporal MPC's can be matched due to optimizing behavior. Secondly, the model is simpler because all the equations pertaining to the hand-to-mouth households disappear. This significantly reduces model and calibration complexity as we also have heterogeneity in the age dimension.

The rest of the note proceeds as follows: I first show in a simple theoretical model how habits and splurging can be used to match inter-temporal consumption evidence (Section 2). I then show how implementing this idea into the full MAKRO model can replace hand-to-mouth households and their ad-hoc consumption friction (Section 3). Section 4 concludes.

[1] Though to get enough on-impact bang for the buck, the literature has introduced several additional modeling details such as two assets (Kaplan et al. 2018), discount factor heterogeneity (e.g. Hagedorn et al. 2019), or a splurge-factor, as in the present note, see Carroll et al. (2023).

[2] Note that it is possible to solve a particular class of HANK models without numerical stochasticity by assuming zero-liquidity (zero savings), see e.g. Bilbiie 2020. This is not possible in our case, since we want to match the model to the rich features of wealth in data. Additionally, it is also possible to get similar behavior in a perpetual youth setup with sufficiently high death rates. We opt for a different solution, since the full MAKRO model is "true-blue" overlapping genaration.

2 Theoretical foundations

2.1 Model

I first present a simple consumption-savings model to illustrate how splurging and external consumption habits can generate inter-temporal marginal propensities to consume (iMPC's) consistent with the empirical evidence in Fagereng et al. (2021). Splurging generates high on-impact spending of transfers, while habits can generate smoothing consistent with data.

The following perfect-foresight Bellman equation represents the consumers problem

$$\begin{aligned} V_t(b_t) &= \max_{c_t, b_{t+1}} \frac{(c_t - \gamma y_t - \omega \tilde{c}_{t-1})^{1-\sigma}}{1-\sigma} + \xi \frac{b_t^{1-\sigma}}{1-\sigma} + \beta V_{t+1}(b_{t+1}) \\ \text{s.t. } & c_t + b_{t+1} = y_t + (1+r_t) b_t \end{aligned} \tag{1}$$

where c_t is consumption, b_t are savings, r_t is the real return on savings, y_t is income and $\tilde{c}_t$ is the (external) reference habit stock such that $\tilde{c}_t = c_t$, σ is the constant relative risk-aversion (CRRA) parameter common to both consumption and wealth, $\gamma \in [0,1]$ is the HtM factor, $\omega \in [0,1]$ is the degree of habit formation and $\xi > 0$ scales utility of wealth. The HtM factor can be interpreted in various ways economically. For example, high on-impact spending is typically explained by liquidity constraints in the two-agent New-Keynesian literature (TANK), e.g., models with hand-to-mouth consumers and the HANK literature. Thus, the HtM factor of the representative (mean) agent may reflect that some households are constrained. A different contender for high first-period excess spending that does not rely on liquidity is durable purchases. Durables have layouts that are more front-loaded due to the long-lasting consumption flow of the stock cf. Laibson et al. (2022). Note that wealth in utility closes this simple problem.

Re-writing the problem by inserting the budget constraint into utility yields

$$\begin{aligned} V_t(b_t) = \max_{b_{t+1}} \; & \frac{1}{1-\sigma} \left(\underbrace{y_t + (1+r_t) b_t - b_{t+1}}_{c_t} - \gamma_c y_t - \omega_c \tilde{c}_{t-1} \right)^{1-\sigma} + \xi \frac{b_t^{1-\sigma}}{1-\sigma} \\ & + \beta V_{t+1}(b_{t+1}), \end{aligned} \tag{2}$$

Define $u(c_t) = \frac{(c_t - \gamma y_t - \omega \tilde{c}_{t-1})^{1-\sigma}}{1-\sigma}$. First-order and envelope conditions are then

$$\partial_c u(c_t) = \beta \partial_{b_{t+1}} V_{t+1}(b_{t+1}) \tag{3}$$

$$\partial_{b_t} V_t(b_t) = (1+r_t) \partial_c u(c_t) + \xi b_t^{-\sigma} \tag{4}$$

The Euler equation is then given by combining equations (3) and (4)

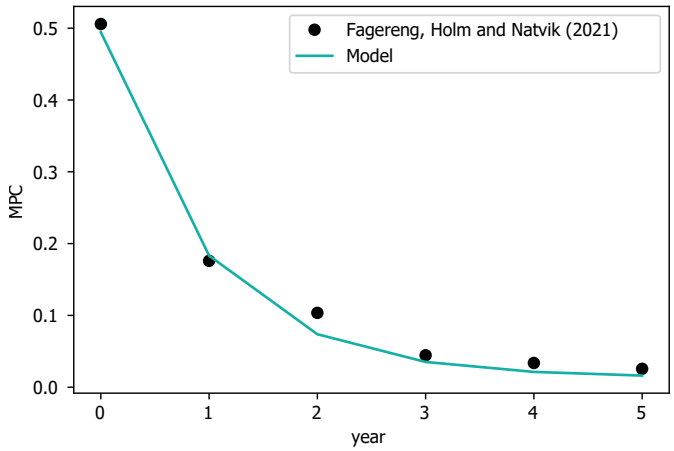
$$\begin{aligned} & \partial_c u(c_t) = \beta (1+r_{t+1}) \partial_{c'} u(c_{t+1}) + \beta \xi b_t^{-\sigma} \\ \Rightarrow \; & (c_t - \gamma y_t - \omega \tilde{c}_{t-1})^{-\sigma} = \beta (1+r_{t+1}) (c_{t+1} - \gamma y_{t+1} - \omega \tilde{c}_t)^{-\sigma} + \beta \xi b_t^{-\sigma} \end{aligned} \tag{5}$$

Given equation (5), we are ready to bring the model to the computer and do numerical experiments as to compare the theoretical properties with empirical evidence.

2.2 Numerical results

I set $r = 0.04$ as in MAKRO, $\beta = 0.95$[3] and set $\xi = 0.4$ such that the soft borrowing constraint binds sufficiently to close the problem. I calibrate $\gamma = 0.48$ and $\omega = 0.38$ to target the iMPCs from Fagereng et al. (2021). As documented in Figure 2.2.1, I obtain an excellent fit. The HtM factor helps hit the large on impact outlay, while habits ensure that year $t+1$ effects are sufficiently large. Note that I need a sufficiently high HtM factor to offset the negative effect of habits on the year-0 (on-impact) MPC. This formulation makes it feasible to work with one agent in the full MAKRO model, as shown in Section 3 - where we can target both wealth (over the life-cycle in the data covered years) and MPC's (from Fagereng et al. 2021).

Figure 2.2.1: iMPC, representative agent model with habits vs. Norwegian lottery estimates



Note: The figure plots empirical inter-temporal MPC's (point estimates) vs. model generated inter-temporal MPC's.

3 Implementation in MAKRO

3.1 Modelling and calibration details

For a general description of the household problem in MAKRO, see the consumer chapter in the MAKRO model documentation, Bonde et al., 2023. For this note, suffice it to say that consumers solve a life-cycle consumption-savings problem (MAKRO has an overlapping generations structure) where there are both durables (housing) and non-durables and where utility over those is nested in a constant elasticity of substitution (CES) index. There are habits in both consumption types, and we now introduce a HtM factor for each. Mechanically, the HtM factors enter the household problem in the same way as habits, see eq. (1). Finally, note that we calibrate the model such that we neutralize the HtM factor along the growth path. Specifically, let the HtM factor enter utility for any consumption type as

$$u(c_{a,t}) = u\left(c_{a,t} - \gamma_{a,t}\left(y_{a,t} - \mu_{a,t}\mathbf{GVA}_{a,t}\right) - \omega_c \tilde{c}_{a,t-1}\right) \tag{6}$$

where $y_{a,t}$ is an income term from which households splurge from in which we assume that households do not splurge out of age pension, capital pension and an inheritance adjustment term[4], $\mathbf{GVA}_{a,t}$ is an AR(1) smoothed measure of gross-value added pr. work-hour such that

[3] β has to be less than $1/(1+r)$ due to wealth of utility.

[4] These pensions are regularly payed out in large lump sums, which would imply unrealistic jumps in consumption. The inheritance adjustment term is a term to make up for the fact that when households die in a cohort, the dying households are typically poorer than the average household. Such re-distributive transfers would also induce unrealistic jumps in consumption if included in the splurge income term.

the model stays homogeneous and $\mu_{a,t}$ is a parameter. We calibrate $\mu_{a,t}$ along the growth-path such that $y_{a,t} = \mu_{a,t}\mathbf{GVA}_{a,t}$, i.e. the HtM factors are neutralized in the baseline path. Thus, the HtM factors only affect shock dynamics.

3.2 Numerical results

3.2.1 Impulse response matching and impulse response comparison between the HtM factor and the hand-to-mouth models

I re-calibrate the model by matching the model generated impulse responses (IRF's) to the empirical structural vector auto-regressions (SVAR's) shown in Figure 3.2.1 (for further details, see DREAM, 2021). The model version used is the developer model from 25-08-2023.

The matched model parameters are presented in Table 3.2.1.

