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Macroprudential policies in the EAGLE FLI model calibrated for Hungary

(Makroprudenciális eszközök Magyarországon az EAGLE FLI modellben)

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Contents

Abstract

In this paper we develop the Hungarian version of the EAGLE FLI (**E**uro **A**rea **GL**obal **E**conomy model with **F**inancial **LI**nkages) model which is the EAGLE model enriched with financial frictions and country-specific banking sector. The EAGLE FLI features the intermediation of loanable funds (ILF) view in banking whereby the creation of new loans requires banks to collect additional deposits. Households and firms borrow in the model using housing as collateral. We find that macroprudential policies such as an increase in capital requirements, decreases in the loan-to-value ratio or loan-to-income ratio of borrower households (and firms) limits banks' credit creation with negative spillover effects to the real economy due to the financial accelerator mechanism in the model. On the other hand, these policies strengthen banks' capital and limit the vulnerability of households and firms to negative financial shocks.

JEL: E12, E13, E52, E58, F11, F41.

Keywords: macroprudential policy, multi-country DSGE, capital requirements, loan-to-value ratio, loan-to-income ratio.

Összefoglaló

A tanulmányban az EAGLE FLI (**E**uro **A**rea **GL**obal **E**conomy model with **F**inancial **LI**nkages) modell Magyarországra fejlesztett verzióját mutatjuk be. A modell az ILF, azaz "intermediation of loanable funds (kihitelezhető források közvetítése)" elvet követi, mely szerint az új hitelekhez a banknak új betétekre van szüksége. A háztartások és vállalatok hitelt vesznek fel ingatlan és fizikai tőke fedezet mellett. Azt találjuk, hogy a makroprudenciális eszközök, mint tőkekövetelmények emelése, hitelfedezeti mutató (HFM) vagy a jövedelemarányos hitelösszeg szigorítása korlátozza a bankok hitelezési tevékenységét, amely eltérő mértékű negatív átgyűrűzési hatással jár a reálgazdaságra. Ugyanakkor ezek az eszközök megerősítik a bankok tőkehelyzetét és csökkentik a háztartások és vállalatok sérülékenységét pénzügyi sokkok esetében.

1 Introduction

The recent global financial crisis pointed to the importance of interlinkages between the real economy and the financial system urging central banks to design policies which promote not only low inflation and high economic growth but also financial stability.

Standard macroeconomic models have been complemented with financial frictions (see e.g. Gertler and Karadi (2011), Gertler and Kiyotaki (2010), Clerc et al. (2015), Bokan et al. (2018). In this paper we employ the EAGLE FLI model to measure the economic effects of macroprudential policies (regulatory capital requirements, borrower-based measures such as loan-to-value ratios and loan-to-income ratios) in Hungary (and the eurozone). We find that as long as the banks have no free capital buffers a regulatory two percentage points increase in capital requirements induces a contraction of loans intermediated in both domestic and interbank loan market. Borrower households and firms reduce their demand for housing services leading to a decrease in house prices. The credit squeeze has effects on the real economy as well: output, consumption, exports and imports fall and real exchange rate appreciates. Due to the small size of Hungary in the population weighted world GDP the credit squeeze has negligible or zero spillover effects on the eurozone and the other two country blocks.

A regulatory change in the maximum loan-to-value (LTV) ratio leading to a one percentage point decrease in the average LTV ratio of borrower households and firms forces them to take less loans for a given amount of collateral. The macroeconomic effects of lower loan-to-value as well as loan-to-income ratio are substantial due to the financial accelerator mechanism in the model. In particular, these policies induce a contraction in real macroeconomic aggregates such as consumption, output, hours worked, exports and imports. They also generate an appreciation of the real exchange rate (after an initial short jump in the opposite direction due to the sluggishness of exports and imports). Patient (savers) and impatient (borrowers) households' substitute away from consumption and increase their demand for housing services and leisure. Our results are in line with Bachmann and Rueth (2017) who use a narrative method to identify shocks to LTV in an SVAR model. In particular, they find that a 25 basis points decrease in the LTV ratio causes real GDP to decline by 0.1 per cent.

The current regulation in Hungary prescribes debt service-to-income (DSTI) ratios. To capture the effects of DSTI in our setup we introduce loan-to-income (LTI) ratio into the model. Imposing an upper bound on the LTI ratio reduces the ability of households to become excessively indebted. Similar to the reduction in the loan-to-value ratio lower loan-to-income ratio results in less credit intermediated with negative spillovers from the financial sector to the real economy. In particular, there is a reduction in the consumption of saver and borrowing households as well as a fall in real GDP and hours worked. Lower demand is associated with a decrease in wages and deflation. Due to general equilibrium effects the change in the households' LTV ratio also lead to a fall in the borrowing of entrepreneurs even if the entrepreneurs are not affected directly by the policy change.

We find that the change in capital requirement has negligible negative short-run effects of about -0.01 per cent and small but non-negligible long run effects (around -0.015) on GDP. In terms of lending, capital requirements lead to a reduction of 0.2 per cent over a year while 0.15 in the long run. In contrast the modification of lending standard induces a reduction of 2.3 per cent in domestic lending in the short and about 2 per cent in the long run. It also has stronger negative effects on the GDP (about -0.4 per cent) relative to capital requirements on the short run with almost zero effects on the long-run.

The EAGLE (FLI) Bokan et al. (2018) was developed by the EAGLE team of the Working Group on Econometric Modelling whose members are recruited from the national banks of the European Union. The EAGLE FLI model emphasizes the traditional intermediation of loanable funds (ILF) approach in banking. To lend more the bank has to collect deposits. This is in contrast to a new strand of models using the so-called financing through money creation (FMC) approach (see Benes et al. (2014), Jakab and Kumhof (2015)). In the latter approach savings is consequence, not a cause, of lending. [1]

[1] The FMC approach emphasizes that lending creates its own funding/deposits, and neither savings nor intermediation is needed to issue loans. Even if the FMC approach seems to provide better account of how loans are created in reality a recent paper by Drechsler et al. (2017) offers compelling empirical evidence in favour of the deposit channel and the ILF approach using US data.

There are several new elements in the EAGLE FLI model relative to the standard EAGLE model without financial frictions. First, there are two types of households: ”savers” and ”borrowers”. The latter is assumed to be more impatient (lower discount rate) than the first one. Second, we introduce a country-specific banking sector which intermediates funds from households to borrowers and entrepreneurs who invest into the capital. Third, we introduce housing services that i) households and entrepreneurs derive utility from, and which ii) can function as a stock of collateral to borrower households and entrepreneurs as well as used as an input in production. In each block banks collect deposits from domestic saver households, raises capital that is subject to regulatory requirement and lends both to borrowing households and entrepreneurs who are subject to a collateral constraint. Borrowers and entrepreneurs can use housing as a form of collateral. Importantly, both households and firms pledge the future value of the collateral. Fourth, there is an interbank market in the model between the banks in Hungary and the eurozone. Hence, domestic banks can issue domestic as well as interbank loans. Interbank loan market in the model is based on the Kollmann (2013) but different from his paper there are no global banks in the EAGLE FLI model. Fifth, we enrich the model with a set of financial shocks such as shocks to the loan-to-value ratio in the collateral constraint of households and firms. Since the recent crises financial shocks are widely accepted to explain significant portion of business cycles beyond real (technology shocks) and nominal shocks (changes in price and wage markups).

Relative to Bokan et al. (2018) we add two more features to the EAGLE FLI model. In particular we assume that there is a redistribution of profit of the Hungarian banking sector to the Euro area (many foreign commercial banks in Hungary) and introduce loan-to-income regulation. Gomes (2016) makes use of the EAGLE FLI model to study the effects of the unconventional monetary policies of the ECB. There are several applications of the baseline EAGLE model, see Békési et al. (2017) for the list. The paper by Kaszab (2016) studies the domestic and spillovers effects of the unconventional monetary policies of the ECB using the EAGLE model with Gertler and Kiyotaki (2010) type financial accelerator. Brzoza-Brzezina et al. (2010) and Brzoza-Brzezina et al. (2017) study the substitution between domestic and foreign currency loans in Central Europe. However, foreign currency loans in Hungary were converted to domestic loans in 2015 and, therefore, the vulnerability of Hungarian households decreased substantially due to the elimination of exchange rate risk.

Our paper is also related to several papers in the literature studying the effects of macroprudential policies using a DSGE model (which are not necessarily based on the EAGLE FLI). One of them is Brzoza-Brzezina et al. (2018) who uses a two-country DSGE model to examine the international propagation of shock induced by the foreign ownership of banks. In particular, they find that foreign ownership of banks magnifies the spillover effects of monetary and macroprudential policies. Gerba and Żochowski (2017) study the impact of Knightian uncertainty on financial stability and the business cycle. Knightian uncertainty means that households are rational but take economic decisions under incomplete information. In their paper households learn by doing once a sufficient number of the state is realised. Due to the limited enforceability of financial contracts households are required to provide collateral. In their framework the financial contract and the learning mechanism ensures that the build-up of risk and leverage takes a longer time than in standard DSGE models. Corrado and Schuler (2017) analyses the effects of several macroprudential policies on the banking sector and its linkages to the macro economy using a New Keynesian type DSGE model. They find that the introduction of liquidity requirements effectively mitigates the negative effects of a shock emerging on the interbank market while capital requirements propagate only through nominal variables such as nominal interest rates and inflation. Gersbach and Rochet (2017) explains that banks tend to lend much in high productivity states and too little in low productivity states even with complete markets and, thus, argue in favour of countercyclical capital requirements. They find that imposing stricter capital requirements in good states corrects capital misallocation, increases expected output and social welfare even with risk-neutral agents.

Angelini et al. (2011) study the effects of macroprudential policies in normal and non-normal times. They find that macroprudential policies yield only small benefits in normal times which is driven mainly by supply shocks and not financial-type shocks. The benefit from macroprudential policies in promoting financial stability becomes substantial when loan supply and housing market shocks dominate. They also point to the importance of the cooperation to avoid conflicts between classic monetary and macroprudential policies. Clerc et al. (2015) develop a DSGE model for a normative and positive analysis of macroprudential policies. Borrowers can default on debt. They apply time-invariant capital requirements as well as countercyclical adjustments to capital ratios. They have three main findings. First, they can calculate an optimal level of capital requirements which help reduce bank leverage, bank failure risk and the implicit subsidies associated with deposit insurance. However, lower leverage will result in larger cost of equity funding (instead of debt) and less credit intermediated. Second, they find that in states with high leverage and low capital requirements the economy is more responsive to shocks (both idiosyncratic and aggregate). Third, countercyclical capital ratio adjusments can significantly improve the benefits of high capital requirements once applied to a certain level. The countercyclical reduction in capital requirements might allow banks to charge lower loan rates on larger amount of loans.

There are also attempts to study macroprudential policies in models with heterogenous agents and idiosyncratic as well as aggregate risks. Guerrieri and Lorenzoni (2017) examine the effects of a credit-crunch on consumer spending in a heterogenous agents model. They find that an unexpected tightening in consumers' borrowing capacity leads constrained agents to repay debt while unconstrained ones increase their precautionary savings. In a similar model Corbae and Quintin (2015) finds the payment-to-income requirements are effective insulating households from over-borrowing in bad times but become unrestricted in booms. Their model approximates key housing and mortgage market facts of the US well before and after the recent financial crisis. Hull (2017) uses a heterogenous agent model and find using Swedish mortgage data that mortgage amortisation requirements are potentially useful in reducing household indebtedness. He finds using an incomplete markets model with three types of debt and a novel mortgage contract specification that in the absence of tight restrictions on the maximum debt service-to-income ratio or implausibly large refinancing cost the policy impact is small in the aggregate level. Corbae and D'Erasmo (2014) study the impact of capital regulation on bank risk-taking, bank failure and market structure. The market structure in their model includes a layer of big banks which interact with a small, competitive fringe banks. The endogenous entry and exit of banks due to shocks induces a non-trivial size distribution of banks. They find that a rise in capital requirements from 4 to 6 per cent leads to sizable reduction in the exit rate of small banks and a more concentrated industry. Loans supply falls and interest rate rises by 50 basis points. It also leads to a reduction in deposit insurance while higher interest rates trigger higher delinquencies and lower level of output in the economy. Goel (2016) has a model similar to Corbae and D'Erasmo (2014) and characterises the optimal size-dependant bank capital regulation. In his model higher leverage induces higher expected return on capital but also increases the variance of returns and bank failure risk. He finds the optimal capital requirement to be tighter relative to the pre-crisis benchmark and also bank-specific: tighter for larger banks than for smaller banks.

The rest of the paper proceeds as follows. Section 2 describes the model. Section 3 explains how the model is calibrated. Section 4 provides four experiments. The first one is an increase in capital requirements in the eurozone, the second one is a rise in capital requirements in Hungary as well as the eurozone. The third one is a regulatory reduction in the loan-to-value ratio (LTV). The fourth one is a decrease in the loan-to-income ratio (LTI). Finally, we conclude in section 5.

2 The model

We only sketch the new features of the FLI version of EAGLE. The description of the EAGLE FLI closely follows Bokan et al. (2018). For features of the EAGLE FLI which are part of the EAGLE model without financial frictions we refer the reader to Gomes et al. (2012) and to Békési et al. (2017).

2.1 HOUSEHOLDS

There are two types of households in the model: patient (”savers”, denoted by I) and impatient (”borrowers”, denoted by J). Patient households discount factor is larger than that of impatient ones ($\beta_I > \beta_J$). Patient and impatient households are $1-\omega_J-\omega_E-\omega_B$ and ω_J share of the H population, respectively such that $\omega_J, \omega_E > 0$, $\omega_J+\omega_E+\omega_B < 1$. Within each type they have identical preferences, constraints and initial asset positions. Each household supplies differentiated labour service to domestic firms and has monopoly power to set a wage for itself. Wage setting is subject to Calvo type frictions. There is perfect risk sharing among wage setters offering the same variety of labour. Both types of households are allowed to hold financial assets such as domestically issued and international bonds (denominated in domestic currency and US dollars, respectively) and physical capital.

