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External Shocks and Monetary Policy Trade-offs in Low-Income Countries

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ABSTRACT: We present an Open Economy HANK model with relevant features for Low-Income Countries (LICs): hand-to-mouth households and a subsistence consumption for tradable goods. With the model calibrated for a representative LIC, we illustrate our broader framework with a shock to external prices. The shock causes a consumption-led recession, an increase in inflation and a drop in real wages. Consumption inequality rises: poor households cannot insure against the shock, unlike richer households who can tap into their wealth. Monetary policy is unable to substantively improve poorer households' welfare, due to offsetting effects on real wages and labor demand. Simulations of the effects of alternative monetary policy responses on inequality yield similar findings. In this setting, fiscal transfers are a more effective tool for redistribution across households.

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WORKING PAPERS

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1 Introduction

A significant proportion of low-income households in developing countries rely heavily on imported food items. The COVID-19 pandemic and the Russian invasion of Ukraine caused a terms of trade shock that drove up food prices, presenting central banks in these countries with challenging trade-offs. A key trade-off is stabilizing inflation while supporting household employment that enables income generation for purchasing essential subsistence goods. In countries with substantial income disparities, this trade-off is particularly stark due to distributional concerns. Well-intended aggressive monetary tightening to tame inflation might depress employment, and hurt the exact households that it is trying to protect. As external shocks become more frequent and intense in an environment of heightened geopolitical risks, rising fragmentation and climate change, finding the optimal policy response will become ever more important for developing countries.

An extensive literature on monetary policy has developed frameworks to understand optimal responses to terms of trade and other shocks. However, most models do not account for the heterogeneity in income and wealth, pervasive in low-income countries (LICs). A framework that incorporates this heterogeneity is needed to understand how monetary policy affects the welfare of households at the lower end of the income distribution. The main goal of our paper is to build such a framework with rich household heterogeneity in order to analyze alternative monetary policy responses to price shocks. We find that adverse terms of trade shocks affect households at the lower end of the income distribution disproportionately. We show that most monetary policy rules are not able to improve the welfare of these agents by much. While our focus is on terms of trade shocks, motivated by the experience during the COVID-19 pandemic and war in Ukraine, our model can be used to analyze other shocks affecting small open economies, such as shocks to risk premia, capital flows and productivity.

We begin by building a model of a small open economy, in which consumers cannot perfectly insure income shocks, in the spirit of Kaplan et al. (2018) and Gali et al. (2004). Domestic producers combine capital and labor to produce intermediate and final goods. A competitive investment firm converts home goods into capital. Households supply labor, and building on Auclert et al. (2021), a continuum of labor unions sets the nominal wage, thereby introducing a nominal rigidity. The hours of labor supplied by households are incorporated via a CES aggregator. The union sets the wage to maximize the utility of its members, and faces a penalty for changing wages a la Rotemberg (1982). Consumers have access to foreign and domestic goods. The small open economy takes as given the international risk-free rate and the price of imported goods. Because we are interested in distributional issues, households differ in their productivity.

Our model has two key features that are important for LICs: limited financial market participation and subsistence preferences. First, a fraction of consumers do not participate in the financial market. Hence, consumers are either financially included or excluded, in addition to their productivity differences. Financially included consumers invest in a risk-free bond, and own shares in the investment firm, whereas financially excluded households do not have any means to smooth consumption. While it may seem like a stark assumption, limited financial inclusion is pervasive in LICs, and captures the evidence of a high share of "hand-to-mouth" consumers in these countries (see, for example, Demirguc-Kunt et al., 2022; Demirgüç-Kunt and Klapper, 2012).[1] Second, households need to maintain a subsistence level of consumption of the imported good, here assumed to be staple consumption (see, for example, Unsal et al., 2022). The subsistence preferences imply that households at different points of the income distribution consume distinct baskets, and these baskets change with income levels. This assumption is consistent with evidence for emerging markets on non-homothetic preferences (see, for example, Cravino and Levchenko, 2017). In addition, Portillo et al. (2016) show that the effects of subsistence preferences go beyond changes in consumption baskets with income levels, but imply a lower substitutability in response to food price shocks.