Table 3.2.1: Key parameters set to match empirical impulse responses

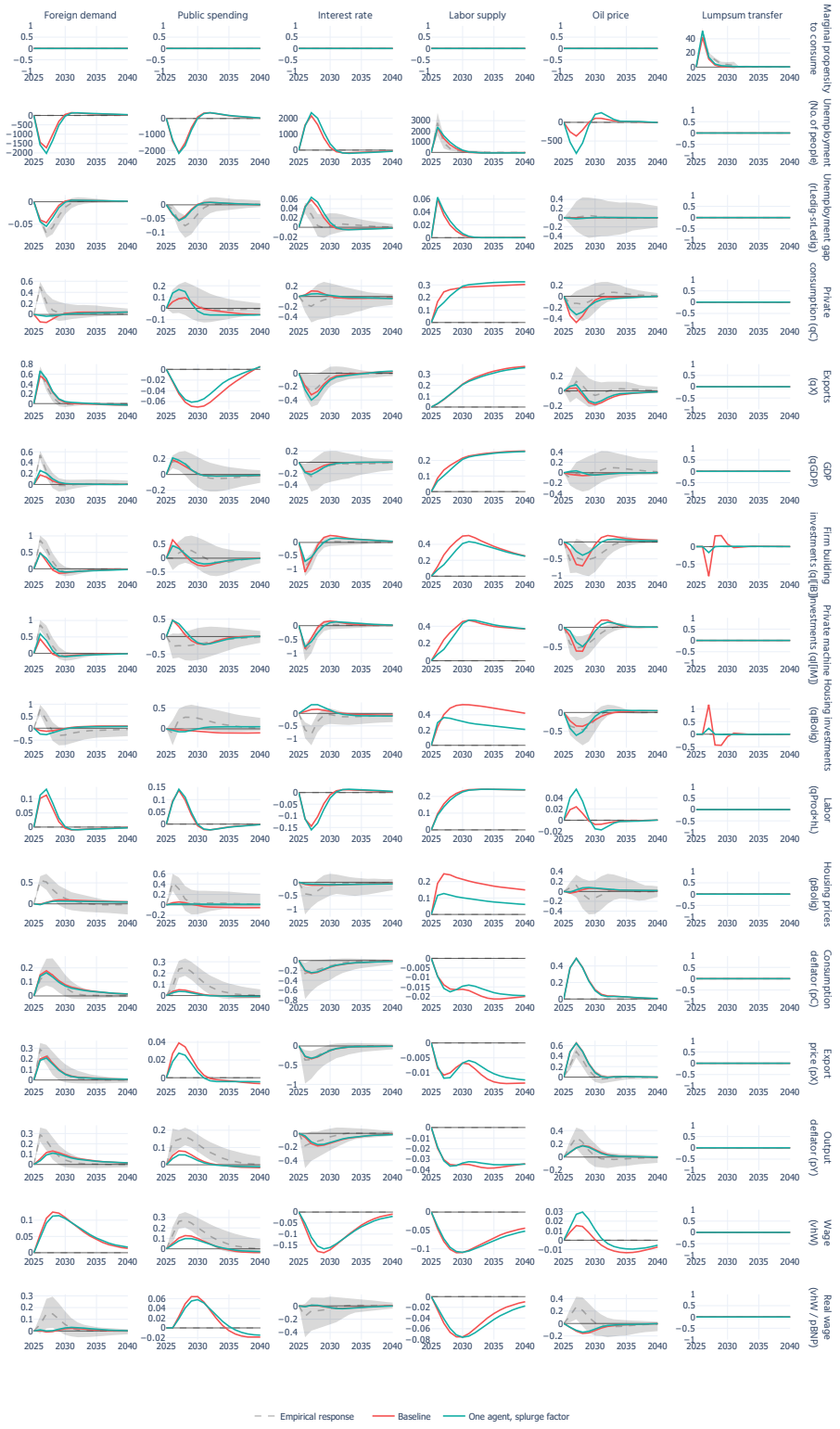
Parameter	Parameter values, model with hand-to-mouth households	Parameter values, model with HtM factors
Building installation costs (uKinstOmk_IB)	6.68	11.85
Machine installation costs (uKInstOmk_IM)	2.83	3.56
Exponent affecting capacity utilization of building capital (eKUdn_IB)	0.66	1.02
Exponent affecting capacity utilization of machine capital (eKUdn_IB)	0.91	1.97
Capacity utilization, labor (eLUdn)	0.79	1.61
Exponent affecting friction in capacity utilization of labor (eLUdnPersistens)	0.5	0.5
Exponent affecting friction in capacity utilization of capital, (eKUdnPersistens)	0.5	0.5
Matching function exponent, (eMatching)	1.22	1.22
Quadratic adjustment cost, labor (uMatchOmkSqr)	0.58	0.67
Outside option for labor union in wage bargaining (rFFLoenAlternativ)	0.063	0.11
Rotemberg-friction in wage bargaining (uWTraeghed)	6.08	9.40
HtM factor, non-durables (rSplurge)	N/A	0.42
HtM factor, housing (rSplurge_bolig)	N/A	0.12
Share of hand-to-mouth households, (rUpsilon_HtM)	0.5	N/A
Reference consumption share (rRef)	0.1	0.26
Reference consumption share, housing (rRefBolig)	0.49	0.079
Scales share of housing owned by HtM households (uBoligHtM_match)	1.39	N/A
Installation costs for housing capital in new housing (ulBoligInstOmk)	1.20	0.026
Friction in HtM consumption (rHtMTraeghed)	0.20	N/A
Rotemberg cost on house price formation (upBoligTraeghed)	1.67	0.8
Friction in export price effect (upXyTraeghed)	15.0	9.83
Export friction (rXTraeghed)	0.35	0.27
Penaltly rate from financial frictions on surplus (deficit) money streams (rFinAccel)	0.040	0.040
Rotemberg-friction on prices (upYTraeghed)	0.61	0.64

Note: The table shows matched parameter values for parameters used to match empirical impulse responses. The parameter values are determined through a method of moments routine. Specifically, we use a minimization algorithm to minimize the distance between empirical and model-generated impulse responses for shocks to the following variables: foreign demand, public spending, the interest rate (foreign), labor supply, the oil price, and a lump-sum transfer to households. We leave eMatching unaffected to preserve the demand multiplier effects on unemployment comparable to the baseline (HtM) model.

In Figure 3.2.1 I present IRFs from the model with hand-to-mouth households, the one-agent model with HtM factors, and the empirical IRF's. The minimized loss function (measured as the distance between the empirical and the model IRF's, taking the confidence bands of the

empirical IRF's into account) is smaller for the one-agent model. This is also true before re-calibrating. Thus, we obtain similar or better marginal properties with a simpler model without any ad-hoc consumption friction for hand-to-mouth households. That is, year $t+1$ MPC's arise due to optimizing behavior through external consumption habits.

Figure 3.2.1: Empirical IRFs vs. model with hand-to-mouthers (baseline) and one-agent model with HtM factor



Note: The impulse responses compare empirical IRF's obtained from structural vector auto-regressions and model generated IRF's from a model with hand-to-mouth households and the one-agent model with HtM factors as described in this note. The y-axis shows percentage deviations from the baseline growth-path, and the x-axis shows years. The shock year is 2026.

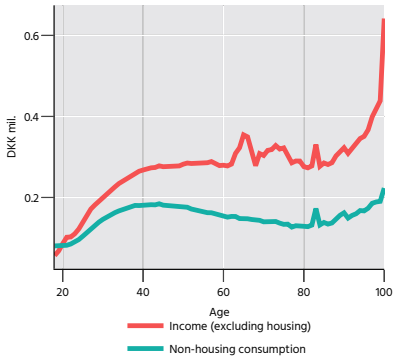
Finally, in Appendix A I plot several standard shocks used to analyze MAKRO, comparing the model with hand-to-mouth agents and the HtM factor model.

3.2.2 Life-cycle profiles

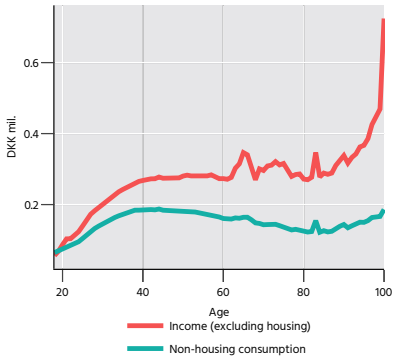
An essential feature of MAKRO is the overlapping generations setup. Given imputed consumption data, we also need to match life-cycle consumption behavior and have that behavior stable as we project the model forward. This has been true in prior versions of MAKRO, see Bonde et al. (2021), and I show in Figure 3.2.2 that it is also true in the HtM factor model.

Figure 3.2.2: Life-cycle profiles, 2030 projection

a) Non-housing consumption, splurge-factor model



b) Non-housing consumption, two-agent model



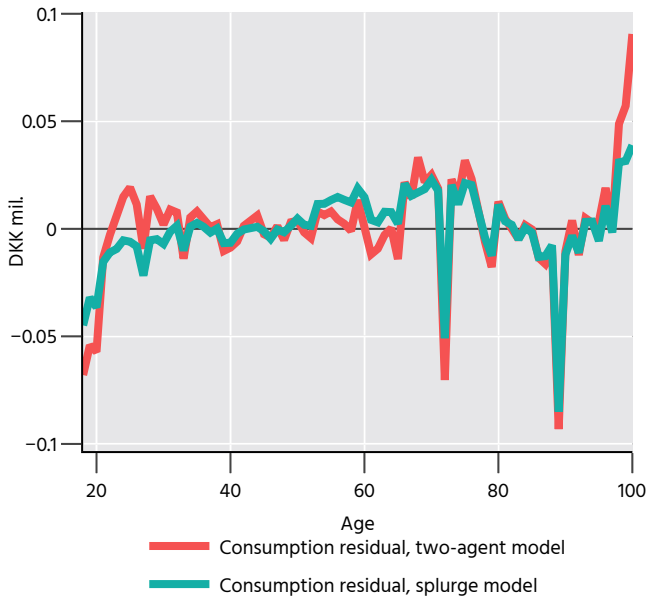
c) Housing, splurge-factor model

d) Housing, two-agent model

Note: The plots show life-cycle profiles over consumption and housing for a 2030 projection in the HtM factor and the two-agent (with HtM households) models. The age distribution starts at 18 and ends at 100.

Indeed, the HtM factor model explains imputed consumption data better in the last calibration year (2019) than the two-agent model, cf. Figure 3.2.3 which shows that consumption residuals for the splurge model have errors closer to zero than the two-agent model. Indeed, the sum of errors over the age distribution for the two-agent model is 0.11, while it is 0.01 for the splurge model - a factor of ten difference.

Figure 3.2.3: Imputed (non-housing) consumption residuals for 2019 data



Note: The figure plots the residuals between the model and data for imputed non-housing consumption in the calibration year 2019 (in MAKRO, the variable is jqCR) in the HtM factor and the two-agent (with HtM households) models. The age distribution starts at 18 and ends at 100.

4 Concluding remarks

In the present note, I have shown theoretically and in practice how introducing consumption HtM factors can match frontier evidence on inter-temporal consumption behavior when combined with consumption habits. Thus, we can eliminate hand-to-mouth (HtM) agents in the full MAKRO model, significantly reducing model complexity while eliminating ad-hoc HtM consumption sluggishness and obtaining all behavior from optimization. I show that the marginal properties of the model are consistent with prior versions of MAKRO when re-calibrating the impulse response matching. In addition, I show that life-cycle consumption profiles are as stable as in previous versions of MAKRO when rolling age profiles forward beyond calibration years. In addition, within calibration, the splurge-factor model achieves lower error terms concerning imputed consumption than the model with HtM-agents.

References

Bilbiie, Florin, Gernot Mueller, and Andre Meier. 2008. "What Accounts for the Change in U.S. Fiscal Policy Transmission?" *Journal of money, credit and banking* 40 (7): 1439–1470. 1

Bilbiie, Florin O. 2020. "The New Keynesian cross." *Journal of monetary economics* 114 90–108. 2

Bonde, Martin, Joao Ejarque, Grane Høgh, Emil Partsch, Peter Stephensen, and Tamás Vasi. 2023. "MAKRO Model Documentation."Technical report, DREAM. 3.1

Bonde, Martin, Anders Kronborg, and Peter Stephensen. 2021. "Marginal propensity to consume: The MPC of temporary and permanent income shocks by age."Technical report, DREAM. 3.2.2

Carroll, Christopher D., Edmund Crawley, Ivan Frankovic, and Håkon Tretvoll. 2023. "Welfare and Spending Effects of Consumption Stimulus Policies." 1–45. 10.17016/feds.2023.002. 1, 1

DREAM. 2021. "Matching af impuls responser og øvrige kortsigtsmomenter: MAKRO ift. empirien."Technical report, DREAM. 3.2.1

Fagereng, Andreas, Martin B. Holm, and Gisle J. Natvik. 2021. "MPC Heterogeneity and Household Balance Sheets." *American economic journal. Macroeconomics* 13 (4): 1–54. 1, 2.2

Hagedorn, Marcus., Iourii. Manovskii, and Kurt. Mitman. 2019. *The Fiscal Multiplier*. NBER working paper series no. w25571, Cambridge, Mass: National Bureau of Economic Research. 1