2.1.1 PATIENT HOUSEHOLDS (”SAVERS”)

Patient households maximise utility derived from consumption (C_I) and housing (H_I) and disutility from working (N_I) on an infinite horizon:

$$E_t\left[\sum_{k=0}^{\infty}\beta_I^k\left(\frac{1-\kappa}{1-\sigma}\left(\frac{C_{I,t+k}-\kappa C_{I,t+k-1}}{1-\kappa}\right)^{1-\sigma}+\iota_I\ln H_{I,t+k}-\frac{1}{1+\zeta}N_{I,t+k}^{1+\zeta}\right)\right]$$

where E_t denotes expectation operator on an information set until t, β is the discount factor, σ is risk-aversion (inverse of the intertemporal elasticity of substitution), ζ is the inverse of Frisch elasticity and κ measures habits in consumption. ι_I is the parameter assigned to housing services in the utility.

The budget constraint of a representative Ricardian household is given by:

$$\begin{aligned}
&D_t^{Dem}-R_{t-1}^{D}D_{t-1}^{Dem}+B_{I,t}-B_{I,t-1}R_{t-1}+B_{I,t}^{EA}-B_{I,t-1}^{EA}R_{t-1}\\
&+S_t^{H,US}B_t^{US}-S_t^{H,US}B_{t-1}^{US}R_{t-1}^{US}\\
&=(1-\tau_t^N-\tau_t^{W^h})W_{I,t}N_{I,t}+(1-\tau_t^D)D_t^F\\
&-Q_t^H(H_{I,t}-(1-\delta_H)H_{I,t-1})-(1+\tau_t^C)P_{C,t}C_{I,t}-P_{C,t}\Gamma_{DH,t}+TR_t-T_t
\end{aligned}$$

where $P_{C,t}$ denote respectively the price of one unit of consumption good, τ_t^C is tax rate on consumption good. D_t^F stands for dividends from domestic firms (profits) received by Ricardians only, τ_t^D is tax rate on dividends. TR_t are lump-sum transfers, while T_t are lump-sum taxes. $S_t^{H,US}$ is the nominal exchange i.e. the domestic currency price of one unit of US dollars, B_t^{US} is holdings of bonds denominated in US dollars paying interest rate R_t^{US}. $B_{I,t}^{EA}$ are euro-denominated bonds. $W_{I,t}N_{I,t}$ is labour income, net income is obtained by paying tax rates τ_t^N and $\tau_t^{W^h}$. δ (δ_H) is the depreciation rate of physical capital (housing stock $H_{I,t}$), Q_t^H is the price of housing. D_t^{dem} is the demand for bank deposits and R_t^D is the gross interest rate on previous period bank deposits.

Γ_{DH} is the cost of adjusting deposits and has a quadratic form:

$$\Gamma_{DH,t}\equiv\frac{\gamma_{DH}}{2}\left(d_t^{dem}-\kappa^D\frac{\bar{p}^Y\bar{Y}}{1-\omega_J-\omega_E-\omega_B}\right)^2$$

where $d_t^{dem} \equiv D_t^{dem}/P_{C,t}$ and

$$\kappa^D \equiv \frac{(1-\omega_J-\omega_E-\omega_B)\bar{d}^{dem}}{\bar{p}^Y\bar{Y}}$$

is the steady state deposit-to-GDP ratio, $(1-\omega_J-\omega_E-\omega_B)\bar{d}^{dem}$ is per capita aggregate deposits and expressed in consumption units. Variables with an upper bar denote steady-state.

2.1.2 IMPATIENT HOUSEHOLDS (”BORROWERS”)

Impatient households who constitute of ω_J part of the population maximise utility derived from consumption (C_J) and housing (H_J) and disutility from working (N_J) on an infinite horizon:

$$E_t\left[\sum_{k=0}^{\infty}\beta_J^k\left(\frac{1-\kappa}{1-\sigma}\left(\frac{C_{J,t+k}-\kappa C_{J,t+k-1}}{1-\kappa}\right)^{1-\sigma}+\iota_J\ln H_{J,t+k}-\frac{1}{1+\zeta}N_{J,t+k}^{1+\zeta}\right)\right]$$

where $0<\beta_J<\beta_I<1$ and ι_J is a parameter attached to the value of housing services in the utility.

The impatient household's budget constraint can be written as:

$$\begin{aligned}B_{J,t}-R_{t-1}^L B_{J,t-1} &= (1-\tau_t^N-\tau_t^{W^h})W_{J,t}N_{J,t}-(1+\tau_t^C)P_{C,t}C_{J,t}\\ &\quad -Q_t^H(H_{J,t}-(1-\delta_H)H_{J,t-1})-P_{C,t}\Gamma_{B_J,t}+\frac{TR_J}{\omega_J}\end{aligned}$$

where $B_{J,t}<0$ is the amount of loans from the domestic bank, $\Gamma_{B_J,t}$ is the real adjustment cost on changing the borrowing position:

$$\Gamma_{B_J,t}\equiv\frac{\gamma_{B_J}}{2}\left(\frac{b_{J,t}}{b_{J,t-1}}-1\right)^2$$

where γ_{B_J} is a parameter of the adjustment cost and $b_{J,t}\equiv\frac{B_{J,t}}{P_{C,t}}$.

To borrow the household has to post collateral in the form of housing. The borrower has to respect the **loan-to-value (LTV)** borrowing constraint:

$$-B_{J,t}R_t^L\leq-\rho_{B_J}\bar{\Pi}B_{J,t-1}\frac{R_{t-1}^L}{\Pi_{C,t}}+(1-\rho_{B_J})V_{J,t}E_t[Q_{t+1}^H\Pi_{C,t+1}H_{J,t}] \tag{1}$$

where $0<V_{J,t}<1$ is average LTV ratio. The borrowing constraint limits the amount lent to a fraction of the value of the asset.

As an alternative, we also introduce the **loan-to-income (LTI)** borrowing constraint:

$$-B_{J,t}R_t^L\leq-\rho_{B_J}\bar{\Pi}B_{J,t-1}\frac{R_{t-1}^L}{\Pi_{C,t}}+(1-\rho_{B_J})LTI_{J,t}W_{J,t}N_{J,t}(1-\tau_{N,t}-\tau_{W_h,t}). \tag{2}$$

On the right side of the borrowing constraint equations, we apply a lagged term of past loans to avoid jumpy figure in impulse-response functions. In the LTI experiments, the LTV and LTI constraints are satisfied simultaneously. Given a shock to the average LTI the LTV adjusts endogenously.

2.2 ENTREPRENEURS

The representative entrepreneur represents ω_E part of the H population and maximises lifetime utility which is derived from consumption:

$$E_t\left[\sum_{k=0}^{\infty}\beta_E^k\left(\frac{1-\kappa}{1-\sigma}\left(\frac{C_{E,t+k}-\kappa C_{E,t+k-1}}{1-\kappa}\right)^{1-\sigma}\right)\right]$$

The entrepreneur owns the whole stock of physical capital and part of real estate.

The budget constraint of the entrepreneur is:

$$\begin{aligned} B_{E,t} - R^L_{t-1}B_{E,t-1} = {} & R_{H,t}H_{E,t-1} - (1+\tau^C_t)P_{C,t}C_{E,t} - P_{I,t}I_{E,t} \\ & + (1-\tau^K_t)(R_{K,t}u_t - \Gamma_u(u_t)P_{I,t})K_{E,t-1} + \tau^K_t\delta_K P_{I,t}K_{E,t} \\ & - Q^H_t(H_{E,t} - (1-\delta_H)H_{E,t-1}) \\ & - P_{C,t}\Gamma_{B_E,t} \end{aligned}$$

where $B_{E,t}$ is the amount of loans from domestic banks. $I_{E,t}$ is the investment into physical capital and $P_{I,t}$ is the price of investment. $R_{K,t}$ is the rental rate of physical capital $K_{E,t}$ while $R_{H,t}$ is the rental rate of real estate $H_{E,t}$. τ^K_t is the tax rate on physical capital. Variable u_t is capacity utilization with adjustment cost $\Gamma_u(u_t)$.

$\Gamma_{B_E,t}$ denotes the real adjustment cost on changing the borrowing position and has a quadratic functional form:

$$\Gamma_{B_E,t} \equiv \frac{\gamma_{B_E}}{2}\left(\frac{b_{E,t}}{b_{E,t-1}} - 1\right)^2$$

where $\gamma_{B_E} > 0$ and $b_{E,t} \equiv \frac{B_{E,t}}{P_{C,t}}$.

The accumulation of physical capital is described by:

$$K_{E,t} = (1-\delta_K)K_{E,t-1} + (1-\Gamma_{I,t})I_{E,t}$$

where $\Gamma_{I,t}$ is investment adjustment costs which have the following quadratic form:

$$\Gamma_{I,t} \equiv \frac{\gamma_I}{2}\left(\frac{I_{E,t}}{I_{E,t-1}} - 1\right)^2$$

where $\gamma_I > 0$ governs the size of investment adjustment costs.

Similarly to impatient households, the borrowing constraint (**LTV**) of entrepreneurs are given by:

$$-B_{E,t}R^L_t \leq -\rho_{B_E}\bar{\Pi}B_{E,t-1}\frac{R^L_{t-1}}{\Pi_{C,t}} + (1-\rho_{E_j})V_{H_E,t}E_t[Q^H_{t+1}\Pi_{C,t+1}H_{E,t}] \tag{3}$$

where $V_{H_E,t} < 1$ are the entrepreneur's LTV ratios associated with housing stock.

2.3 BANKS

The model contains a representative banking as in Kollmann (2013) with a size of ω_B in the population. The representative banks operates under perfect competition maximising profits and taking interest rates as given and choosing the optimal composition of assets and liabilities. As a slight modification, we assume that a fraction banks in the Home country are owned by Euro area banks. This is achieved through the consumption equations (7, 8, 9).

In this model banks intermediate funds between savers and borrowers who cannot directly lend or borrow from each other. The bank accepts deposits from domestic patient households (”savers”) and intermediates funds to domestic impatient households (”borrowers”) and domestic entrepreneurs. Furthermore, the bank takes a position in the cross-country interbank market.

The representative bank maximises its life-time utility which is derived from real dividends (all profits are paid out in the form of dividends).

$$E_t\sum_{k=0}^{\infty}\beta_B^k\frac{1}{1-\sigma}\left(\frac{DIV^B_{t+k}}{P^C_{t+k}}\right)^{1-\sigma} \tag{4}$$

where $0 < \beta_B < 1$ is the discount factor, $1/\sigma$ is the elasticity of intertemporal substitution, DIV^B_t is nominal dividends and P^C_t is domestic consumption deflator.

The profit maximisation of the bank is subject to the following budget constraint:

$$DIV_t^B = -L_t + R_{t-1}^L L_{t-1} - L_t^{IB} + R_{t-1}^{IB} L_{t-1}^{IB} + D_t^{Supply} - R_{t-1}^D D_{t-1}^{Supply} - P_t^C \Gamma_{L,t} - P_t^C \Gamma_{IB,t} - P_t^C \Gamma_{X,t}$$

where the deposits (D_t^{Supply}), loans to borrowers and entrepreneurs (L_t) and the position in the interbank market (L_t^{IB}) are all defined as one-period euro denominated nominal assets and liabilities. L_t^{IB} is the amount of loans provided by a bank in one particular region in the euro area to the representative bank in the rest of the euro area at the gross interest rate R_t^{IB}. The terms $\Gamma_{L,t}$ $\Gamma_{IB,t}$ and $\Gamma_{X,t}$ are costs the banking sector faces when adjusting the position in loans, the interbank market and the excess bank capital, respectively. The adjustment cost of changing loans is

$$\Gamma_L \equiv \frac{\gamma_L}{2}\left(\frac{l_t}{l_{t-1}} - 1\right)^2 .$$

The latter costs are defined below.

The interbank market. Domestic bank H (one particular country in the euro zone) can borrow from or lend to other banks in the rest of the euro zone subject to the following adjustment cost:

$$\Gamma_{IB,t} \equiv \frac{\gamma_{IB}}{2}\left(l_t^{IB} - \frac{\kappa^{IB}\bar{p}^Y\bar{Y}}{\omega_B}\right)^2$$

where γ_{IB} is a parameter that measures the strength of the adjusment cost $l_t^{IB} \equiv L_t^{IB}/P_t^C$ is the amount of loan granted in real consumption units. The adjustment cost introduces a wedge between the interest rate on interbank loans and deposits. $\bar{p}^Y$ and $\bar{Y}$ denote steady-state output deflator and real GDP, respectively. The parameter κ^{IB} is defined as $\omega_B \bar{l}^{IB}/(\bar{p}^Y\bar{Y})$ which is the steady-state interbank loan-to-GDP ratio. The current exposition abstracts from interbank liquidity which can be easily inserted into the model. The introduction of the interbank market allows us to study spillovers between banks in different regions of the eurozone. This also helps to capture the significant cross-country interbank lending. Further, the introduction of an interbank market allows to introduce a bank-specific shock through the parameter, κ^{IB}. The latter shock can be interpreted as a change in the long-run desired amount of interbank lending which is a short-cut for capturing changes in liquidity needs, bank portfolio choices or attitudes towards risk.

Capital requirement. The bank faces a regulatory capital requirement i.e. its period t capital

$$K_t^B = L_t - D_t^{Supply} + L_t^{IB}$$

should not be less than a possibly time-varying fraction $\Upsilon_{K,t}$ ($0 < \Upsilon_{K,t} < 1$) of its loans in the same period to domestic households and entrepreneurs, L_t.

The excess bank capital at the end of period t is defined:

$$X_t \equiv (1 - \Upsilon_{K,t})L_t - D_t^{Supply} + L_t^{IB}.$$

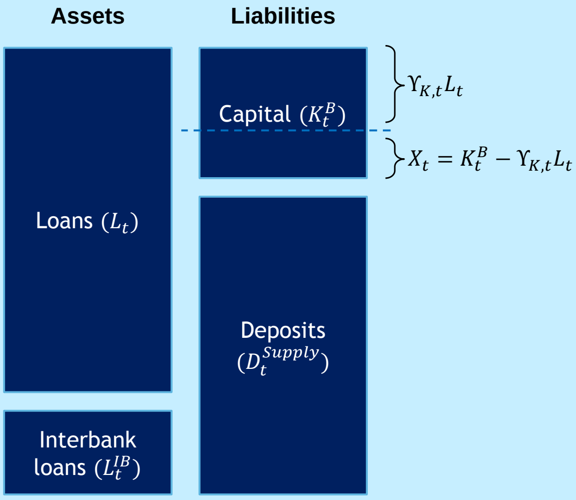
We assume that it is costly to deviate from the long-run (steady-state) value of excess bank capital. The latter cost can be captured by a quadratic adjustment cost which is in consumption units:

$$\Gamma_X \equiv \frac{\gamma_X}{2}(x_t - \bar{x})^2$$

and $\gamma_X > 0$ is a parameter, $x_t \equiv X_t/P_t^C$ and $\bar{x}$ is the corresponding long-run value. This adjustment cost introduces a cost between interest rates on domestic loans and interest on deposits.