After incorporating these features into a standard Heterogeneous Agent New Keynesian (HANK) framework, we calibrate the model to match key characteristics of a representative LIC and proceed with the quantitative analysis.[2] We solve the model using the highly efficient solutions methods proposed by Auclert et al. (2021), in which the algorithm for transitional dynamics updates guesses following Newton's method, using sequence-space Jacobians. The advantage of this methodology is that it does not rely on approximations of the equilibrium distribution or value functions but still captures the richness of non-linearities from the idiosyncratic shocks experienced by heterogeneous

[1] Dabla-Norris et al. (2021) shows the relevance of different financial constraints for credit in a heterogeneous agents setting. For some LICs, entry costs are significant.

[2] Note that these features are also prevalent in many emerging market economies. While our calibration is tailored to a representative LIC, the theoretical framework we propose is general and can be applied to emerging economies as well, although a different parameterization would be required.

agents in the presence of aggregate shocks.

Regarding the *positive implications* of the model, simulations of the impact of shocks to food prices yield intuitive responses in terms of aggregates. Inflation and the nominal interest rate increase, the latter coming from the central bank's reaction via a Taylor rule. The uncovered interest rate parity implies that the nominal exchange rate appreciates, leading to a real exchange rate appreciation. The government raises taxes to pay higher interest rates on debt. Consumers can only cut consumption of foreign goods within subsistence levels, which means they need to adjust their purchases of the domestic good. Due to the appreciation of the exchange rate, exports fall. The declines in consumption and exports drive the home country into recession, which, together with the higher inflation, lead to a drop in the real wage.

The food price shock has significant distributional impacts, raising consumption inequality immediately. Lower productivity households are disproportionately affected due to the decline in their labor income as real wages drop. In contrast, higher productivity households, who have access to financial markets, can smooth the impact of the shock and experience a lower drop in consumption compared to financially excluded households. Analyzing the distribution of agents based on their cash-on-hand (COH) levels (namely the sum of their labor income and accumulated assets) reveals an increase in the mass of agents with below steady-state COH and a decrease in those with above steady-state COH right after the shock. As the shock fades, the distribution gradually returns to steady-state values.

Our *normative analysis* evaluates the welfare effects of the shock, measured as the permanent loss in steady-state consumption that would make agents indifferent, in utility terms, to experiencing the shock. Households with lower initial COH levels experience larger welfare drops, primarily due to the decrease in real wages. Financially excluded (FE) agents, who rely solely on labor income, are adversely affected, especially those with low productivity and COH. However, it is financially included (FI) households with low COH and productivity who suffer the most. Interestingly, the top quantile of COH households experience slightly more negative effects than households in middle quantiles, as their income mainly comes from returns on assets and the shock's impact on output reduces the value of the investment firm equity. In a counterfactual scenario which holds the value of FI households' assets constant, households with the highest COH suffered lower welfare losses than households with lower initial COH positions.

What are the effects of less aggressive interest rate rules? We examine different monetary policy reactions by comparing the baseline scenario with an alternative in which the monetary authority is less aggressive in their fight against inflation. A less aggressive reaction to food price shocks results in higher inflation, a smaller GDP drop, and a greater decrease in real wages due to the sticky nominal wages. While households at the bottom of the COH distribution experience a slightly smaller welfare drop, those with higher COH positions face a more significant negative impact than the baseline simulation. There are two opposing effects at work here: households face a larger drop in real wages due to higher inflation, but a smaller reduction in hours worked due to the smaller output drop, with the two effects almost offsetting each other. In sum, the central bank seems mostly unable to engineer a Pareto-improving outcome for low-income households.

This is confirmed by analyzing alternative rules. When the central bank adjusts interest rates gradually in response to changes in inflation (interest rate smoothing), inflation increases by more than in the baseline scenario but declines faster. This shifts the timing of movements in aggregate demand, leading to slightly smaller welfare losses by all agents with interest rate-smoothing compared to the baseline. Alternatively, when the central bank targets the price of imports (the source of the shock in the baseline), there is a much larger increase in the real interest rate, a larger decrease in domestic demand and output, and a smaller spike in inflation. The drop in labor demand is particularly harmful to low COH households, everybody except for the high COH households, are worse-off. As expected, when the central bank targets only domestic prices, "seeing through" the supply shock and reacting only to the passthrough to "core" prices, the policy rate increases by less, the recession is slightly less pronounced, but much longer. All quantiles seem to benefit in terms of welfare, with more improvement for those at the top.