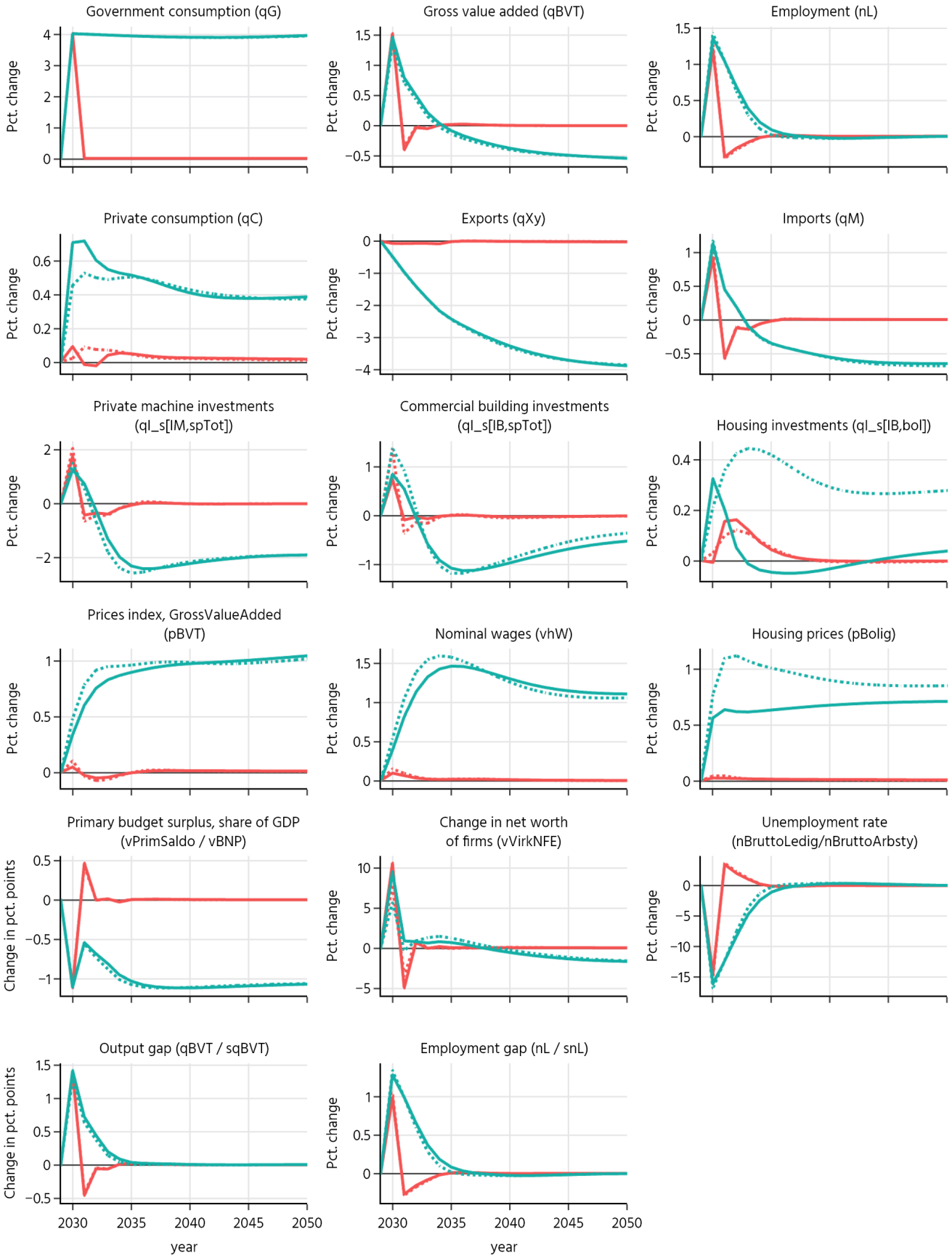
Kaplan, Greg, Benjamin Moll, and Giovanni L. Violante. 2018. "Monetary Policy According to HANK." *The American economic review* 108 (3): 697–743. 1

Laibson, David, Peter Maxted, and Benjamin Moll. 2022. "A Simple Mapping from MPCs to MPXs." *NBER Working Paper Series*. 2.1

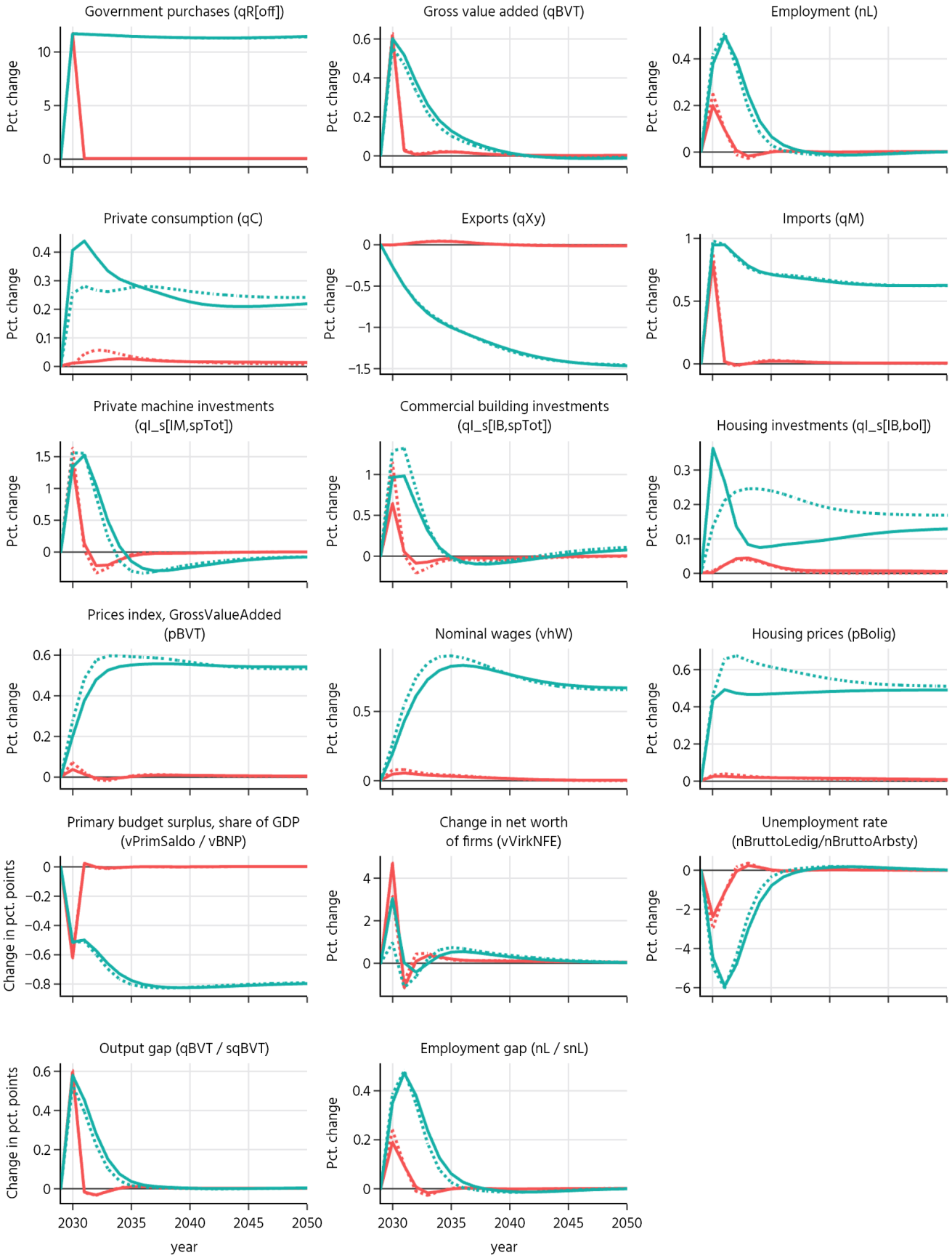
A Appendix

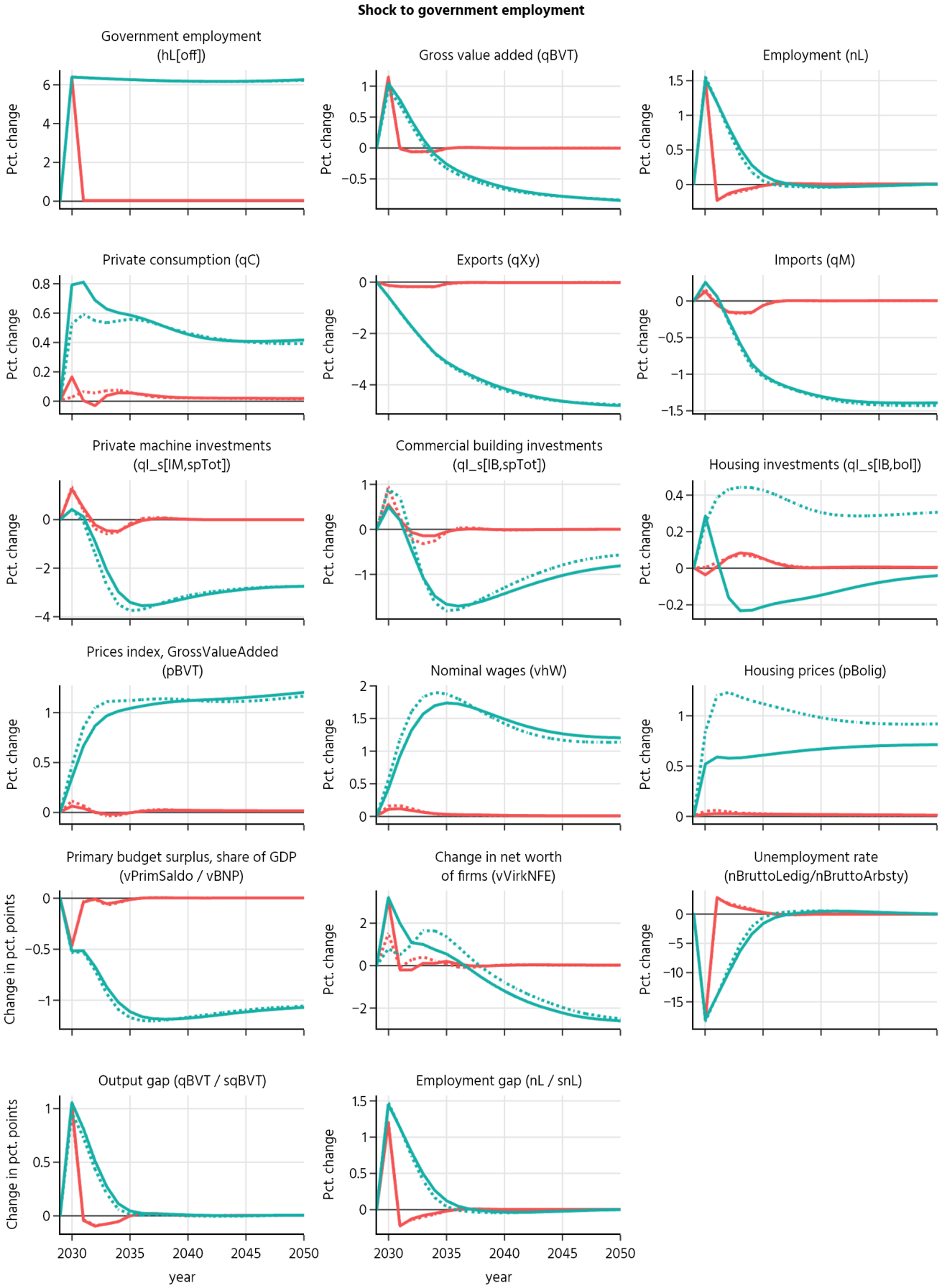
The following plots a range of standard shocks in MAKRO for the HtM two-agent and the splurge-factor one-agent model respectively.