One can take the first-order conditions of the above profit maximisation problem with respect to dividends, deposits supply, loans supply and interbank position.

Figure 1
Balance sheet of banks



2.4 PRODUCTION

Tradable and non-tradable goods are produced with a Cobb-Douglas technology using three inputs: physical capital rented from domestic entrepreneurs ($K^D(h)$, $K^D(n)$), domestic labour ($N^D(h)$, $N^D(n)$, each being an aggregate of patient and impatient households labour services) and real estate ($H^D(h)$, $H^D(n)$) also rented from domestic entrepreneurs:

$$Y_t^{S,T} = z_{T,t}(K_t^D)^{\alpha_{KT}}(H_t^D)^{\alpha_{HT}}(N_t^D)^{1-\alpha_{KT}-\alpha_{HT}}, \tag{5}$$

$$Y_t^{S,N} = z_{N,t}(K_t^D)^{\alpha_{KN}}(H_t^D)^{\alpha_{HN}}(N_t^D)^{1-\alpha_{KN}-\alpha_{HN}}, \tag{6}$$

where α_{KT}, α_{KN}, α_{HT}, $\alpha_{HN} > 0$ and $\alpha_{KT} + \alpha_{HT} < 1$, $\alpha_{KN} + \alpha_{HN} < 1$, $z_{T,t}$ and $z_{N,t}$ are sector-specific productivity shocks (they are identical accross firms within a particular sector).

The demand functions for each type of input can be derived from the cost-minimisation problem of the intermediary good firm. In particular, a representative intermediary minimises total production costs subject to the production technologies in equations (5) and (6) taking input prices as given.

2.5 MARKET CLEARING CONDITIONS

Housing market clears in equilibrium:

$$(1 - \omega_J - \omega_E - \omega_B)H_t^I + \omega_J H_t^J + \omega_E H_t^E = \bar{H}$$

where $\bar{H}$ denotes a fixed amount of the housing stock.

Entrepreneurs rent housing to firms producing tradable and non-tradable intermediate goods:

$$H_t^T + H_t^{NT} = \omega_E H_t^E.$$

Bankers supply loans to domestic impatient households and entrepreneurs:

$$\omega_B L_t + \omega_J B_t^J + \omega_E B_t^E = 0.$$

Banks accept deposits from patient households:

$$D_t^{Supply} = (1 - \omega_J - \omega_E - \omega_B)D_t^{Dem}.$$

Home country (Hungary) and EA banks lend to each other:

$$s^H \omega_B^H L_t^{IB,H} + s^{EA} \omega_B^{EA} L_t^{IB,EA} = 0,$$

where s^H and s^{EA} are the size of the home and euro area regions, respectively.

2.6 NET FOREIGN ASSET POSITION AND INTERNATIONAL RELATIVE PRICES

Home holdings of foreign bonds denominated in US dollars evolve according to:

$$B_{US,t} + \frac{L_{IB,t}}{S_t^{H,US}} = B_{US,t-1} R_{t-1}^{US} + \frac{R_{t-1}^{US} L_{IB,t-1}}{S_t^{H,US}} + \frac{TB_t^H}{S_t^{H,US}}.$$

where TB_t^H stands for trade balance and $S_t^{H,US}$ is the nominal exchange rate.

The home trade balance is given by:

$$TB_t^H \equiv \sum_{CO \neq H} \frac{s^{CO}}{s^H} S_t^{H,CO} P_{X,t}^{H,CO} IM_t^{CO,H} - \sum_{CO \neq H} P_{IM,t}^{H,CO} IM_t^{H,CO},$$

where $S_t^{H,CO}$ is bilateral nominal exchange rate of the Home country relative to country CO. $IM_t^{CO,H}$ is Home exports, $IM_t^{H,CO}$ is Home imports.

The aggregate resource constraint can be written as:

$$\begin{aligned} P_{Y,t} Y_t = {} & P_{C,t} C_t + P_{I,t}(I_t + \Gamma_u(u_t) K_t) + P_{G,t} G_t + \sum_{CO \neq H} \frac{s^{CO}}{s^H} S_t^{H,CO} P_{X,t}^{H,CO} IM_t^{CO,H} \\ & - \sum_{CO \neq H} P_{IM,t}^{H,CO} \left(IM_{C,t}^{H,CO} \frac{1 - \Gamma_{IM^C}^{H,CO}(IM_t^{C,CO}/Q_t^C)}{\Gamma_{IM^C}^{H,CO\dagger}(IM_t^{C,CO}/Q_t^C)} \right) \\ & - \sum_{CO \neq H} P_{IM,t}^{H,CO} \left(IM_{I,t}^{H,CO} \frac{1 - \Gamma_{IM^I}^{H,CO}(IM_t^{C,CO}/Q_t^I)}{\Gamma_{IM^I}^{H,CO\dagger}(IM_t^{C,CO}/Q_t^I)} \right), \end{aligned}$$

where G_t is public consumption, $P_{G,t}$ is its price deflator. $I_t = \omega_E I_{E,t}$, $K_t = \omega_E K_{E,t}$.

$\Gamma_{IM^C}^{H,CO}$ is standard adjustment cost on imports and $\Gamma_{IM^C}^{H,CO\dagger}$ is defined as:

$$\Gamma_{IM^C}^{H,CO\dagger} \equiv 1 - \Gamma_{IM^C}^{H,CO}\left(IM_t^{C,CO}/Q_t^C\right) - \left(\Gamma_{IM^C}^{H,CO}\left(IM_t^{C,CO}/Q_t^C\right)\right)' IM_t^C.$$

The aggregate consumption is defined as:

$$C_t^{HU} = \omega_B C_t^{B,HU} \lambda_B + (1 - \omega_J - \omega_E - \omega_B) C_{I,t} + \omega_J C_{J,t} + \omega_E C_t^E, \tag{7}$$

$$C_t^{EA} = \omega_B C_t^{B,EA} + \omega_B C_t^{B,HU}(1 - \lambda_B) + (1 - \omega_J - \omega_E - \omega_B) C_{I,t} + \omega_J C_{J,t} + \omega_E C_t^E, \tag{8}$$

$$C_t^{US/RW} = \omega_B C_t^{B,US/RW} + (1 - \omega_J - \omega_E - \omega_B) C_{I,t} + \omega_J C_{J,t} + \omega_E C_t^E, \tag{9}$$

where

$$C_t^B \equiv div_t^B = \frac{DIV_t^B}{P_t^C}.$$

λ_B is the fraction of domestic banks' profit distributed to contribute to domestic aggregate consumption (HU) and $(1 - \lambda_B)$ is the fraction redistributed to the euro area (EA) for the reason that some commercial banks in Hungary are owned by Euro area banks.

3 Calibration

The calibration of the core of the model without financial frictions follows Békési et al. (2017) who used the so called EAGLE Calibration Help Tool (ECHT) software to calibrate the four blocks of the model. The calibration of model parameters can also be found in Békési et al. (2017). The parameters of the Taylor rule are calibrated in line with the recent study on Hungarian monetary policy Abaligeti et al. (2018). The calibration of the banking sector variables as a percentage of GDP such as the loan-to-GDP ratio to households and entrepreneurs can be found in Table 1. The model produces the deposit-to-GDP ratio endogenously. The excess bank capital-to-loans ratio is roughly five (4.67) according to the financial accounts of commercial banks in Hungary. We find that a positive value of the excess bank capital in Hungary does no jeopardise the equalisation of risk-free rates across the four model blocks. In the absence of data the excess bank capital-to-loans ratio is set to zero for the other blocks.

The parameters related to the financial sector can be found in Table 2. The loan-to-value ratio for impatient household is calibrated on the basis of the regular reports of financial institutions to the MNB. The loan-to-income ratios are based on Hungarian loan-level data for new loans disbursed from 2012. We have no data available for the other three regions. We note that standard aggregate debt-to-income measures are inappropriate as they are calculated for the whole population instead of the indebted population. Due to lack of data the LTV ratio for physical capital and housing in the case of entrepreneurs is set to the corresponding values in Bokan et al. (2018).The share of banks, impatient households and entrepreneurs in the whole population follows Bokan et al. (2018). The adjustment cost on the dynamic relationships in the banking sector such as loan and deposit adjustment costs follow Bokan et al. (2018). Importantly, impatient households and entrepreneurs face a cost when adjusting their loan. Banks have to pay a cost when adjusting the excess bank capital and interbank capital positions.

4 Experiments

4.1 AN PERMANENT INCREASE IN CAPITAL REQUIREMENTS IN THE EUROZONE

On Figure 2-5 we study a permanent two percentage points increase in the capital requirement in the eurozone. The shock to capital requirements in the eurozone is meant to study spillovers from the eurozone to Hungary. In this experiment there is no excess capital over the regulatory minimum in any regions to examine the possible maximum of spillover effects in the model. Holding free capital buffers would mean that an unexpected increase in macroprudential capital requirements have reduced negative effects on bank lending because free capital buffer allows banks to reduce credit by less.

The model includes interbank lending between Hungary and the eurozone. The interbank market is introduced in simple fashion into the model. If either of the two regions is a borrower then the other region must be the lender and the equilibrium on the interbank market is achieved by one particular interest rate which is the interbank rate. One can see a contraction in interbank lending meaning that Hungary borrows more. The eurozone has larger impact on the interbank interest rate due to its greater size relative to Hungary. Overall we find that the impulse responses of a number of variables exhibit similar responses to those in Bokan et al. (2018). In particular, the increase in capital requirement generates a decline in interbank lending and a rise in interbank in interest rate consistent with the findings of Bokan et al. (2018). It is of interest to point out that the interbank market in our model behave similar to the one in Bokan et al. (2018) only when the transaction cost on interbank lending is somewhat higher in our model.

We plot two cases to examine the importance of interbank market in the model. In one case there is interbank market between Hungary and the eurozone. In the second case there is no interbank market. We find that the introduction of the interbank market (black dashed line for Hungary and red dashed line for the eurozone) has negligible effects on our results. Shocks emerging in the eurozone have moderate spillover effects on the variables of Hungary (see black lines) due to the fact that in the model euro area banks do not operate abroad and, therefore, the only spillover channel is restricted to international trade which has little impact on domestic variables.

Figure 2 shows the effect of greater capital requirements on banking sector related variables. Eurozone banks decrease lending and, thus, the scarcity of loans is associated with an increase in the interest rate on domestic loans. The model emphasizes the financial intermediary role of banks where banks can issue more loans if they accept more deposits. Hence, the contraction in loan demand implies a reduction in deposits.

Figure 3 exhibits that greater capital requirements reduce the borrowing of impatient households as well as entrepreneurs. They also reduce their demand for housing services. The greater supply of housing which is not offset by the rise in the housing demand of patient households leads to a sharp reduction in the house price.

Figure 4 provides how tighter credit conditions impact real macro variables. One can observe that GDP, aggregate consumption, investment, exports and imports decline. The appreciation of the real exchange rate supports the decline in exports. Figure 4 also reveals that the increase in the capital requirements in the eurozone has strong negative spillover effects on the exports and imports of Hungary even though this is not much reflected in aggregate output and consumption. The real exchange rate in Hungary appreciates when accounting for the spillovers. Due to the relatively large size of the eurozone among the four country blocks the increase in the capital requirements in the eurozone will have strong spillover effects on Hungary through trade connection.[2] In particular, the reduction of import demand in the eurozone has negative effect on the net export in Hungary.

Figure 5 offers a detailed picture of the components of aggregate consumption. One can see that the reduction in aggregate consumption is mainly borne out by the reduction in the consumption of impatient households and entrepreneurs which decline

[2] The most significant trade partners of Hungary are located in the eurozone.

more than the consumption of patient ones. The regulatory change also implies deflation which results in a decline of the nominal interest rate through the Taylor rule provided that the response to the output gap which also turns negative is small. Figure 5 also contains the variables related to the labour market. Real wages as well as the labour supplies of both patient and impatient households plummet in line with the fall in their consumption demand.

4.2 AN INCREASE IN CAPITAL REQUIREMENT IN HUNGARY AND THE EURO AREA

On Figures 6-9 we assess a two percentage points rise in capital requirements either only in Hungary (called 1 shock in the figure, capital requirement increases from 12.3 per cent to 14 per cent, the shock should be interpreted as the introduction of macroprudential capital requirements over SREP requirements.) or in both Hungary and the eurozone (denoted as 2 shocks). In these experiments we assume that banks in Hungary hold excess capital consistent with Hungarian banking sector data while it is held at zero for the remaining three regions due to lack of data[3]. Holding free capital buffer implies that an unexpected increase in macroprudential capital requirements have slightly reduced negative effects on bank lending because free capital buffer allows banks to reduce credit by less.

Our findings are well in line with those described in the previous section. The only difference now that besides the spillover effects from the eurozone there are direct effects associated with the rise in capital requirements in Hungary.

When there is only shock to Hungary there is huge decline in domestic loans which have to be followed by a fall in deposits (the model is based on the loanable funds view of banking where less lending is consistent with less deposits) and interbank lending changes to small extent. Figure 6 shows that higher capital requirements are consistent with a higher level of capital in the eurozone than in Hungary. Capital levels do not have to rise as much in Hungary to satisfy higher regulatory capital levels when there is an simultaneous and equal increase in capital requirements in both regions. The latter is due to the difference in the original levels and also the reaction of loans (domestic and interbank) in the two regions. In particular, domestic loans in the eurozone contract more than in Hungary. In line with reaction of domestic and interbank loans the bank capital has to increase by less when there are higher bank capital requirements in both regions. In this sense we can say that the higher capital requirements in the eurozone have positive spillover effects on Hungary. However, entrepreneurs' borrowing declines more due to the spillover effects. There is marked difference in the borrowing of impatient households across the 1 and 2 shocks cases. For other variables such as the borrowing of impatient households and entrepreneurs as well as the consumption there is less difference between the 1 and 2 shock case. These impulse responses are also consistent with the findings of Bokan et al. (2018).