Given the limited ability of monetary policy to improve distributional outcomes following a shock, we examine the case in which the bottom quantiles of COH households receive transfers financed by higher taxes to the higher COH quantiles. Compared to the baseline, this policy has small effects on macroeconomic aggregates, but is able to offset to a great extent the welfare loss of the bottom quantiles of households.

Literature review. Our paper is closely related to a recent stream of literature that studies the transmission of external shocks in small open economies with heterogeneity at the micro level. This literature tackles classic topics of international macroeconomics such as contractionary devaluations (Aggarwal et al., 2022a), the impact of financial and real integration for the conduct of monetary policy (Guo et al., 2023), the response to capital flow shocks in dollarized economies (Zhou, 2022; De Ferra et al., 2020), exchange rate policy (Oskolkov, 2023) and fear of floating (De Ferra et al., 2020).[3] This literature focused mostly on advanced and emerging economies. As in most of these papers, we study an open economy model with limited insurance of income shocks, and nominal rigidities, building on the closed economy lessons of Kaplan et al. (2018) and on the open economy framework of Gali et al. (2004).

Differently from the previous literature, we focus on examining how monetary policy shapes the transmission of foreign shocks in a representative LIC. We do so by extending a standard HANK framework with two features that are particularly relevant in this context: (i) non-homothetic preferences and (ii) limited asset market participation. These additions have important implications. Non-homothetic preferences imply that low-income households, whose consumption baskets are heavily weighted toward imported goods, are disproportionately affected by increases in foreign prices. Limited asset market participation means that contractionary monetary policy, which reduces aggregate employment, is especially costly for these households, whose consumption depends entirely on labor income. These two channels are key to understanding the sizable welfare losses that adverse external shocks generate for low-income households in our setting.

Our paper also contributes to a large literature that studies terms of trade shocks in emerging market and developing economies. Early studies tried to understand the role of terms of trade shocks in driving the business cycle (see, for example, Mendoza, 1995a; Kose, 2002; Kehoe and Ruhl, 2008; Corsetti et al., 2007), a question reexamined in more recent work by Schmitt-Grohé and Uribe (2018). Most of this literature uses representative agent models, while our paper focuses on the distributional impact of terms of trade shocks. Recent exceptions include Auclert et al. (2024a) and Aggarwal et al. (2022b). Our contribution to this literature is to highlight that concerns over the distributional impacts of terms of trade shocks could lead central banks to allow for higher inflation than the target as a response to the shock, despite poorer households being disproportionately affected by higher prices (Easterly and Fischer, 2001).

Our paper relates to the literature that studies monetary and fiscal policies transmis-

[3] Closely related to this agenda is Cugat (2019), which focuses on a Two Agent New Keynesian model, building on the work of Debortoli and Galí (2024).

sion mechanisms in LICs. Mishra et al. (2012), Mishra and Montiel (2013), Mishra et al. (2014) and Acharya (2017) argue that monetary policy transmission to the real economy is weaker in LICs than in advanced economies and operates mostly through the banking sector channel. Although this finding is challenged by Berg et al. (2013),[4] by limiting consumption sensitivity to real rates and allowing for financial exclusion for part of the population, our paper captures this limited pass-through.

Our study also contributes to a growing literature that examines the distributional consequences of monetary policy in HANK models. Auclert (2019) provides a general framework to decompose the transmission of monetary policy and shows how household heterogeneity, particularly in marginal propensities to consume and net asset positions, can lead to unequal consumption responses. In recent work, McKay and Wolf (2023a) apply these insights to advanced economies and argue that, despite heterogeneity at the household level, the aggregate effects of monetary policy on consumption inequality tend to be limited. In line with this conclusion, McKay and Wolf (2023b) show that inequality concerns do not substantially alter optimal monetary policy rules, as the overall distributional effects are relatively muted (similar findings are found in Lama and Medina, 2011, in the context of an open-economy model). In our setting, which focuses on how monetary policy responds to external shocks in a representative LIC, we find that the impact on household consumption varies considerably across the income distribution. These heterogeneous effects are shaped by structural features specific to low-income economies, such as non-homothetic preferences and limited asset market participation, which amplify the unequal consequences of both the external shock and the policy response.