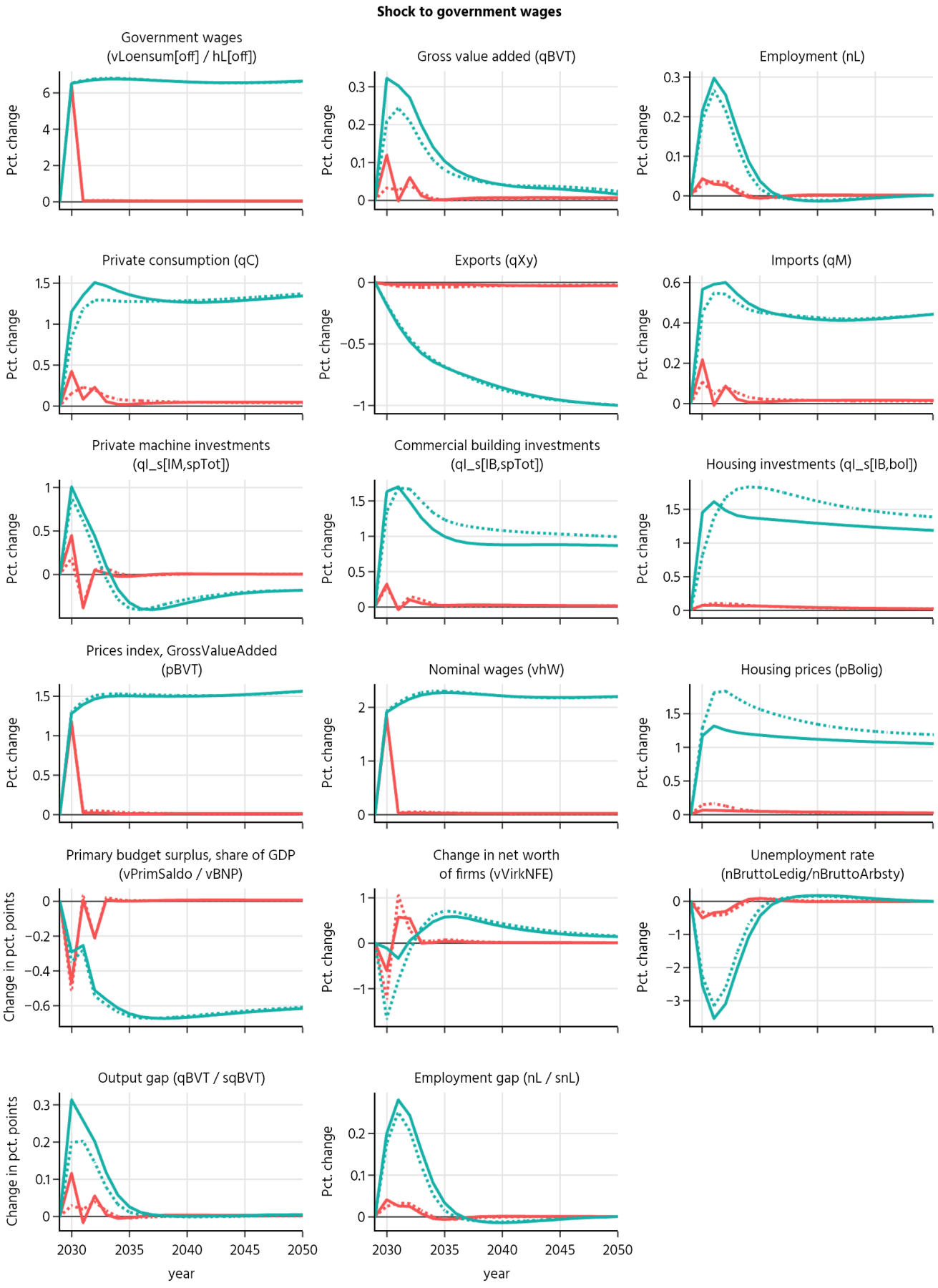
Shock to government consumption



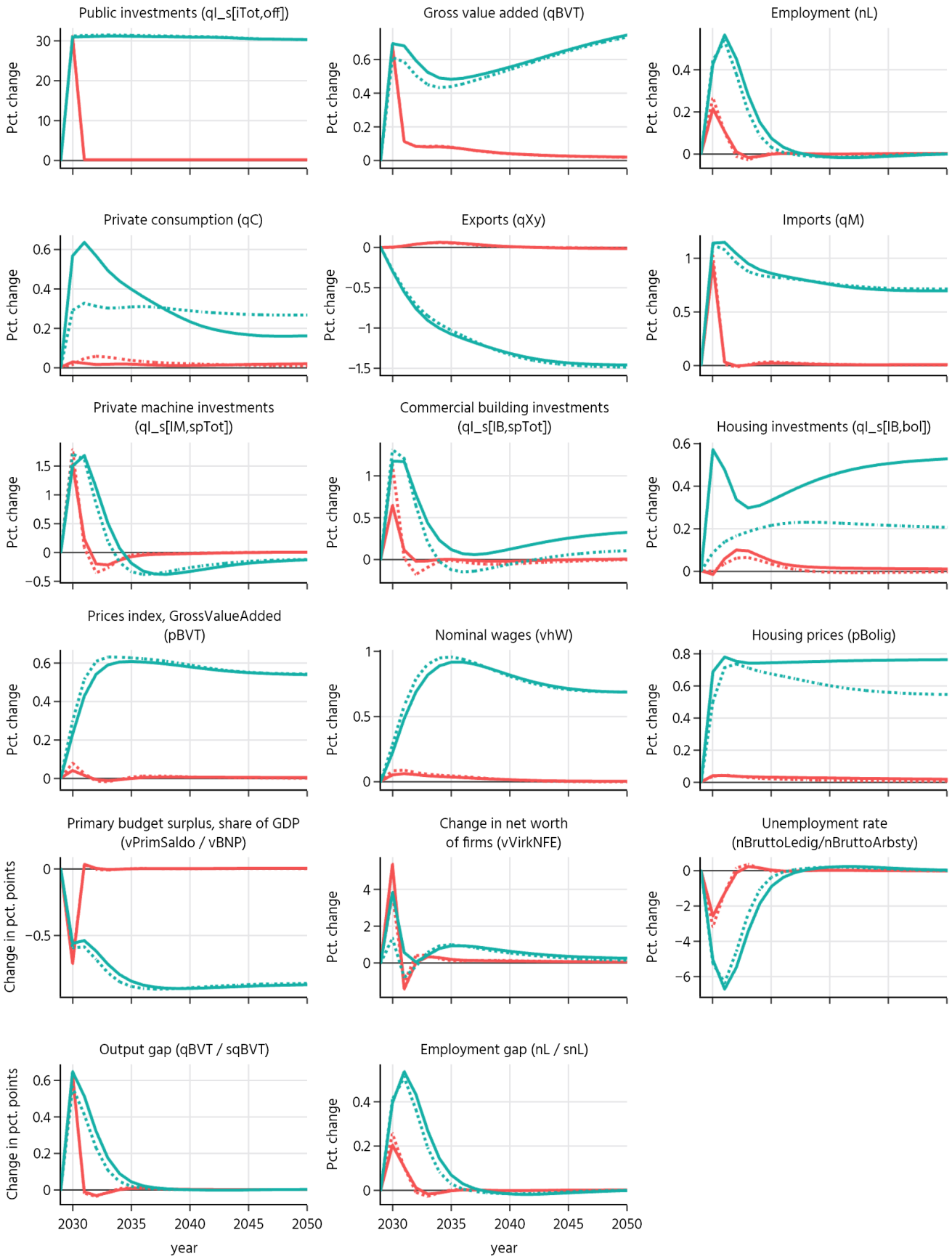
Shock to government purchases

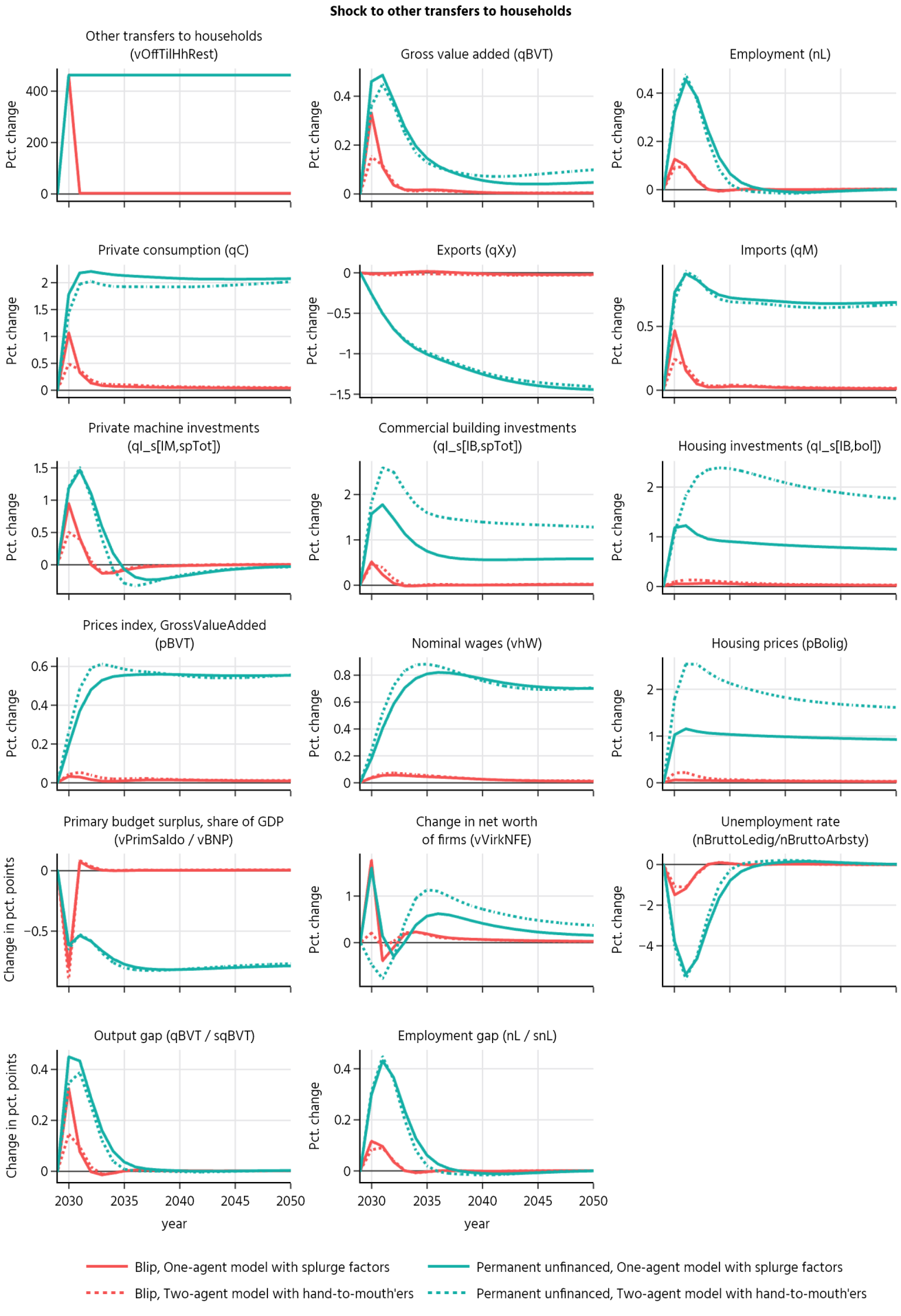


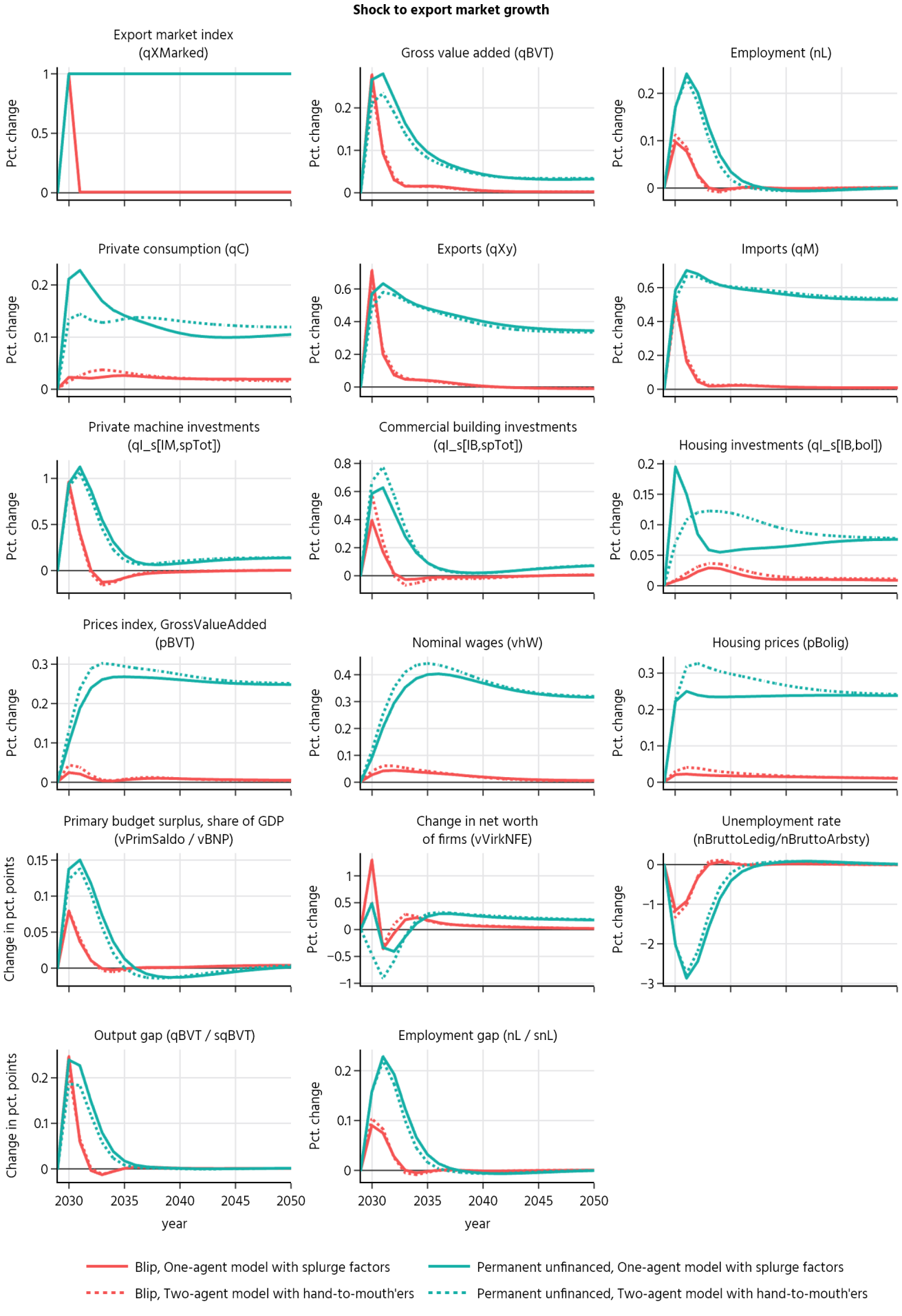

Shock to government employment
Government employment (hL[off])
Gross value added (qBVT)
Employment (nL)
Private consumption (qC)
Exports (qXy)
Imports (qM)
Private machine investments (qI_s[IM,spTot])
Commercial building investments (qI_s[IB,spTot])
Housing investments (qI_s[IB,bol])
Prices index, GrossValueAdded (pBVT)
Nominal wages (vhW)
Housing prices (pBolig)
Primary budget surplus, share of GDP (vPrimSaldo / vBNP)
Change in net worth of firms (vVirkNFE)
Unemployment rate (nBruttoLedig/nBruttoArbsty)
Output gap (qBVT / sqBVT)
Employment gap (nL / snL)
Pct. change
Change in pct. points
2030
2035
2040
2045
2050
year
Blip, One-agent model with splurge factors
Permanent unfinanced, One-agent model with splurge factors
Blip, Two-agent model with hand-to-mouth'ers
Permanent unfinanced, Two-agent model with hand-to-mouth'ers


Shock to government wages
Government wages (vLoensum[off] / hL[off])
Gross value added (qBVT)
Employment (nL)
Private consumption (qC)
Exports (qXy)
Imports (qM)
Private machine investments (qI_s[IM,spTot])
Commercial building investments (qI_s[IB,spTot])
Housing investments (qI_s[IB,bol])
Prices index, GrossValueAdded (pBVT)