Shocks emerging in Hungary have negligible or zero spillover effects on the variables of the eurozone (see red dashed lines) due to the miniscule size of Hungary (0.0028) among the four blocks.

4.3 A PERMANENT DECREASE IN LOAN-TO-VALUE RATIO FOR HOUSEHOLDS IN HUNGARY

Figure 10-13 show a permanent one percentage point decrease in the average loan-to-value ratio of impatient households and entrepreneurs. The shock can alternatively be interpreted as a change in the lending standards of commercial banks. Dashed lines on the figures correspond to a lower ratio of impatient households as a sensitivity check ($\omega_J = 0.3$ instead of 0.5, 'omegaimp' on figures). The shock has zero persistence but permanent and, therefore, the transition from the initial steady-state to the new steady-state is imminent. Impatient households can pledge housing like entrepreneurs. In the case of entrepreneurs we assume that the loan-to-value ratio for physical capital and housing is reduced to the same extent. A regulatory change leading to the reduction in the loan-to-value ratio implies that less loans can be taken for given value of the collateral.

For given asset prices more restrictive lending standards induce households to take up less loans which is followed by a reduction in deposits. The latter is due to the fact our modelling framework allows for more loans if more deposits are guaranteed. The

[3] Note that we explored whether free capital buffers (positive excess capital) has impact on our results but found negligible effects (these experiments are not reported in the paper but available upon request).

shortfall in lending reduces the consumption and housing demand of impatient households and leading to a decline in the price of physical capital and housing. The fall in credit demand leads to small decline in the interest rate on loans. Importantly the decline in asset prices reduces the collateral value of housing and capital. Hence, the decline in asset prices will induce further reduction of credit demand for given lending standards and facilitate an appreciation of the real exchange rate and, thus, a fall in export. Less consumption, investment and exports leads to lower output.

The figures also display robustness checks for the share of impatient households. Clearly, a lower share of impatient households (black dashed line) imply smaller effects of the LTV regulation for the simple reason that the LTV regulation impacts the borrowing constraint of impatient households. A lower share of impatient households imply smaller decrease in bank-related such as domestic and interbank lending as well as real variables such as consumption and output. The impulse responses of most variables exhibit a hump-shape and is similar to the those in Bokan et al. (2018). In contrast to the previous experiment – a raise in capital requirements – the decline in the LTV reduces the interbank interest rate. For instance, figure 11 shows that a smaller share of impatient households lead to less change in patient and impatient consumption, housing, labor and real wages. The red solid and dashed lines indicate that the spillover effects of the macroprudential policy changes in Hungary on the eurozone are virtually zero in line with our expectations.

It is necessary to discuss why a restriction in LTV regulation has stronger real effects than a rise in capital requirements. The LTV regulation has direct effect on the consumption of indebted households and, hence, on aggregate consumption. The capital regulation has no direct effect on real variables, however. Following a rise in capital requirements the bank decreases lending as well as accepting fewer deposits. Deposits are held by savers who can smooth their consumption by risk-free bonds as well and, therefore, a reduction in deposits will not have significant effect on the behaviour of savers as well as on aggregate consumption. The profit of banks has direct impact on aggregate consumption. The LTV regulation has stronger effects on the lending and deposit policy of banks and, hence, has greater impact on the profitability of banks as well as aggregate consumption.

4.4 A PERMANENT DECREASE IN LOAN-TO-INCOME RATIO FOR HOUSEHOLDS IN HUNGARY

Figures 14-17 exhibit the effects of a one percentage point reduction in the loan-to-income ratio of impatient households in Hungary. The decrease in the loan-to-income ratio reduces the maximum amount of loans that can be taken by the borrower household and the entrepreneur against future value of the collateral. Figure 14 shows that the amount of domestic loans decrease leading to the decline in the domestic lending rate. Indeed, figure 14 tells us that the impatient households and entrepreneurs borrow less, reduce their demand for housing and causing a decline in house prices. The permanent reduction in the loan-to-income ratio results in lower consumption of Ricardian and non-Ricardian households. Further, the tightening of households' borrowing constraint reduces the build-up of excess capacities in the economy in terms of aggregate output and hours worked. Investment also declines. There is also a slight decrease in the real wages of the two types of households (patient and impatient) as well as the aggregate real wage. As the policy has negative effect on households' spending and real wages inflation declines.

5 Conclusion

We have studied the effects of macroprudential policies in Hungary as well as the eurozone. In particular, we examined the effects of an increase in regulatory capital requirements (with or without additional capital buffers), a reduction in the loan-to-value ratio of households and entrepreneurs and a decrease in loan-to-income ratio of borrower households. We also considered the effects of the inclusion of an interbank lending channel in the model and found that it has moderate effects on domestic macroeconomic aggregates. We show that macroprudential policies of the eurozone have moderate spillover effects on Hungary. In particular, we find that an increase in capital requirements in both Hungary and the eurozone requires lower accumulation of bank capital relative to the case when there are higher capital requirements only in Hungary.

We find that a rise in capital requirement has negligible negative short-run effects of about -0.01 per cent and small but non-negligible long run effects (around -0.015) on GDP. In terms of lending, capital requirements lead to a reduction of 0.2 per cent over a year while 0.15 in the long run. In contrast stricter lending standards induce 2.3 per cent decline in domestic lending in the short and about 2 per cent in the long run. The latter has stronger negative effects on the GDP (about -0.4 per cent) relative to capital requirements on the short run with almost zero effects on the long-run.

Our future research will introduce cross-border lending between the euro area and Hungary which could make the foreign ownership in the Hungarian banking system more plausible than the current setup. Cross-border lending would also generate more realistic spillovers of macroprudential policies. Regarding macroprudential interventions, we could include features that would allow for monitoring the probability of default on loans taken by households. Estimating such a complex model is extremely challenging and we leave it for research in the future.

6 Tables and figures

Table 1
Steady-state financial accounts as fraction of annual GDP, %

	HU	EA	US	RW
Loans	32	119	148	146
Loans to households	16	61	90	76
Loans to entrepreneurs	16	58	58	70
Interbank	4.41	0.00	n.a.	n.a.
Deposits	26.5	109	137	134
Excess bank capital/loans	4.67	0.00	0.00	0.00

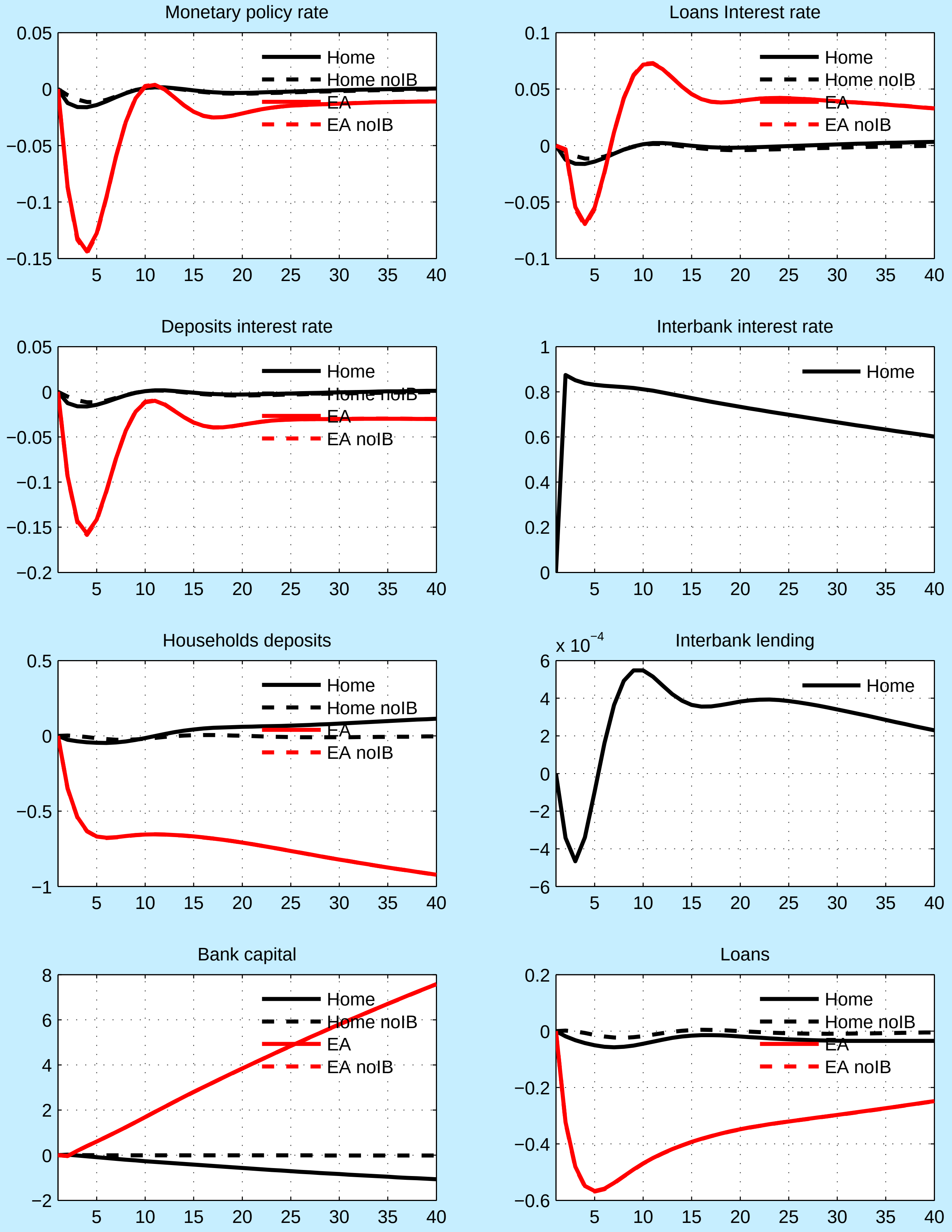
Notes: HU, EA, US, RW denote Hungary, eurozone, United States and the rest of the world, respectively.
Excess bank capital is in percentage of total loans.

Table 2
Financial and bank parameters

	HU	EA	US	RW
Discount factor (β)	0.99	0.99	0.99	0.99
Households LTV ratio (V_J)	0.63	0.7	0.7	0.7
Households LTI ratio (LTI_J)	1.6	1.6	1.6	1.6
Entrepreneurs LTV ratio (V_{H_E})	0.7	0.7	0.7	0.7
Entrepreneurs LTV ratio (V_{K_E})	0.3	0.3	0.3	0.3
HHs Loans smoothing (ρ_{B_J})	0.3	0.3	0.3	0.3
Entrepreneurs Loans smoothing (ρ_{B_E})	0.4	0.4	0.4	0.4
Capital Requirement (Υ^K)	0.123	0.08	0.08	0.08
Banks discount factor (β_B)	$1.03^{-\frac{1}{4}}$	$1.03^{-\frac{1}{4}}$	$1.03^{-\frac{1}{4}}$	$1.03^{-\frac{1}{4}}$
Banks share in population (ω_B)	0.10	0.10	0.10	0.10
Adjustment costs				
Deposits (γ_{DH})	0.0001	0.0001	0.0001	0.0001
Excess bank capital (γ_X)	0.001	0.001	0.001	0.001
Interbank capital (γ_{IB})	10	n.a.	n.a.	n.a.
Loans–banks (γ_L)	1.5	1.5	1.5	1.5
Loans–impatient HHs (γ^{BJ})	1.5	1.5	1.5	1.5
Loans–entrepreneurs (γ^{BE})	1.5	1.5	1.5	1.5

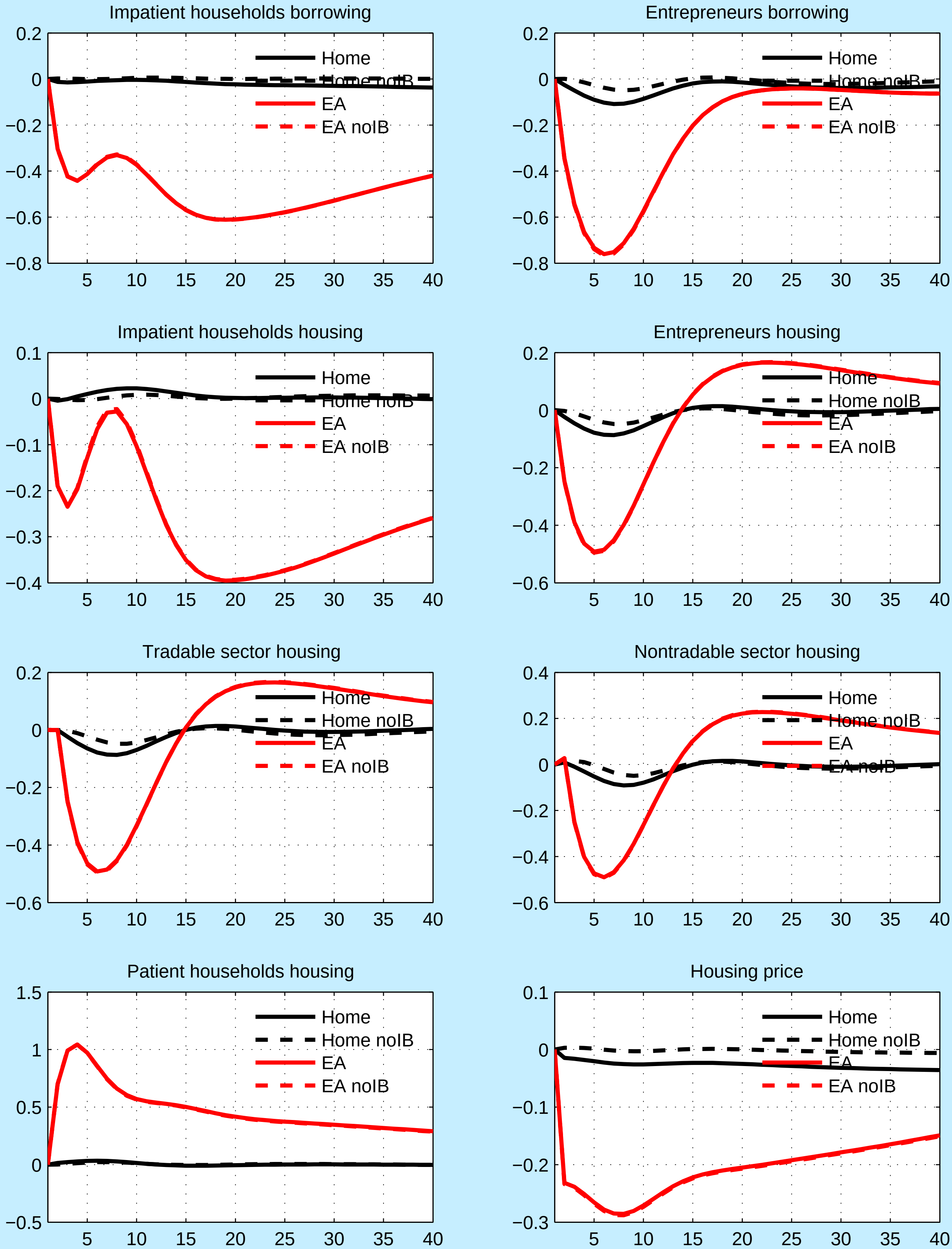
Notes: HU, EA, US, RW denote Hungary, eurozone, United States and the rest of the world, respectively.