Finally, on the theoretical side, our work builds on Portillo et al. (2016), who examine how subsistence requirements in food consumption affect the design of monetary policy in a RANK model and find that, in most cases, even in the presence of subsistence consumption, optimal policy calls for the stabilization of sticky prices non-food inflation, roughly correspondent to core inflation. Our analysis yields similar results in a HANK framework when the goal of monetary policy is stabilizing domestic prices (in our setting, equivalent to core inflation). By combining heterogeneous agents with an open economy, our paper highlights other mechanisms affecting the outcome of monetary policy, such as the role

[4] Li et al. (2016) offers a methodological explanation for the differences in findings, especially those from VAR-based inference. Lack of transparent communication may also play a role. See Adam et al. (2018) for a summary of the discussion in the 2010s.

of households who can smooth consumption through international financial markets.[5] Other related papers include, among others, Baldini et al. (2015), who examines monetary policy in the case of Zambia, and Peralta-Alva et al. (2023), who studies the welfare impact of alternative measures for fiscal consolidation in the case of Ethiopia.

The next section presents the model, followed by the quantitative analysis in Section 3 and a brief conclusion in Section 4.

2 Model

We build on the setup of Aggarwal et al. (2022a) and De Ferra et al. (2020) and study a one asset, heterogeneous agents, open economy model, with wage rigidity and capital accumulation. There are two key features in our environment. First, a fraction of the households are poor and have no access to the financial market. This fact is in line with evidence from developing economies as documented in Demirguc-Kunt et al. (2022).[6] Second, households need to consume a subsistence level of the tradable goods, which we introduce via Stone-Geary preferences. This assumption implies that poorer households spend a larger fraction of their income on tradable goods, which is in line with the evidence of Cravino and Levchenko (2017) for the 1994 Mexican devaluation.[7] It also introduces an externality, as richer households do not internalize the impact of their consumption decisions on the prices faced by poorer households. As a result, unlike the findings by Gali and Monacelli (2005), perfect home good price stabilization might not be a desirable outcome, as shown in Fanelli and Straub (2021). Time is discrete and there are no aggregate shocks to the economy.

Households. Households are subject to idiosyncratic shocks to their labor productivity. These shocks are indexed by the variable $e_{i,t}$, which follows a Markov chain on the space

[5] Portillo et al. (2016) extend their model to reflect financial exclusion, but agents with access to financial instruments are unable to smooth consumption in a closed economy with zero net supply of assets.

[6] Limited asset market participation is also a feature in developed markets, as discussed in Mankiw and Zeldes (1991), Vissing-Jørgensen (2002), Parker and Vissing-Jorgensen (2009), and Guvenen (2009), among many others studies.

[7] Recent studies examining the impact of price changes on different groups of consumers include Argente and Lee (2021) and Jaravel (2019), among others.

$\{e^1, \ldots, e^S\}$. Households belong to one of two groups: *Financially excluded* (*FE*) and *Financially included* (*FI*). *FE* households are of size $\lambda \in [0, 1]$ and do not participate in financial markets. *FI* households, on the other hand, can buy real government bonds and equity of an investment firm.

Preferences. Households' preferences are represented by the following separable utility function:

$$\mathbb{E}_0 \left[\sum_{t=0}^{\infty} \beta^t U(c, n) \right], \tag{1}$$

$$U(c, n) = u(c) - v(n) = \frac{c^{1-\sigma}}{1-\sigma} - \psi \frac{n^{1+\phi}}{1+\phi}, \tag{2}$$

$$c = \left[(\chi)^{\frac{1}{\eta}} (c_H)^{\frac{\eta-1}{\eta}} + (1-\chi)^{\frac{1}{\eta}} (c_F - \bar{c})^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}}. \tag{3}$$