Nominal wages (vhW)
Housing prices (pBolig)
Primary budget surplus, share of GDP (vPrimSaldo / vBNP)
Change in net worth of firms (vVirkNFE)
Unemployment rate (nBruttoLedig/nBruttoArbsty)
Output gap (qBVT / sqBVT)
Employment gap (nL / snL)
Pct. change
Change in pct. points
year
Blip, One-agent model with splurge factors
Blip, Two-agent model with hand-to-mouth'ers
Permanent unfinanced, One-agent model with splurge factors
Permanent unfinanced, Two-agent model with hand-to-mouth'ers

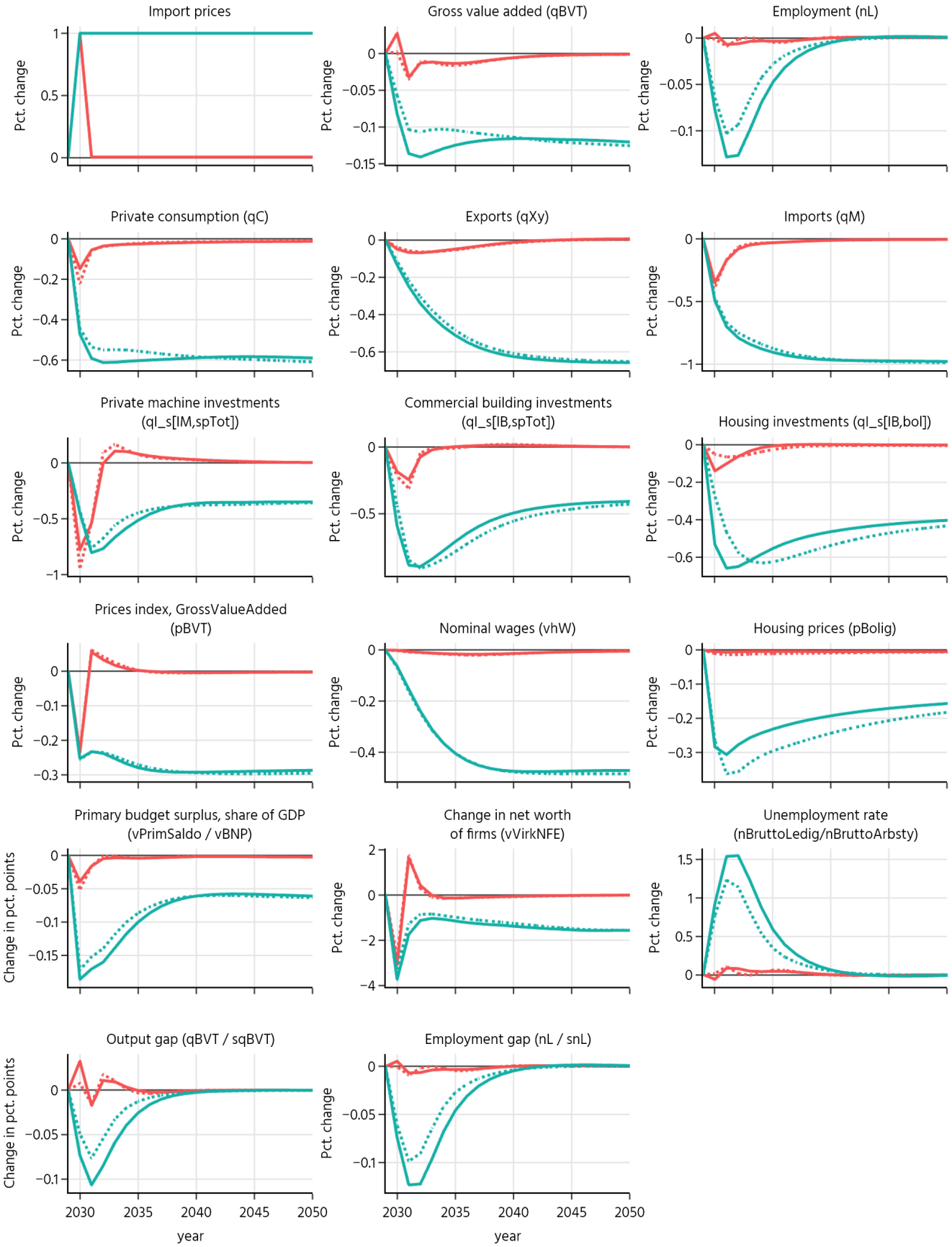
Shock to public investments




Shock to other transfers to households
Other transfers to households (vOffTilHhRest)
Gross value added (qBVT)
Employment (nL)
Private consumption (qC)
Exports (qXy)
Imports (qM)
Private machine investments (qI_s[IM,spTot])
Commercial building investments (qI_s[IB,spTot])
Housing investments (qI_s[IB,bol])
Prices index, GrossValueAdded (pBVT)
Nominal wages (vhW)
Housing prices (pBolig)
Primary budget surplus, share of GDP (vPrimSaldo / vBNP)
Change in net worth of firms (vVirkNFE)
Unemployment rate (nBruttoLedig/nBruttoArbsty)
Output gap (qBVT / sqBVT)
Employment gap (nL / snL)
Pct. change
Change in pct. points
year
Blip, One-agent model with splurge factors
Blip, Two-agent model with hand-to-mouth'ers
Permanent unfinanced, One-agent model with splurge factors
Permanent unfinanced, Two-agent model with hand-to-mouth'ers