Figure 2
Increase in euro area capital requirements – Bank variables



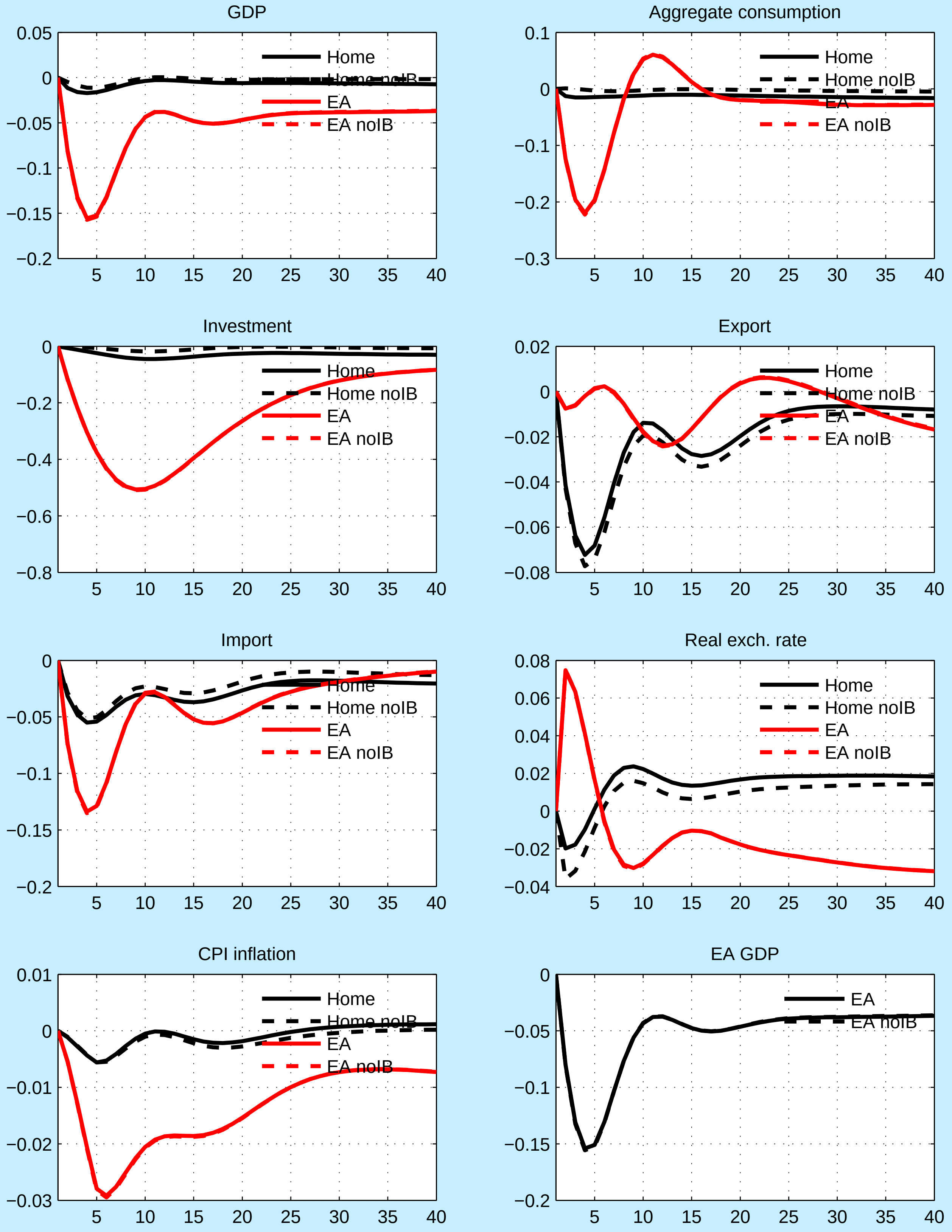
Horizontal axis: quarters. Vertical axis: percentage deviations from steady state. In case of interest rates: percentage point deviations. Interbank lending is in percentage-point deviation to Home GDP.

Figure 3
Increase in euro area capital requirements – Borrowing and housing



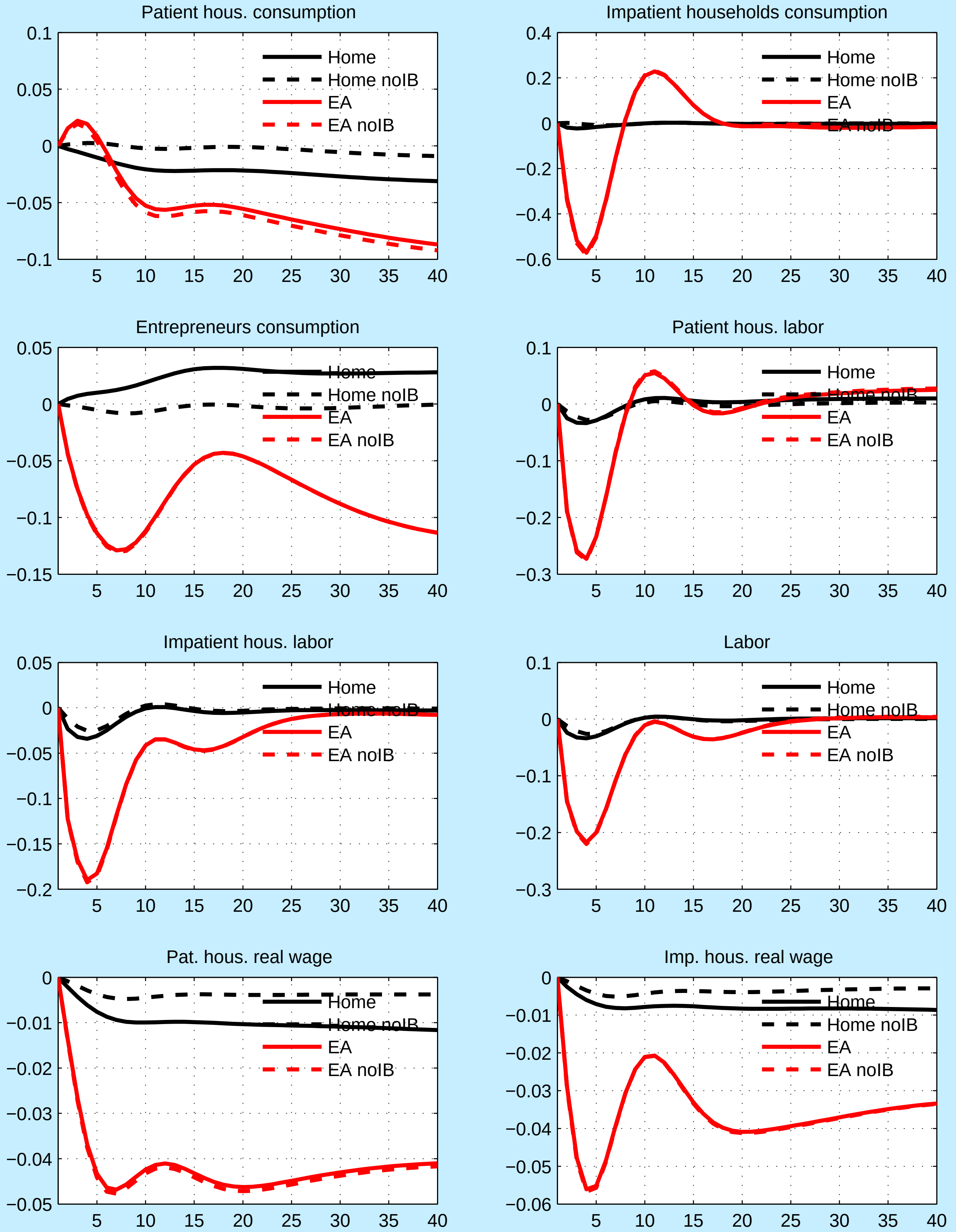
Horizontal axis: quarters. Vertical axis: percentage deviations from steady state.

Figure 4
Increase in euro area capital requirements – Macro variables



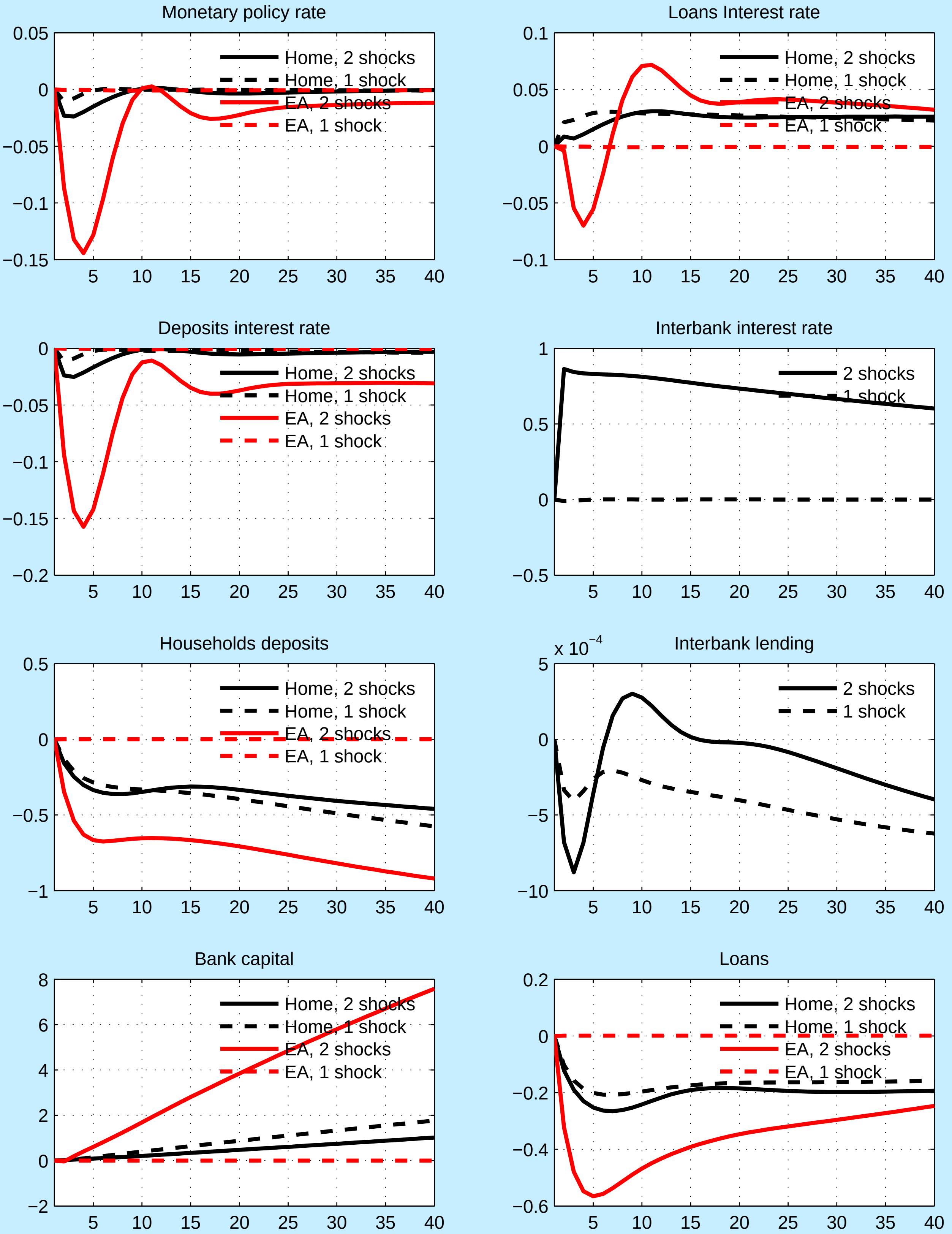
Horizontal axis: quarters. Vertical axis: percentage deviations from steady state. Inflation is percentage-point deviation from steady state.