In the equations, c is the consumption basket, defined in equation (3), n are hours worked, c_H is consumption of the home good, c_F is consumption of the foreign (tradable) good, σ is the elasticity of intertemporal substitution, ϕ is the Frisch elasticity of labor supply, χ is the weight of the home good in the consumption basket, and η is the elasticity of substitution between domestic and foreign goods. Importantly, the consumption basket in (3) is a non-homothethic CES aggregator, where non-homotheticity arises due to the presence of a subsistence level for the consumption of the foreign good, $\bar{c}$. As we document in appendix B, the inclusion of $\bar{c}$ allows us to better capture specific features of LICs. The consumption basket in equation (3) can be rewritten with appropriate re-labelling of foreign consumption as:

$$\begin{aligned} \tilde{c_F} &:= c_F - \bar{c}, \\ \tilde{c} &:= \left[(\chi)^{\frac{1}{\eta}} (c_H)^{\frac{\eta-1}{\eta}} + (1-\chi)^{\frac{1}{\eta}} (\tilde{c_F})^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}}. \end{aligned} \tag{4}$$

The price index P_t associated with the consumption aggregator in equation (4) is given by:

$$P_t = \left[\chi P_{H,t}^{1-\eta} + (1-\chi) P_{F,t}^{1-\eta} \right]^{\frac{1}{1-\eta}}, \tag{5}$$

where $P_{F,t}$ and $P_{H,t}$ are, respectively, the foreign and domestic good prices.

Financially excluded households (FE). FE households are hand-to-mouth agents who solve the following programming problem:

$$\begin{aligned} V_t^{FE}(e_t) &= \max_{\{c_{H,t}, c_{F,t}\}} u(c_t) - v(n_t) + \beta \mathbb{E}_t[V_{t+1}(e_{t+1})], \\ &\text{s.t.} \quad \frac{P_{H,t}}{P_t} c_{H,t} + \frac{P_{F,t}}{P_t} c_{F,t} = z_t, \\ &\quad z_t = w_t e_t n_t - \frac{P_{H,t}}{P_t} Tax_t, \end{aligned}$$

where w_t is the real wage, expressed in terms of the economy's price index (i.e., $w_t = \frac{W_t}{P_t}$),[8] and Tax_t are lump sum taxes.[9,10] Households choose consumption of the domestic and foreign good, $c_{H,t}, c_{F,t}$. As is standard in models with sticky wages, hours worked, n_t, are chosen by a labor union. Re-labelling equation (4), the FE household's problem can be re-written as:

$$\begin{aligned} V_t^{FE}(e_t) &= \max_{\{\tilde{c}_t\}} u(\tilde{c}_t) - v(n_t) + \beta \mathbb{E}_t[V_{t+1}(e_{t+1})], \\ &\text{s.t.} \quad \tilde{c}_t = z_t - \frac{P_{F,t}}{P_t} \bar{c}, \\ &\quad z_t = w_t e_t n_t - \frac{P_{H,t}}{P_t} Tax_t. \end{aligned}$$

Given the CES structure, optimal consumption choices are:

$$c_{H,t} = \chi \left(\frac{P_{H,t}}{P_t} \right)^{-\eta} \tilde{c}_t, \tag{6}$$

$$c_{F,t} = (1 - \chi) \left(\frac{P_{F,t}}{P_t} \right)^{-\eta} \tilde{c}_t + \bar{c}. \tag{7}$$

Equation (7) highlights the implications of the subsistence level of imported good consumption. The presence of a positive subsistence level, $\bar{c} > 0$, reduces the elasticity of demand for foreign goods: households need to consume at least $\bar{c}$ units of the imported good regardless of its relative price. In other words, the demand of the foreign good is non-homothethic, and as its price rises, consumers spend a larger fraction of their total expenditure on the foreign good.

[8]Following standard practice, the relevant price index used in the definition of the real wage is the aggregate price index P_t. For a framework that incorporates heterogeneous price indexes based on household-specific consumption baskets, see the recent work by Ting Lan and Li (2024).

[9]In our benchmark calibration, taxes are allocated proportionally to households' productivity levels, e_t, so that more productive households pay more taxes to the government.

[10]Note that, for FE households, their COH is given by $w_t e_t n_t - \frac{P_{H,t}}{P_t} Tax_t$.