Shock to export market growth
Export market index (qXMarked)
Gross value added (qBVT)
Employment (nL)
Private consumption (qC)
Exports (qXy)
Imports (qM)
Private machine investments (qI_s[IM,spTot])
Commercial building investments (qI_s[IB,spTot])
Housing investments (qI_s[IB,bol])
Prices index, GrossValueAdded (pBVT)
Nominal wages (vhW)
Housing prices (pBolig)
Primary budget surplus, share of GDP (vPrimSaldo / vBNP)
Change in net worth of firms (vVirkNFE)
Unemployment rate (nBruttoLedig/nBruttoArbsty)
Output gap (qBVT / sqBVT)
Employment gap (nL / snL)
Pct. change
Change in pct. points
year
Blip, One-agent model with splurge factors
Blip, Two-agent model with hand-to-mouth'ers
Permanent unfinanced, One-agent model with splurge factors
Permanent unfinanced, Two-agent model with hand-to-mouth'ers

Shock to import prices



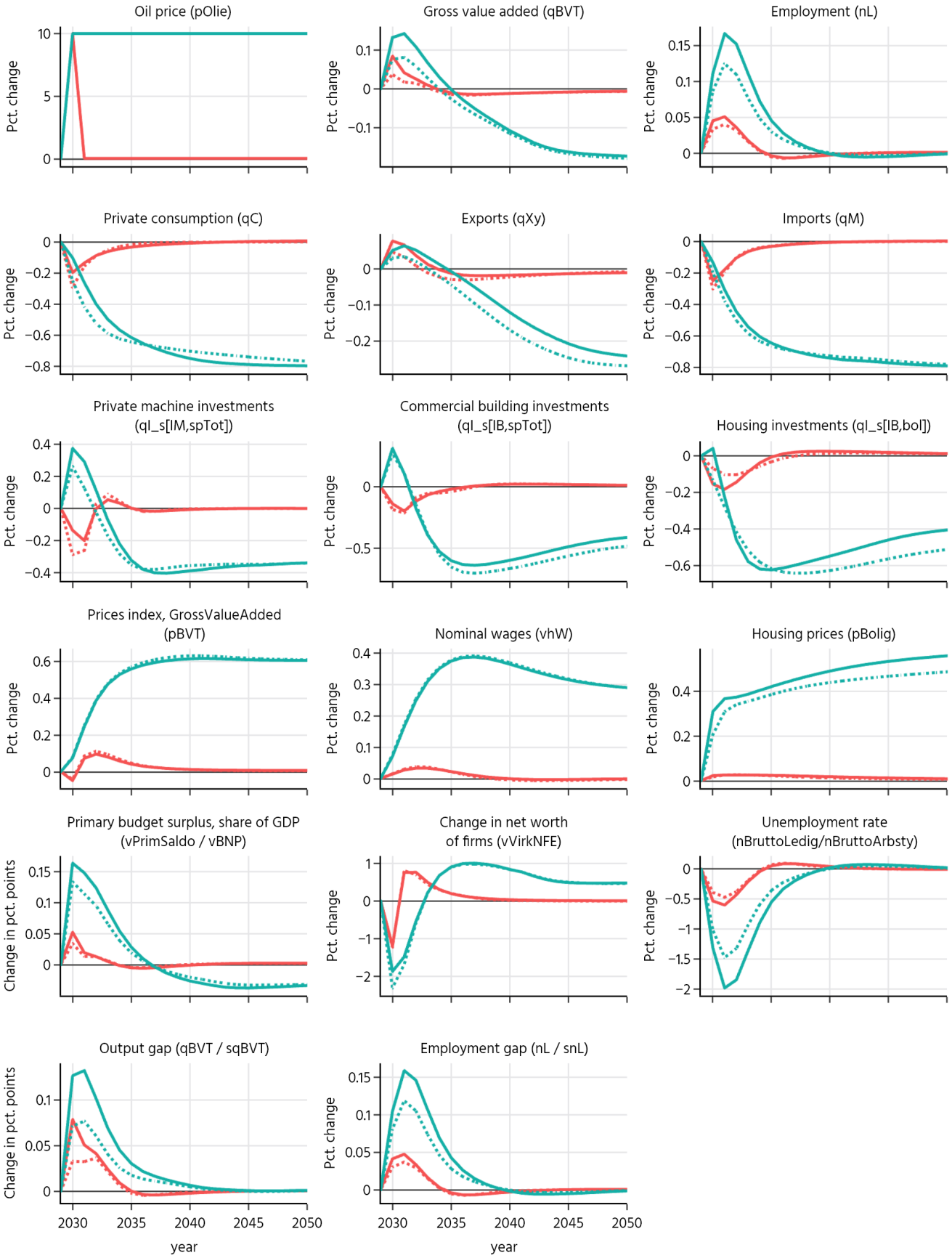
Blip, One-agent model with splurge factors

Blip, Two-agent model with hand-to-mouth'ers

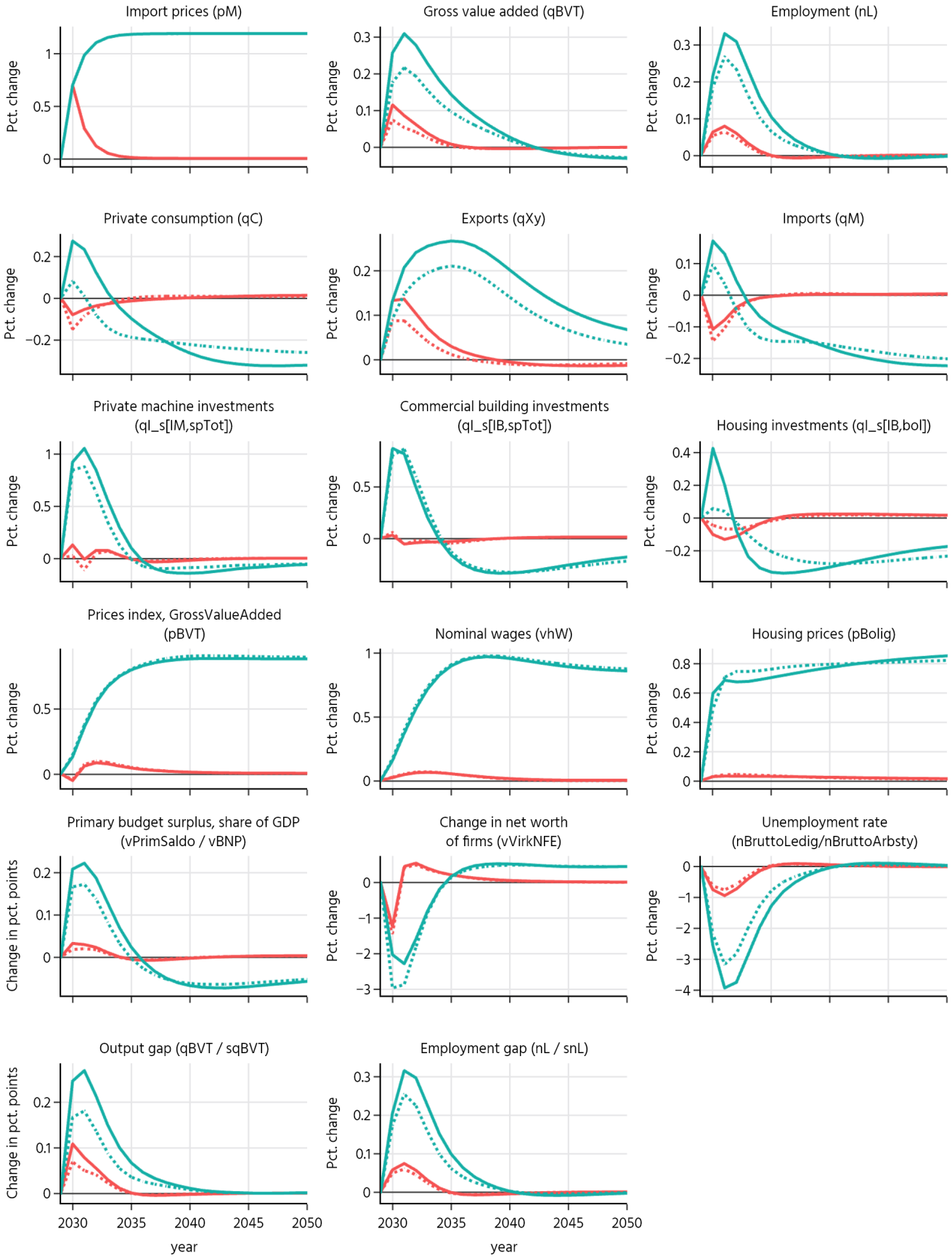
Permanent unfinanced, One-agent model with splurge factors

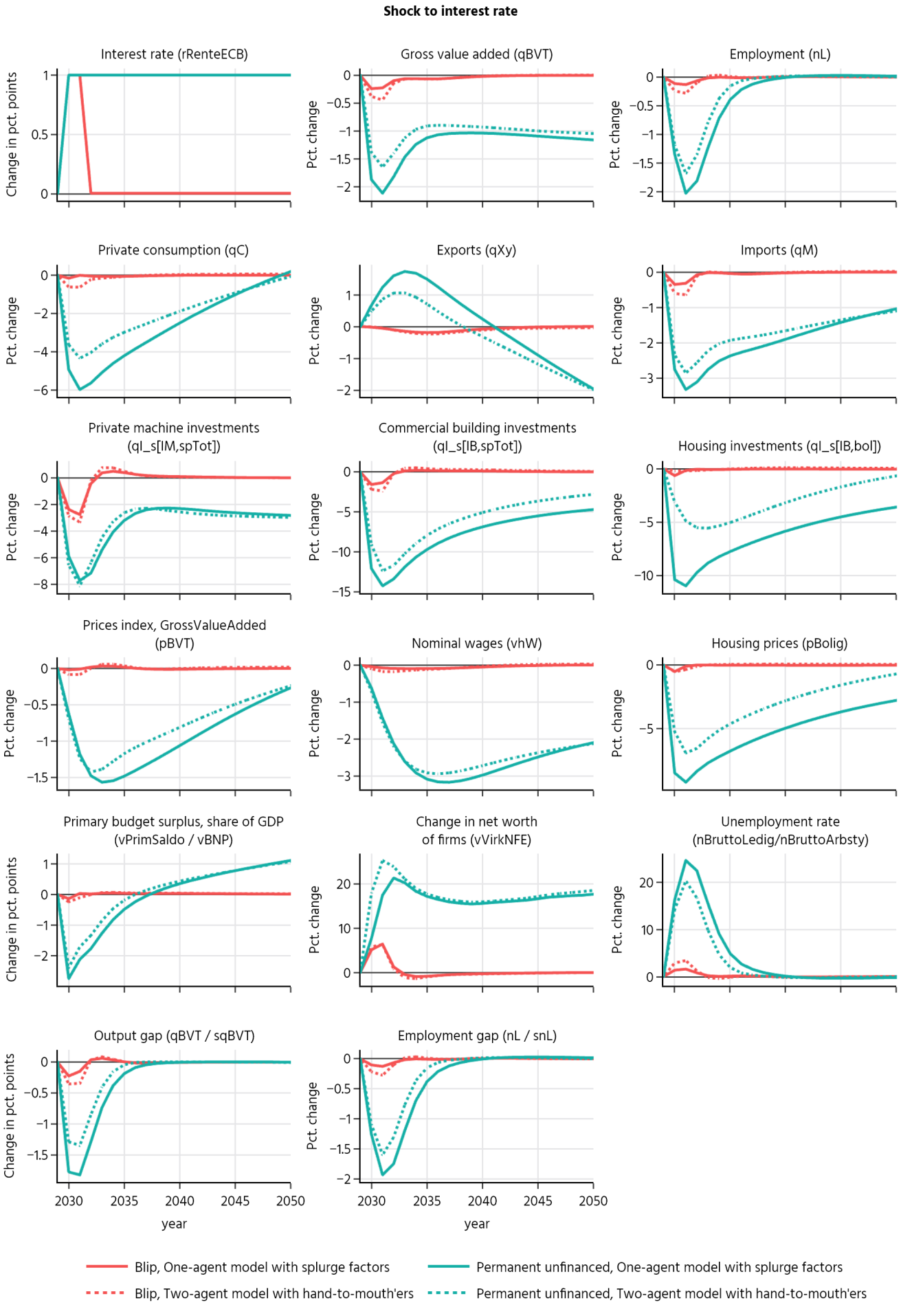
Permanent unfinanced, Two-agent model with hand-to-mouth'ers