Figure 5
Increase in euro area capital requirements – Consumption and labour



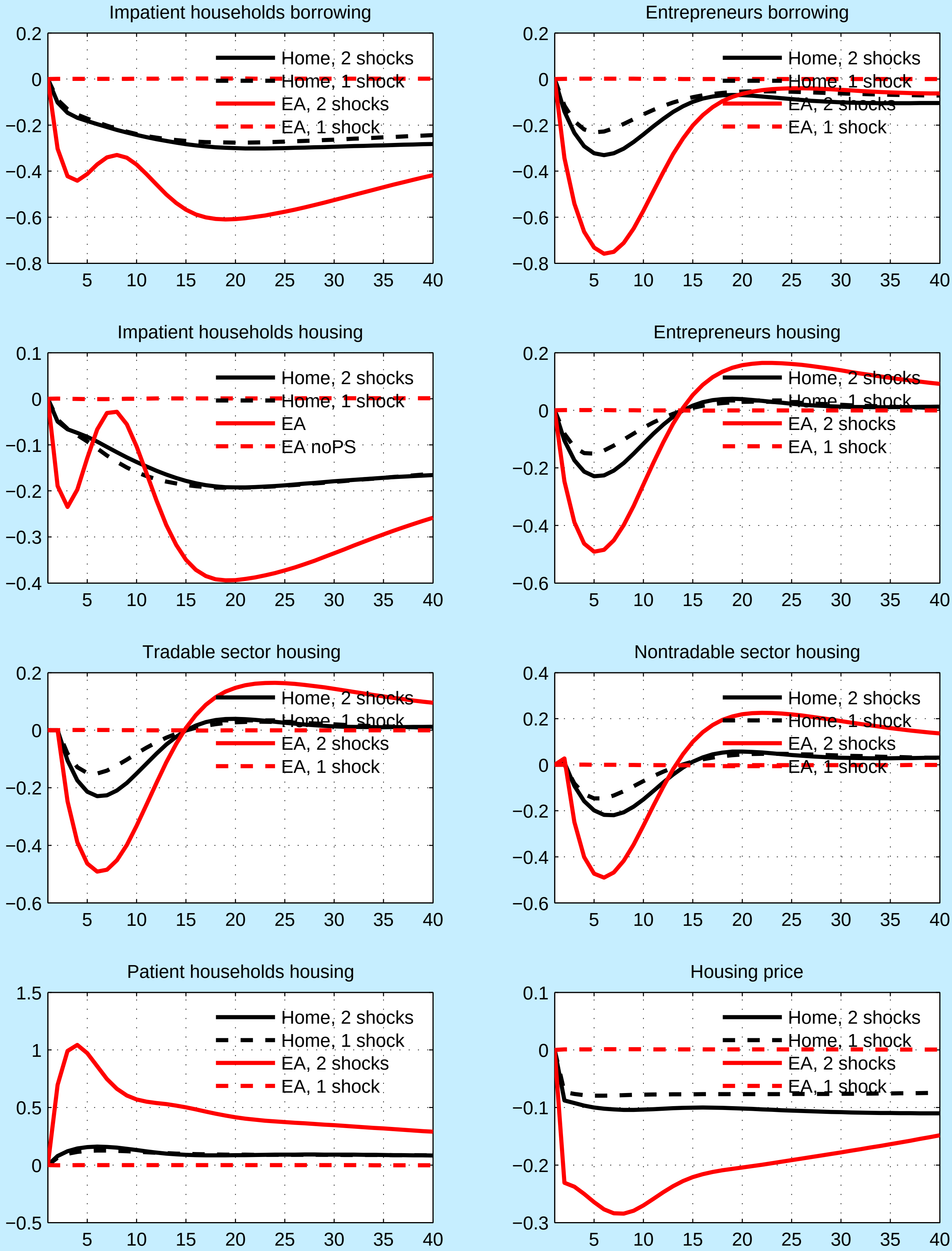
Horizontal axis: quarters. Vertical axis: percentage deviations from steady state.

Figure 6
Increase in EA and HU capital requirements – Bank variables



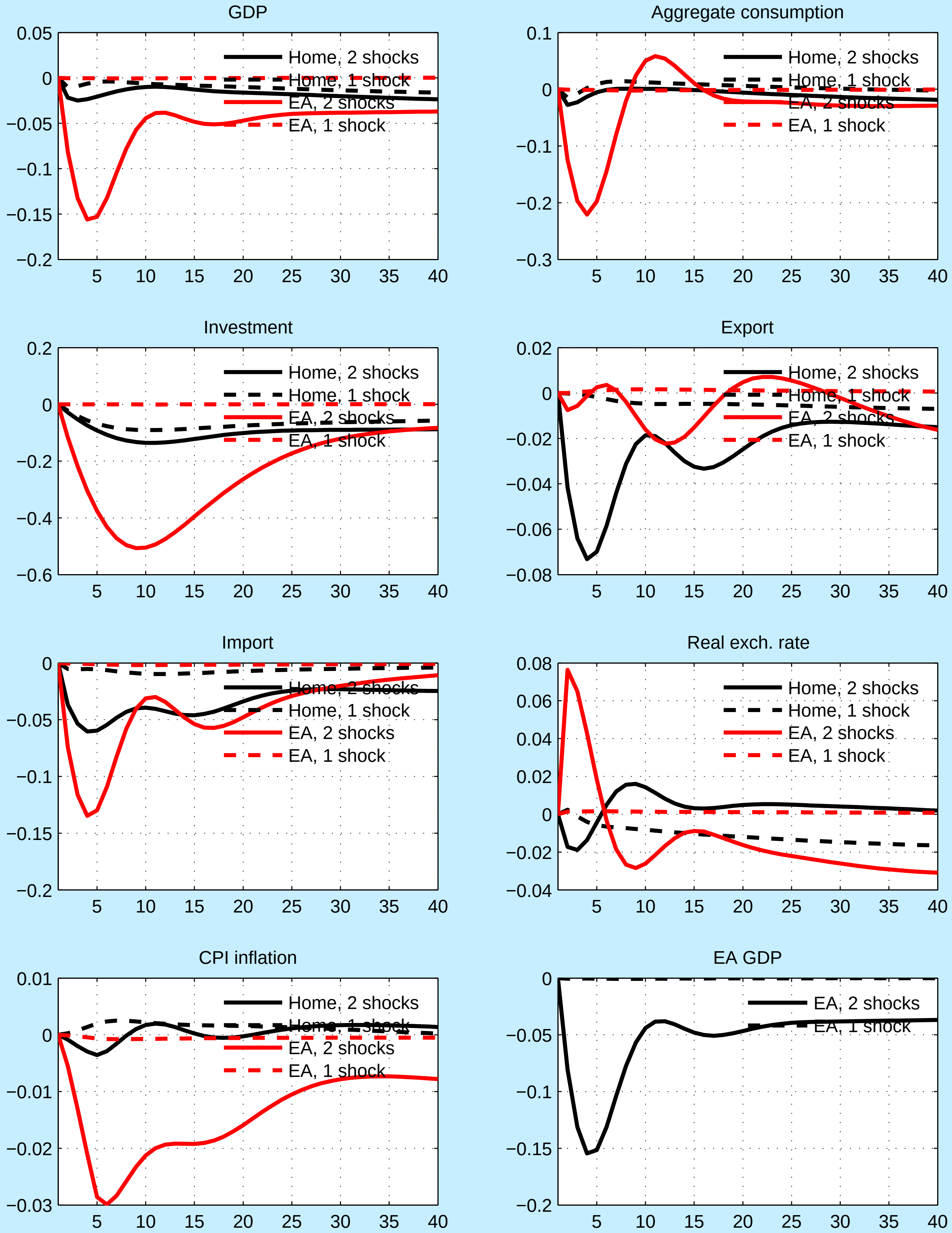
Horizontal axis: quarters. Vertical axis: percentage deviations from steady state. In case of interest rates: percentage point deviations. Interbank lending is in percentage-point deviation to Home GDP.

Figure 7
Increase in EA and HU capital requirements – Borrowing and housing



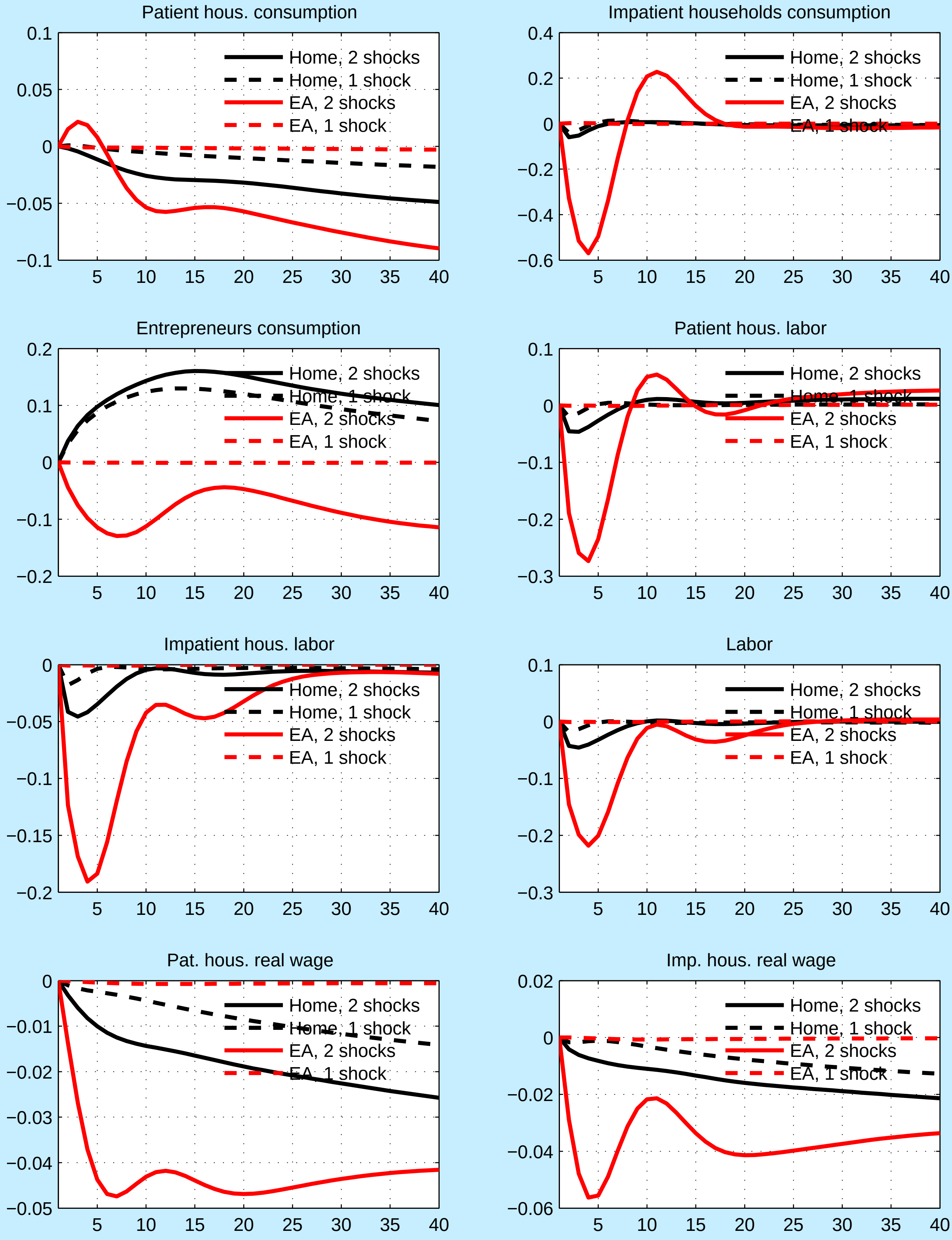
Horizontal axis: quarters. Vertical axis: percentage deviations from steady state.

Figure 8
Increase in EA and HU capital requirements – Macro variables



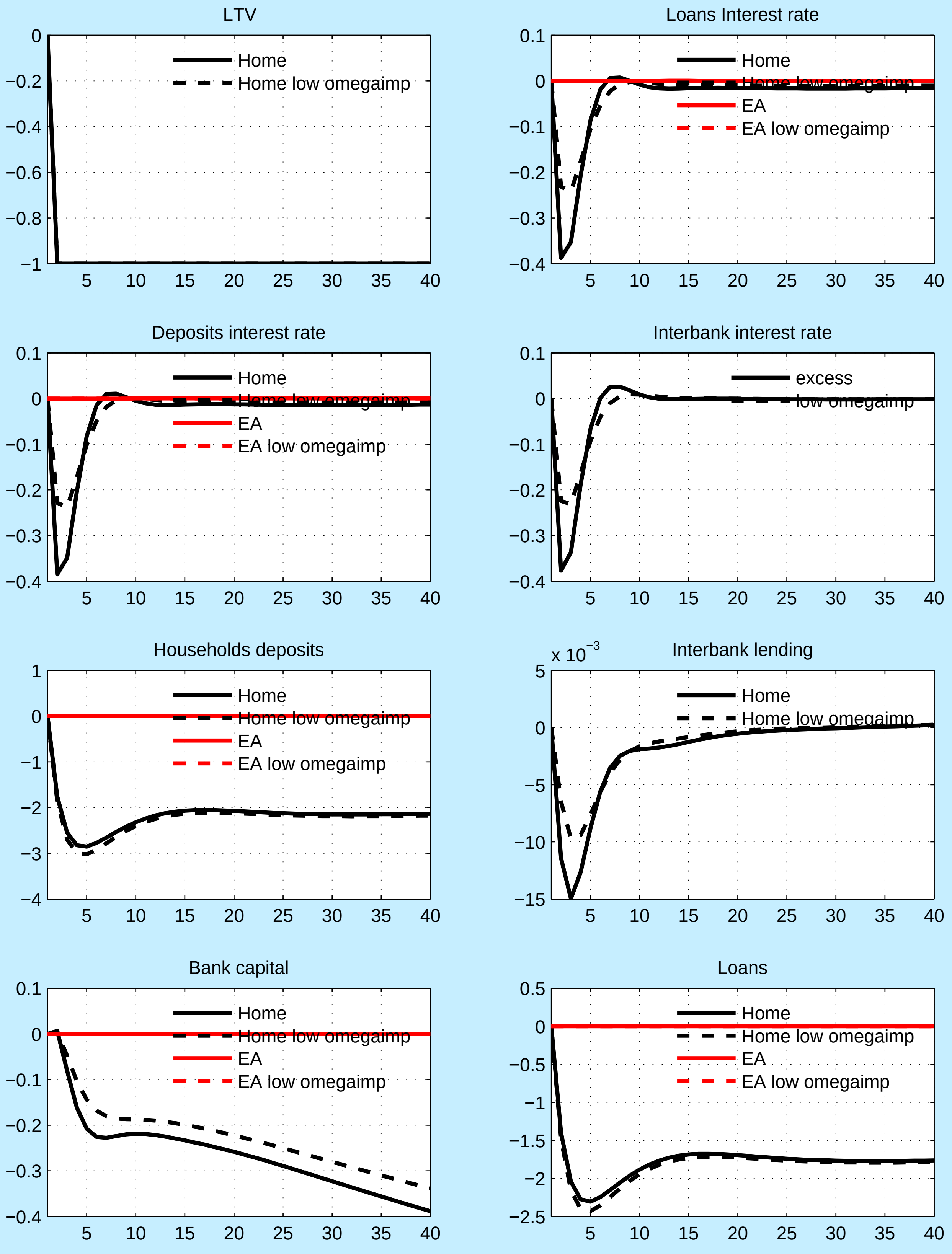
Horizontal axis: quarters. Vertical axis: percentage deviations from steady state. Inflation is percentage-point deviation from steady state.