Financially included households (FI). FI households participate in financial markets, after re-labelling equation (4), their programming problem can be written as:

$$
\begin{aligned}
V_t^{FI}(a_t, e_t) \quad &= \quad \max_{\{\tilde{c}_t, a_{t+1}\}} u(\tilde{c}_t) - v(n_t) + \beta \mathbb{E}_t[V_{t+1}(a_{t+1}, e_{t+1})], \\
\text{s.t.} \quad & \tilde{c}_t + a_{t+1} = (1 + r_t)a_t + z_t - \frac{P_{F,t}}{P_t}\bar{c}, \\
& z_t = w_t e_t n_t - \frac{P_{H,t}}{P_t} Tax_t, \\
& a_{t+1} \geq \underline{a},
\end{aligned} \tag{8}
$$

where a_t captures the value of household assets, $\underline{a}$ is the borrowing constraint, and r_t is the real interest rate on assets.[11] The solution to this programming problem defines $\tilde{c}_t$, which is then allocated to foreign and domestic goods according to equations (6) and (7).

Labor unions. We introduce sticky wages following Auclert et al. (2024b). Each household i is assumed to provide hours of work, n_i, to a continuum of unions indexed by k. Each union k aggregates hours into a union-specific task, $N_{k,t} = \int e_{i,t} n_{i,k,t}$, where $n_{i,k,t}$ are the hours provided by household i to union k. Union-specific tasks are then aggregated into employment services, N_t through a CES aggregator with elasticity of substitution ϵ:

$$
N_t = \left(\int_k N_{k,t}^{\frac{\epsilon-1}{\epsilon}} \right)^{\frac{\epsilon}{\epsilon-1}}. \tag{9}
$$

Employment services are sold to firms at the nominal wage W_t. The union sets the wage to maximize the average utility of its members subject to an additive quadratic disutility term from wage changes: $\frac{\xi}{2} \int_\kappa \left(\frac{W_{\kappa,t}}{W_{\kappa,t-1}} - 1 \right)^2$. We assume that the union allocates hours demanded by firms equally across its members, so that all households end up working the same amount of hours. As shown in Auclert et al. (2024b), this setting implies the following New Keynesian wage Phillips curve:

$$
\pi_t^W = \kappa \left(\frac{v'(N_t)}{\frac{\epsilon}{\epsilon-1} w_t (\lambda u'(C_t^{FE}) + (1-\lambda) u'(C_t^{FI}))} - 1 \right) + \beta \pi_{t+1}^W, \tag{10}
$$

where $\pi_t^W = \frac{W_t}{W_{t-1}} - 1$ and $\kappa = \frac{\epsilon}{\xi}$.

[11] Note that, for FI households, their COH is given by $(1 + r_t)a_t + w_t e_t n_t - \frac{P_{H,t}}{P_t} Tax_t$

Firms. Firms produce consumption goods using labor and capital according to a Cobb-Douglas production function: $Y_t = K_t^{\alpha} L_t^{1-\alpha}$, where K_t is capital used in production, and L_t is labor in effective units.[12] The firm's maximization implies:

$$w_t = \frac{P_{H,t}}{P_t}(1-\alpha)Y_t/L_t, \tag{11}$$

$$r_t^k = \alpha Y_t/K_t, \tag{12}$$

where r_t^k denotes the marginal product of capital. Equation (11) implies the following relation between π_t^W and $\pi_t^H = \frac{P_{H,t}}{P_{H,t-1}} - 1$:

$$1 + \pi_t^H = (1 + \pi_t^W)\frac{N_t/Y_t}{N_{t-1}/Y_{t-1}}. \tag{13}$$

Foreign demand. Foreign demand for domestic goods is computed assuming foreign households face a problem analogous to domestic consumers. Consequently, the demand for domestic goods by foreign households, $C_{H,t}^*$, is given by:

$$C_{H,t}^* = (1-\chi^*)\left(\frac{P_{H,t}^*}{P_t^*}\right)^{-\eta^*} C^*, \tag{14}$$

where $P_{H,t}^*$ is the price of the domestic good expressed in foreign currency, P_t^* is the foreign price index, χ^* is the weight of the foreign good in the foreign consumption basket, η^* is the elasticity of substitution between foreign and domestic goods in the foreign consumption basket, and C^* is foreign aggregate demand.