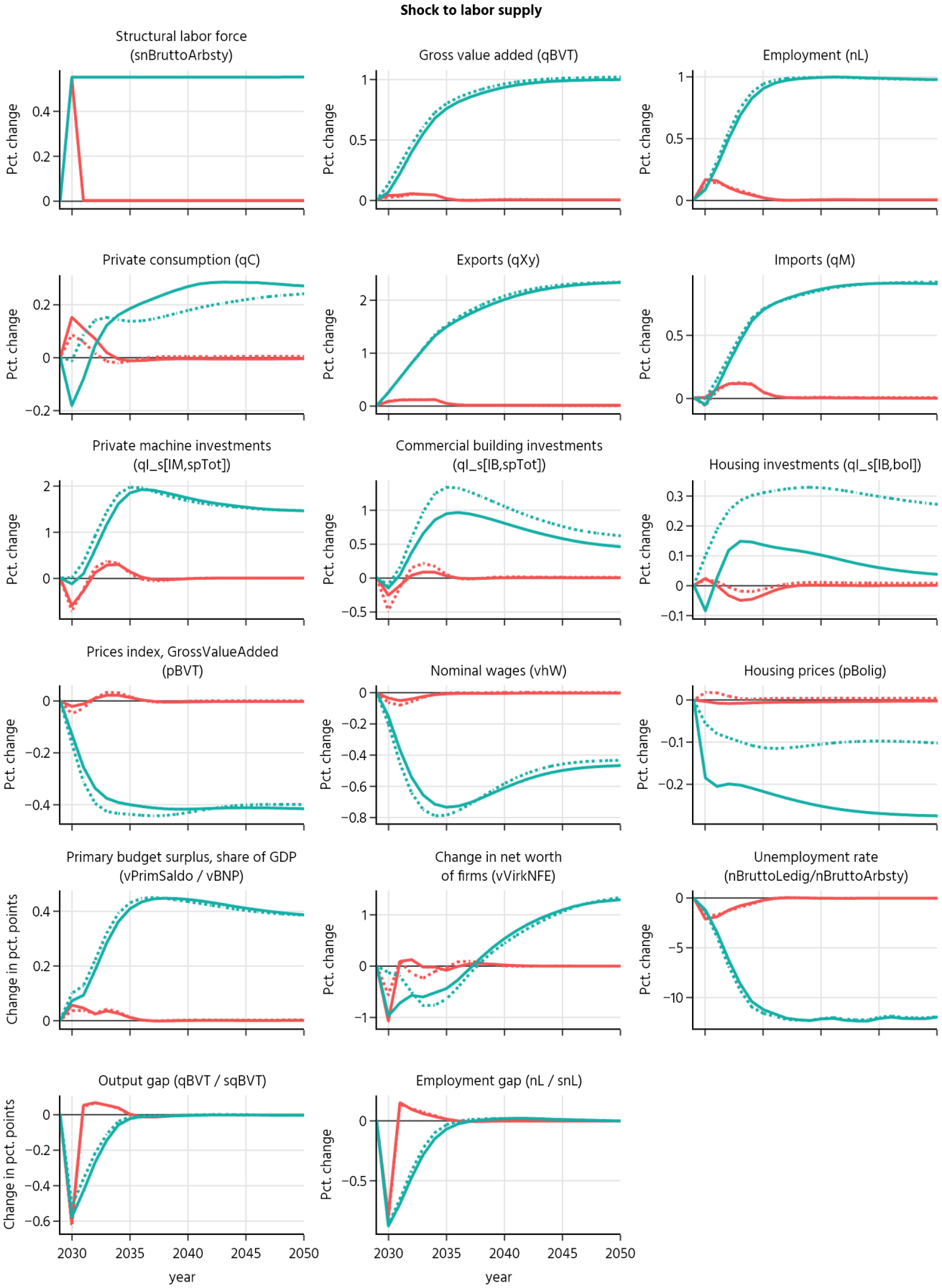
Shock to oil prices



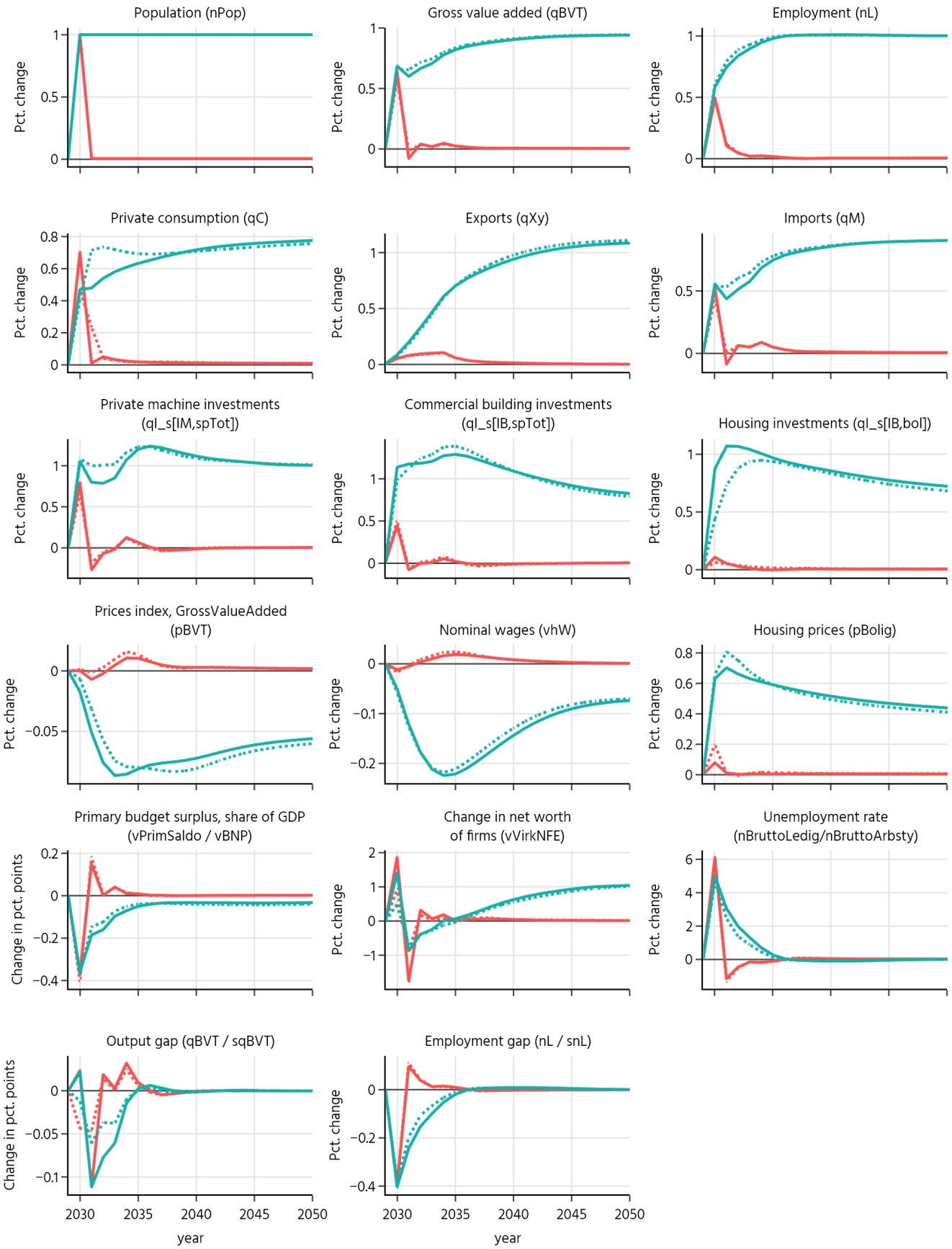
Shock to foreign prices (sluggish pass-through)