Figure 9
Increase in EA and HU capital requirements – Consumption and labour



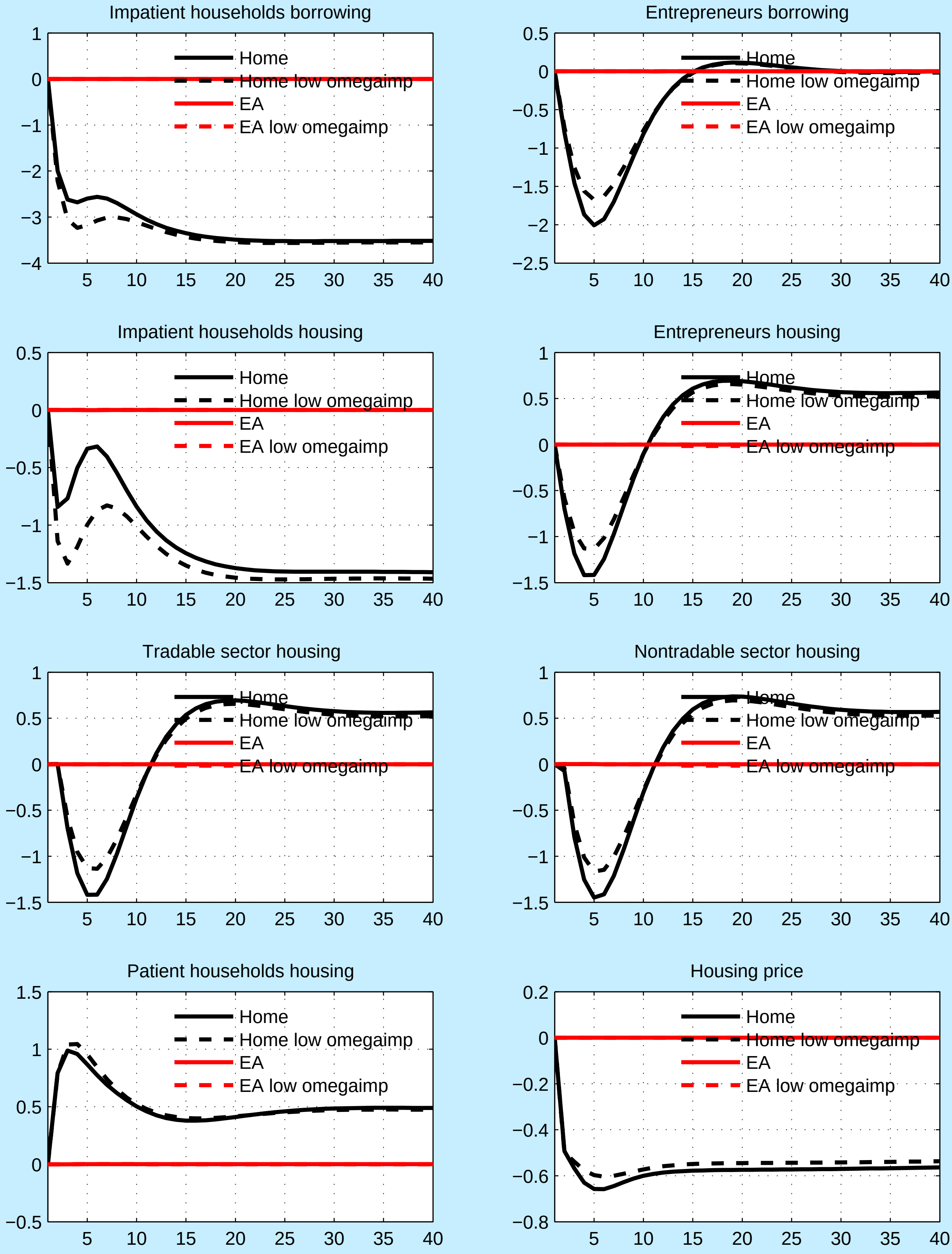
Horizontal axis: quarters. Vertical axis: percentage deviations from steady state.

Figure 10
Decrease in HU LTV ratio – Bank variables



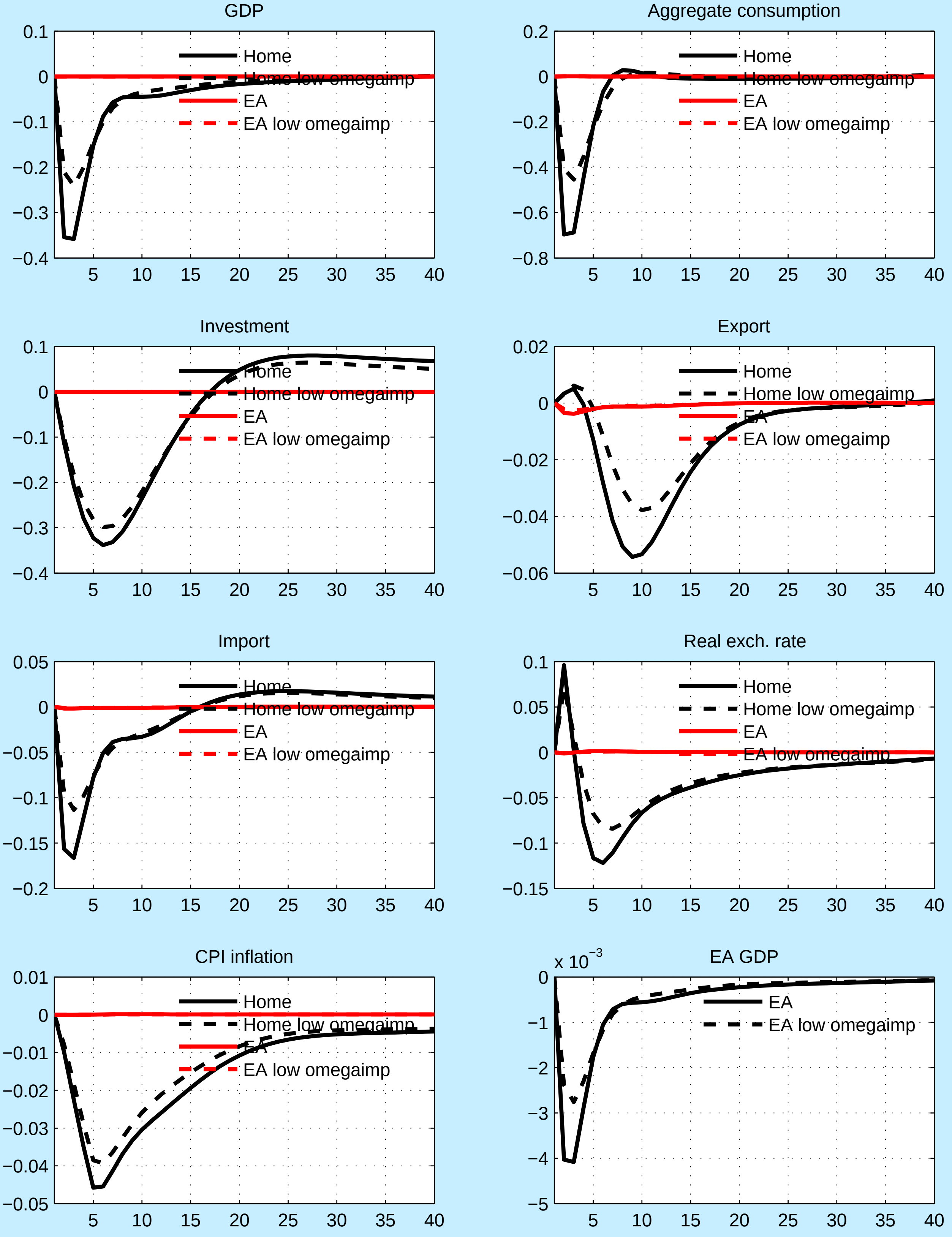
Horizontal axis: quarters. Vertical axis: percentage deviations from steady state. In case of interest rates: percentage point deviations. Interbank lending is in percentage-point deviation to Home GDP.

Figure 11
Decrease in HU LTV ratio – Borrowing and housing



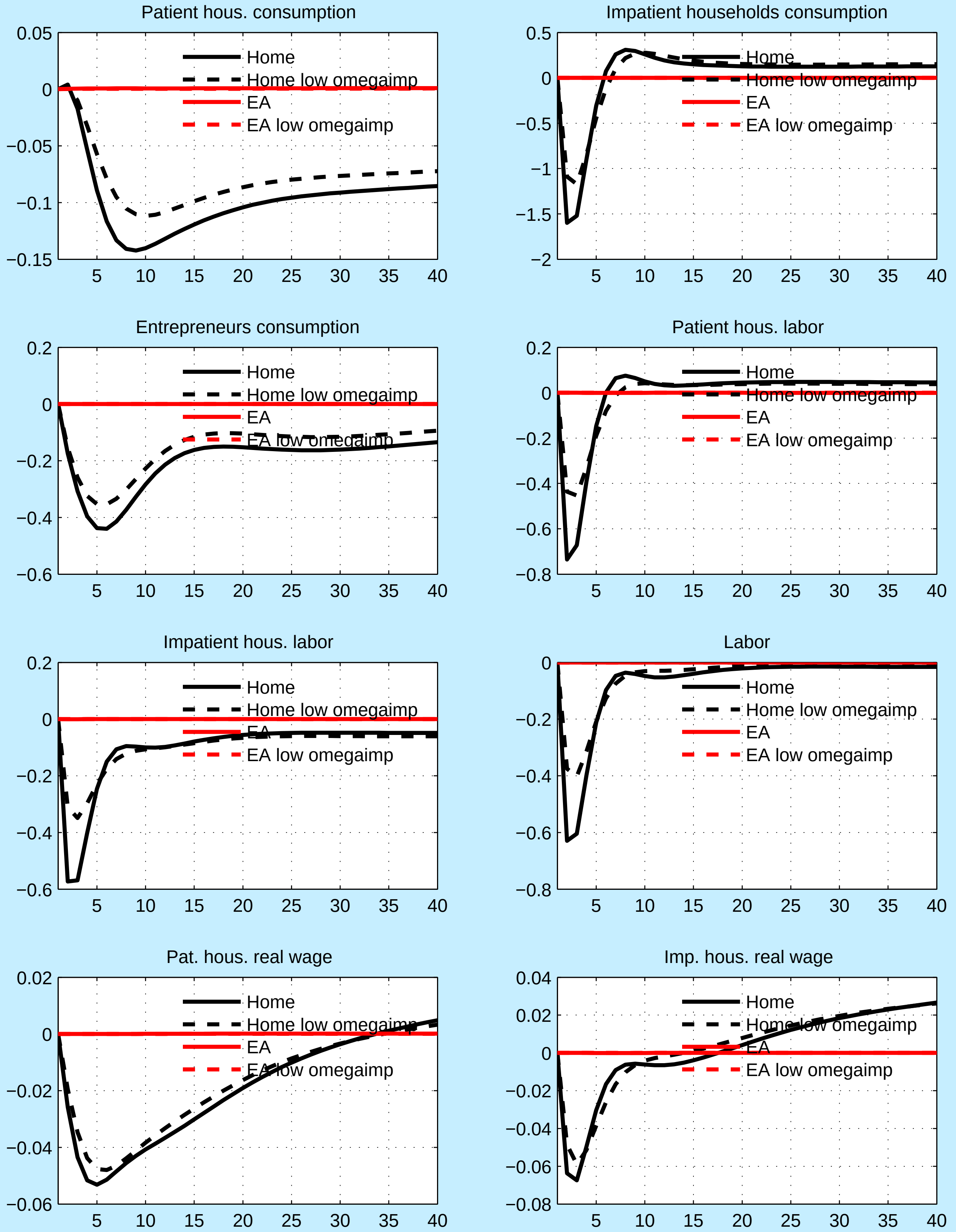
Horizontal axis: quarters. Vertical axis: percentage deviations from steady state.