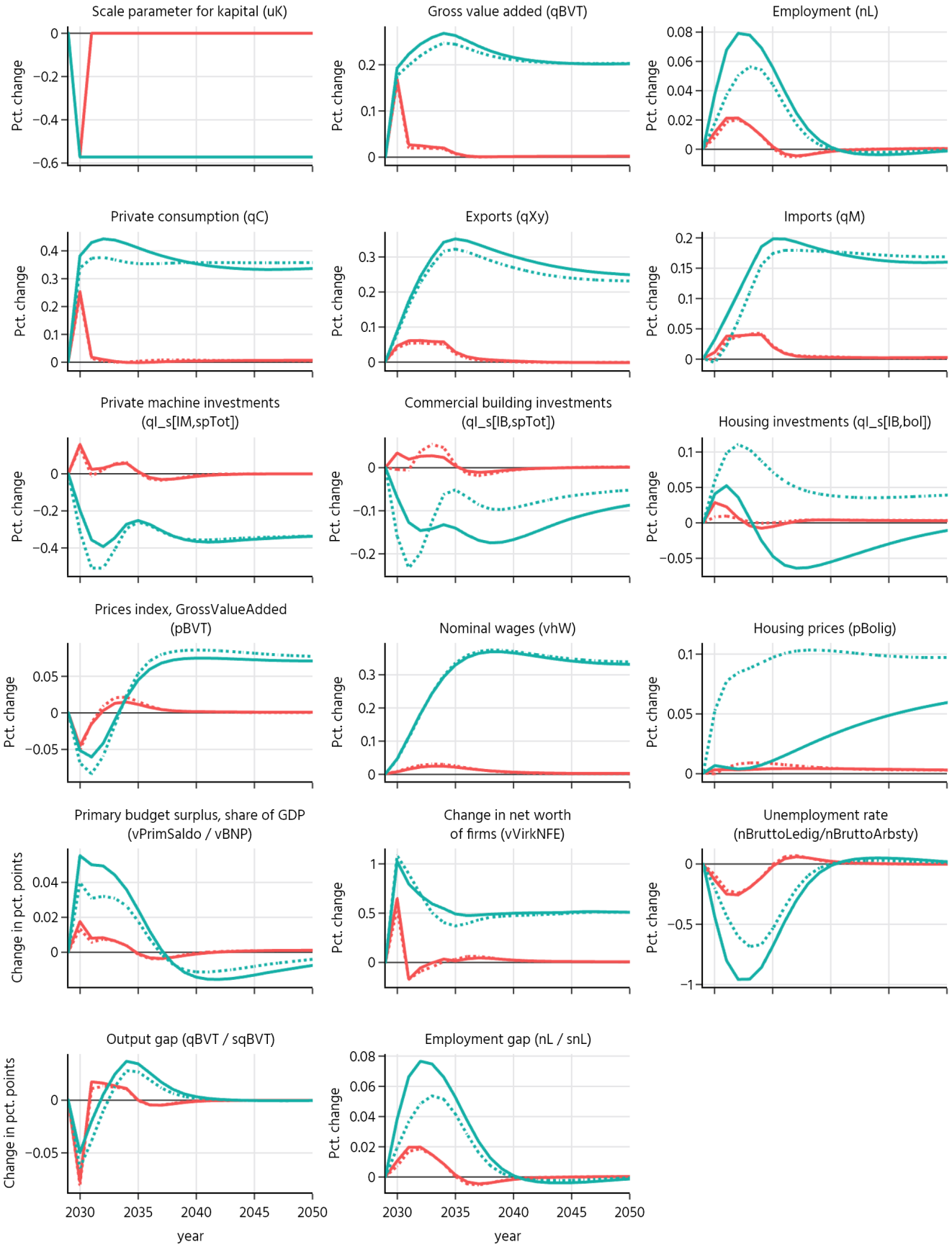

Shock to interest rate
Interest rate (rRenteECB)
Change in pct. points
Gross value added (qBVT)
Pct. change
Employment (nL)
Pct. change
Private consumption (qC)
Pct. change
Exports (qXy)
Pct. change
Imports (qM)
Pct. change
Private machine investments (qI_s[IM,spTot])
Pct. change
Commercial building investments (qI_s[IB,spTot])
Pct. change
Housing investments (qI_s[IB,bol])
Pct. change
Prices index, GrossValueAdded (pBVT)
Pct. change
Nominal wages (vhW)
Pct. change
Housing prices (pBolig)
Pct. change
Primary budget surplus, share of GDP (vPrimSaldo / vBNP)
Change in pct. points
Change in net worth of firms (vVirkNFE)
Pct. change
Unemployment rate (nBruttoLedig/nBruttoArbsty)
Pct. change
Output gap (qBVT / sqBVT)
Change in pct. points
Employment gap (nL / snL)
Pct. change
2030
2035
2040
2045
2050
year
Blip, One-agent model with splurge factors
Permanent unfinanced, One-agent model with splurge factors
Blip, Two-agent model with hand-to-mouth'ers
Permanent unfinanced, Two-agent model with hand-to-mouth'ers


Shock to labor supply
Structural labor force (snBruttoArbsty)
Gross value added (qBVT)
Employment (nL)
Private consumption (qC)
Exports (qXy)
Imports (qM)
Private machine investments (qI_s[IM,spTot])
Commercial building investments (qI_s[IB,spTot])
Housing investments (qI_s[IB,bol])
Prices index, GrossValueAdded (pBVT)
Nominal wages (vhW)
Housing prices (pBolig)
Primary budget surplus, share of GDP (vPrimSaldo / vBNP)
Change in net worth of firms (vVirkNFE)
Unemployment rate (nBruttoLedig/nBruttoArbsty)
Output gap (qBVT / sqBVT)
Employment gap (nL / snL)
Pct. change
Change in pct. points
year
Blip, One-agent model with splurge factors
Permanent unfinanced, One-agent model with splurge factors
Blip, Two-agent model with hand-to-mouth'ers
Permanent unfinanced, Two-agent model with hand-to-mouth'ers

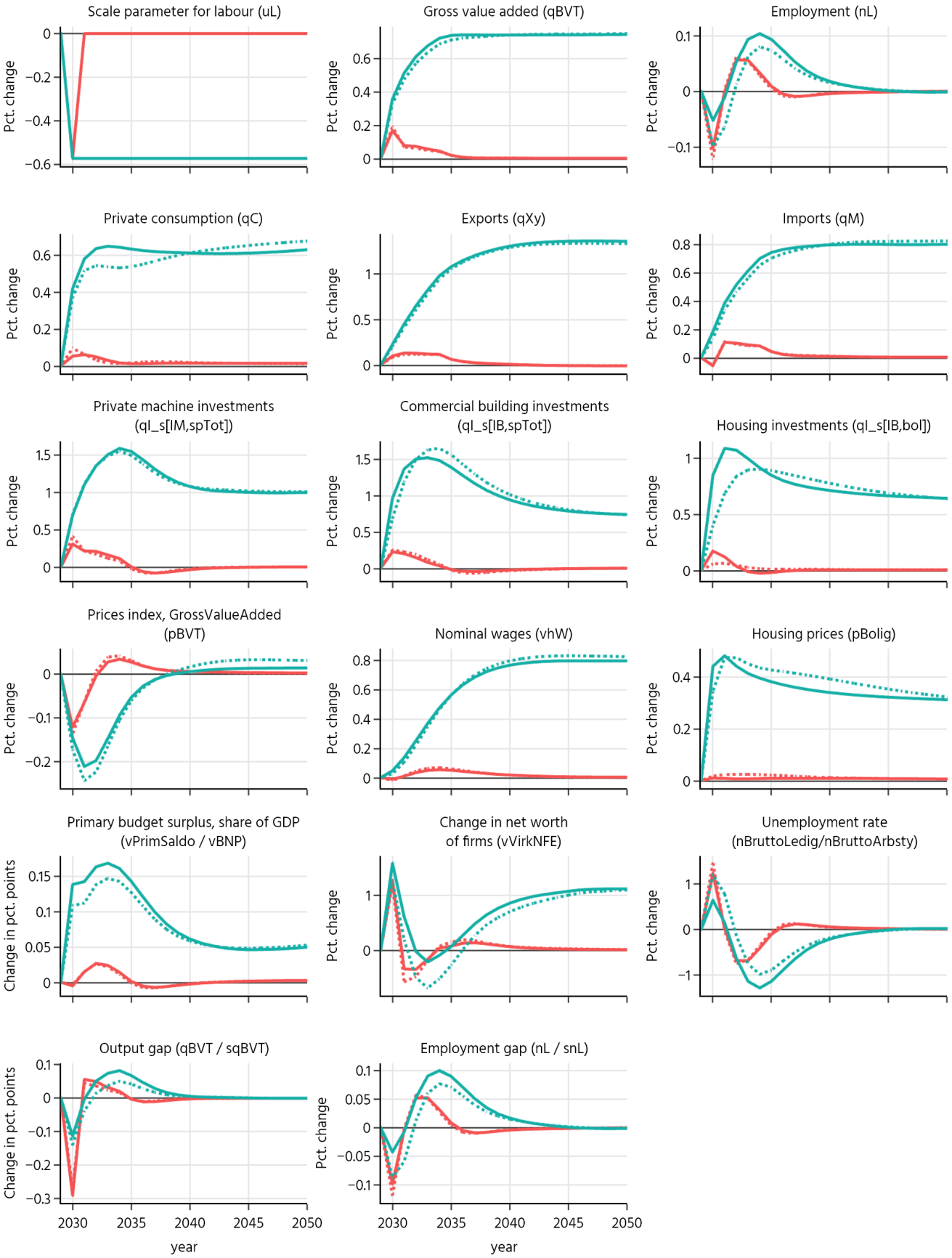
Shock to population



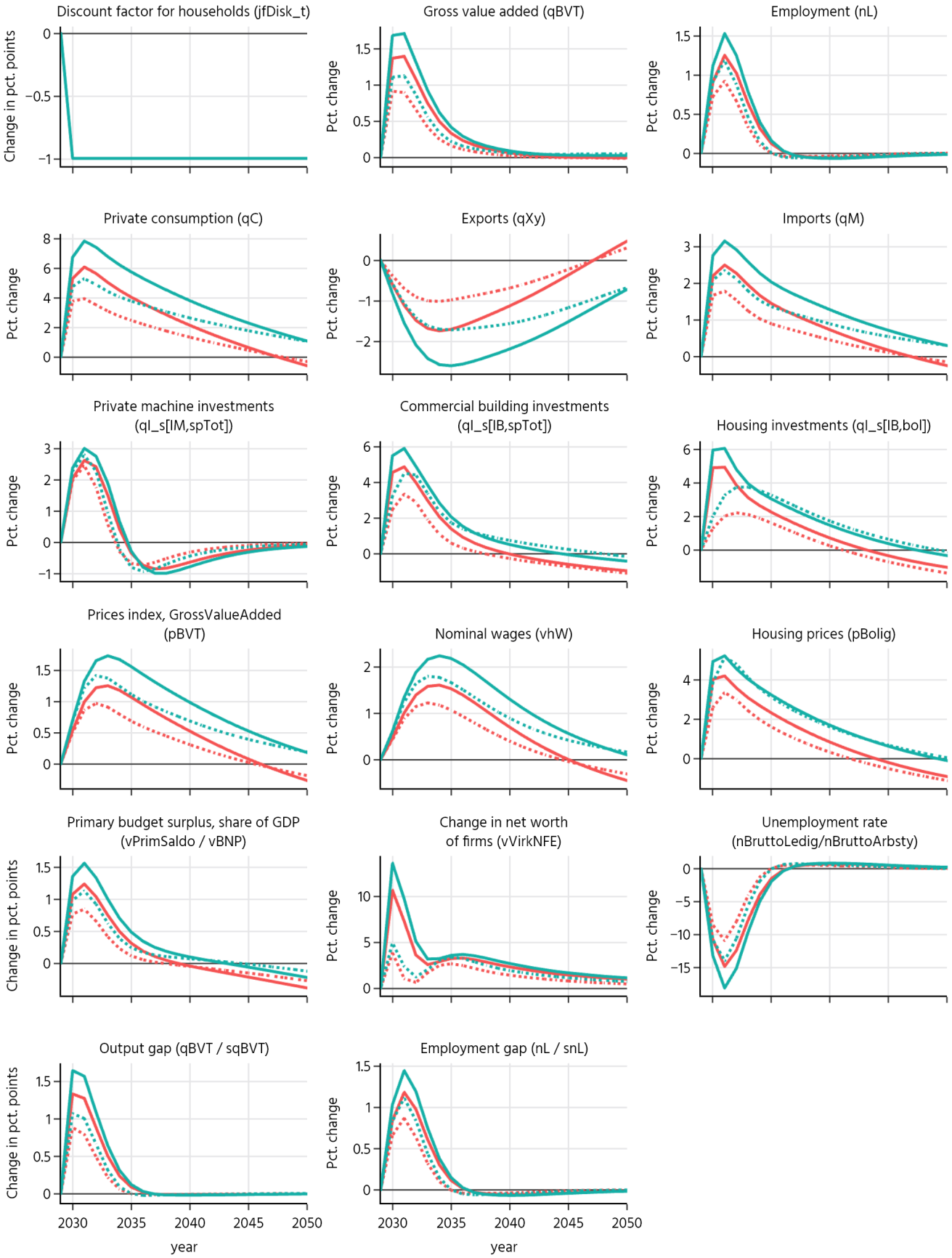
Shock to capital productivity



Shock to productivity of labour



Shock to discount factor for households



Shock to bargaining power of wage earners