Figure 12
Decrease in HU LTV ratio – Macro variables



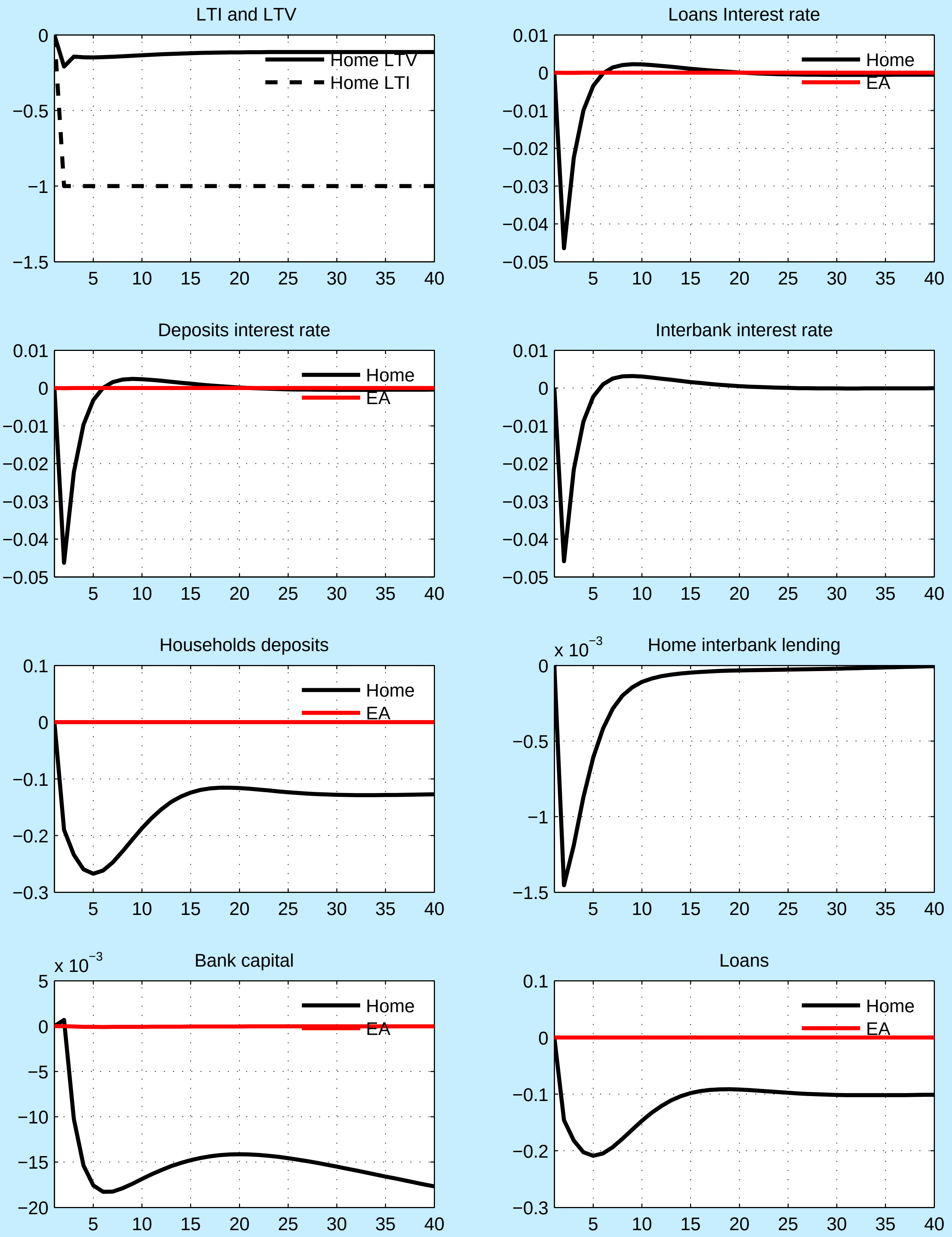
Horizontal axis: quarters. Vertical axis: percentage deviations from steady state. Inflation is percentage-point deviation from steady state.

Figure 13
Decrease in HU LTV ratio – Consumption and labour



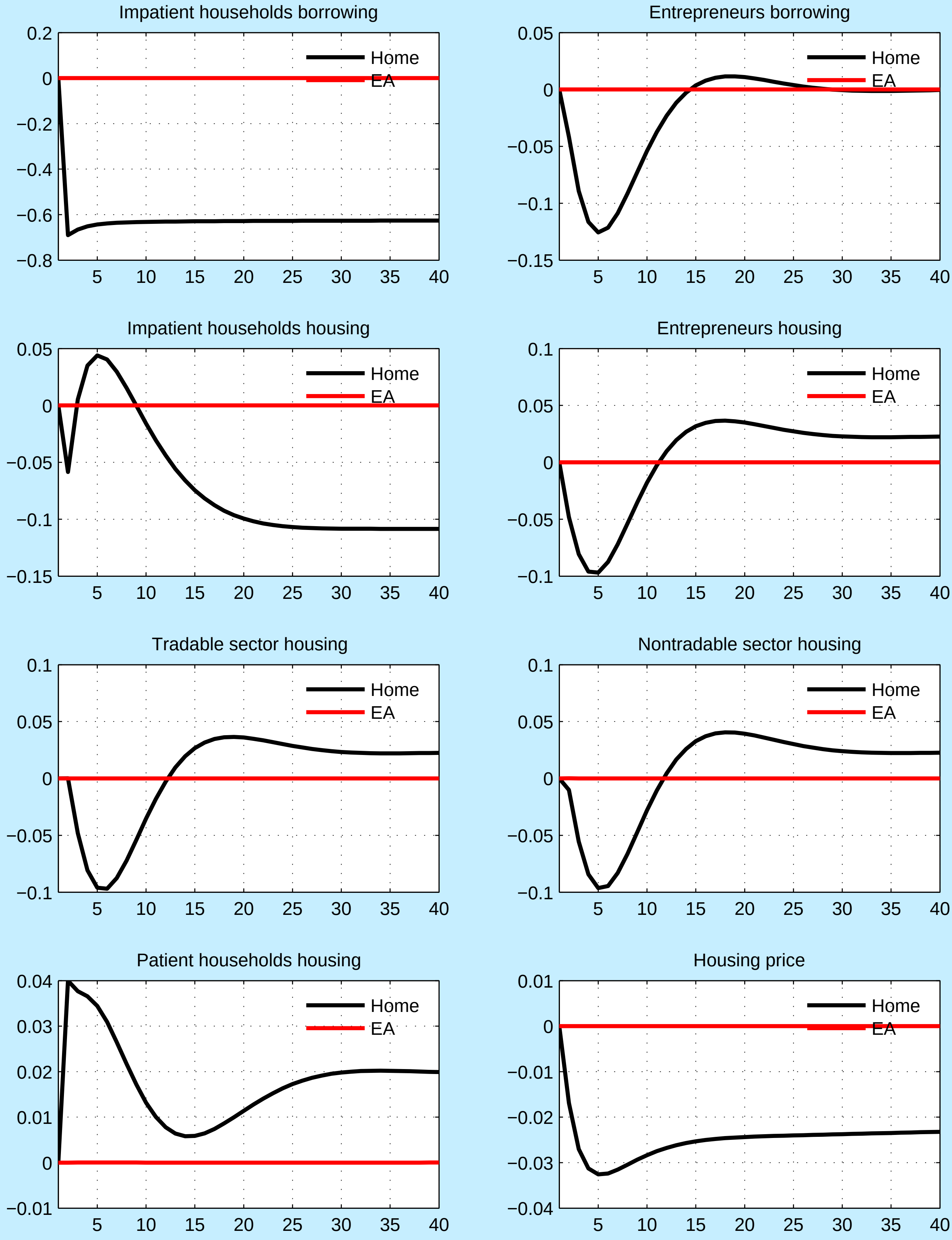
Horizontal axis: quarters. Vertical axis: percentage deviations from steady state.

Figure 14
Decrease in HU LTI ratio – Bank variables



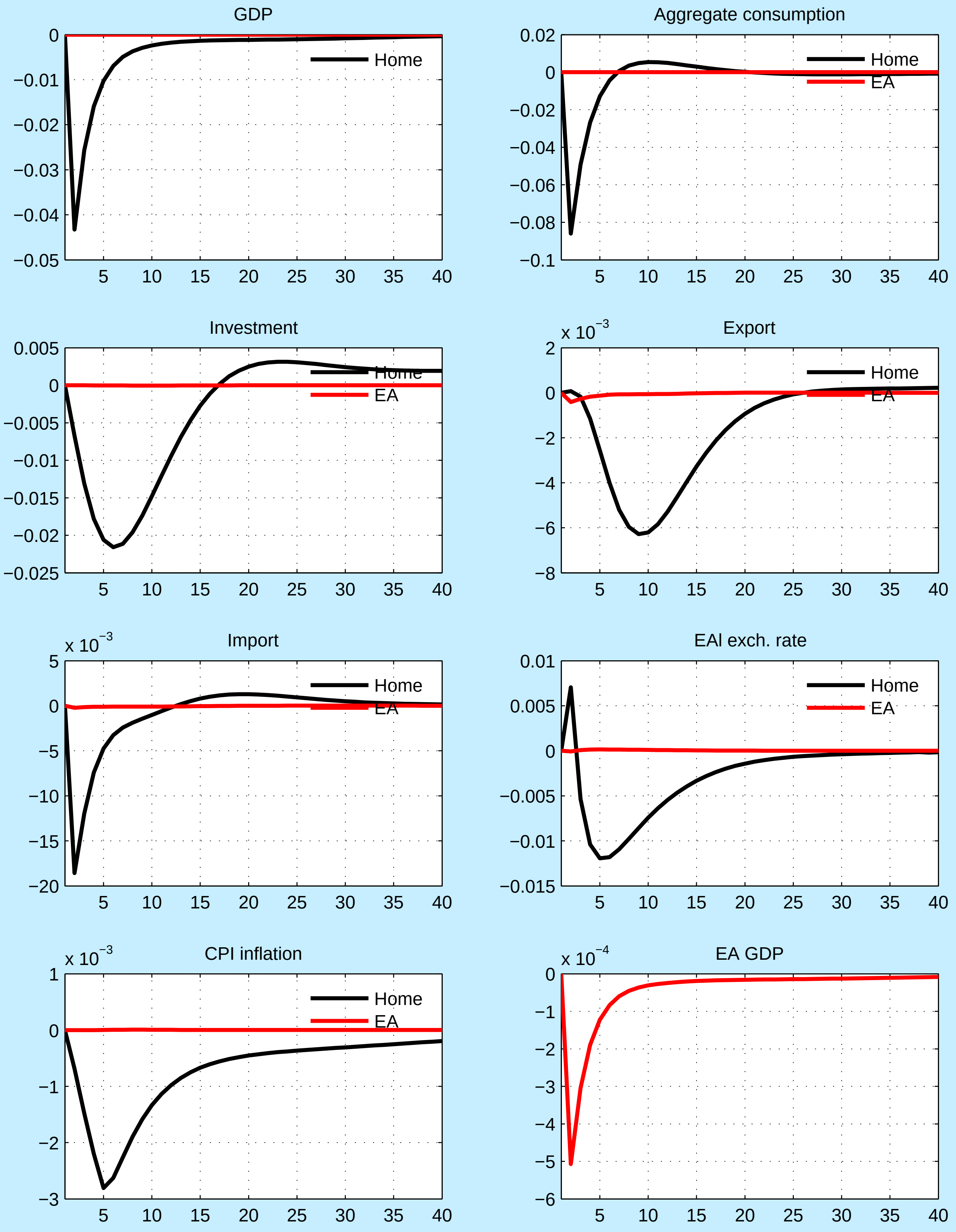
Horizontal axis: quarters. Vertical axis: percentage deviations from steady state. In case of interest rates: percentage point deviations. Interbank lending is in percentage-point deviation to Home GDP.

Figure 15
Decrease in HU LTI ratio – Borrowing and housing



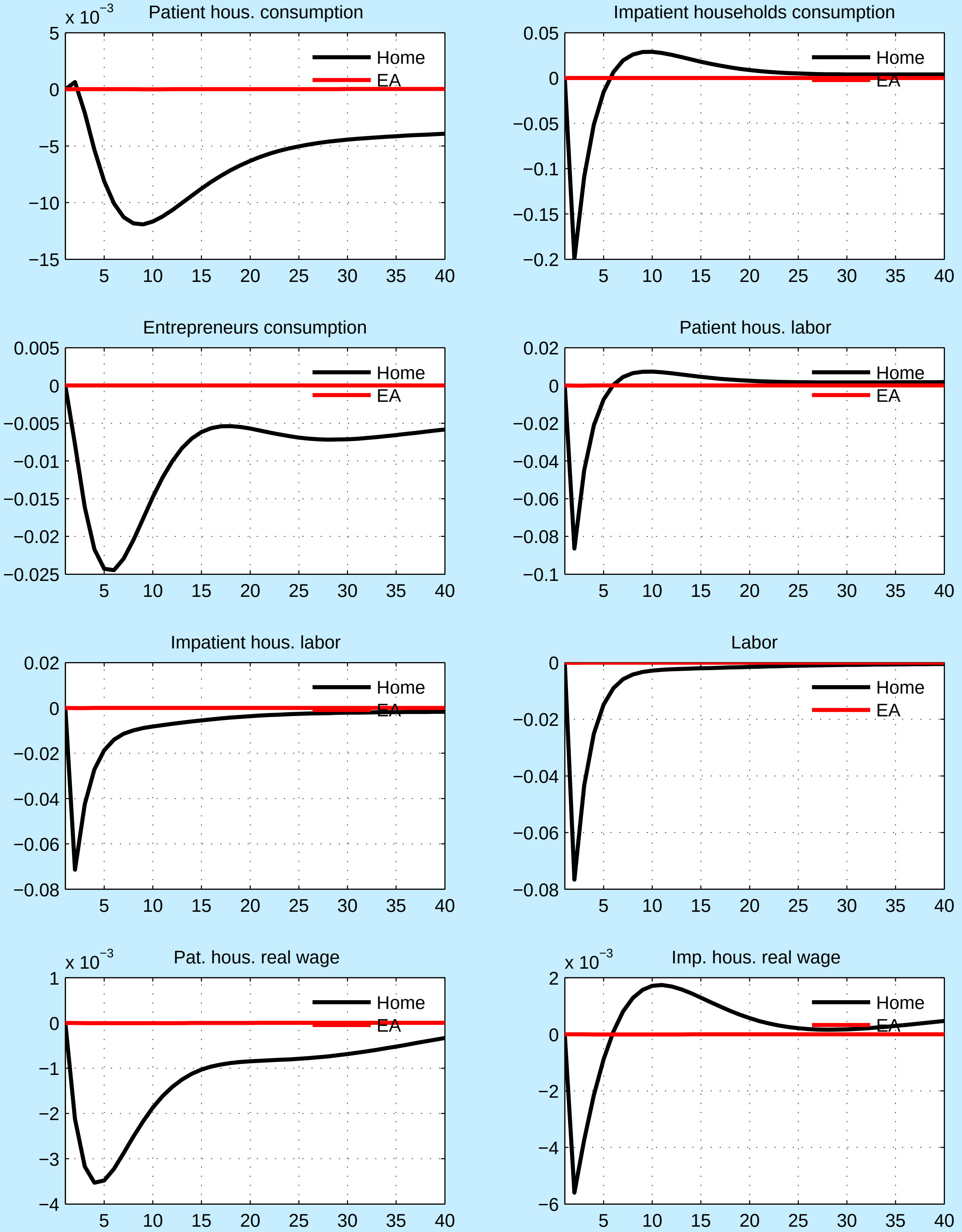
Horizontal axis: quarters. Vertical axis: percentage deviations from steady state.

Figure 16
Decrease in HU LTI ratio – Macro variables



Horizontal axis: quarters. Vertical axis: percentage deviations from steady state. Inflation is percentage-point deviation from steady state.

Figure 17
Decrease in HU LTI ratio – Consumption and labour



Horizontal axis: quarters. Vertical axis: percentage deviations from steady state.

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