Real exchange rate. We assume that the foreign central bank keeps foreign inflation constant and normalize $P_t^* = P^* = 1$. Together with the small open economy assumption, it follows that $P_{F,t}^* = P_t^* = 1$. Additionally, given the nominal exchange rate $\mathcal{E}_t$, the law of one price holds:

$$P_{H,t} = \mathcal{E}_t P_{H,t}^*, \tag{15}$$

$$P_{F,t} = \mathcal{E}_t P_{F,t}^* = \mathcal{E}_t. \tag{16}$$

We define the real exchange rate as:

$$\mathcal{Q}_t = \frac{\mathcal{E}_t P_t^*}{P_t} = \frac{\mathcal{E}_t}{P_t}. \tag{17}$$

[12] Effective labor is the product of the number of hours worked and the idiosyncratic productivity of the household.

Combining equations (5), (15), (16) and (17), we can create a mapping between the real exchange rate, $\mathcal{Q}_t$, and the price ratios necessary to solve the programming problems of domestic households, and compute foreign demand for domestic goods.:

$$\frac{P_{H,t}}{P_t} = \left(\frac{1 - (1-\chi)\mathcal{Q}_t^{1-\eta}}{\chi} \right)^{\frac{1}{1-\eta}}, \tag{18}$$

$$P^*_{H,t} = \left(\frac{\mathcal{Q}_t^{\eta-1} - (1-\chi)}{1-\chi} \right)^{\frac{1}{1-\eta}}, \tag{19}$$

$$\frac{P_{F,t}}{P_t} = \mathcal{Q}_t. \tag{20}$$

Investment. A competitive investment firm operates a technology that converts home goods into investment goods, facing quadratic adjustment costs $\Xi_t = \frac{\zeta}{2}(\frac{K_{t+1}}{K_t} - 1)^2 K_t$. The law of motion of capital is given by: $K_{t+1} = (1-\delta)K_t + I_t$, where δ is the depreciation rate. The investment firm's profits are given by:

$$\Pi_t^{Inv} = \frac{P_{H,t}}{P_t} \left(r_t^k K_t - I_t - \Xi_t \right). \tag{21}$$

Optimization by the firm implies:[13]

$$q_t = \frac{P_{H,t}}{P_t} \left[1 + \zeta \left(\frac{K_{t+1}}{K_t} - 1 \right) \right], \tag{22}$$

$$q_t = \frac{\frac{P_{H,t+1}}{P_{t+1}}}{(1+r_{t+1})} \left[\left(r_{t+1}^k - \frac{d\Xi_{t+1}(K_{t+1}, I_{t+1})}{dK_t} \right) \right] + \frac{q_{t+1}(1-\delta)}{(1+r_t)}, \tag{23}$$

where q_t captures the constraint's shadow value.

Assets market. Three types of assets are available in this economy: domestic government bonds, B_t, foreign government bonds, B_t^*, and equity shares of the investment firm. Domestic bonds have a return equal to $(1 + r_t)$, while foreign bonds have a return equal

[13] The programming problem of the firm is given by

$$V(K_t) = \max_{I_t, K_{t+1}} \left(r_t^k K_t - I_t - \Xi_t \right) \frac{P_{H,t}}{P_t} + \frac{1}{1+r_t} V(K_{t+1})$$
$$K_{t+1} = (1-\delta)K_t + I_t$$

where $q_t K_t = V(K_t)$. This follows because $V(\lambda K_t) = \lambda V(K_t)$. Appendix A.3 provides the derivation of the investment firm's optimality conditions.

to $(1+i_t^*)\frac{\mathcal{Q}_{t+1}}{\mathcal{Q}_t}$. The return on the equity of the investment firm is given by $\frac{\mathbb{E}_t[p_{t+1}+\Pi^I_{t+1}]}{p_t}$, where p_t is the price of a share of the investment firm. No-arbitrage implies the uncovered interest parity condition (UIP):

$$(1+r_t) = (1+i_t^*)\frac{\mathcal{Q}_{t+1}}{\mathcal{Q}_t}, \tag{24}$$

and that:

$$(1+r_t) = (1+i_t^*)\frac{\mathcal{Q}_{t+1}}{\mathcal{Q}_t} = \frac{\mathbb{E}_t[p_{t+1}+\Pi^{Inv}_{t+1}]}{p_t}. \tag{25}$$

Government. The government budget constraint is given by:

$$B_t = (1+r_{t-1})B_{t-1} + \frac{P_{H,t}}{P_t}G_t - \frac{P_{H,t}}{P_t}T_t \tag{26}$$

where G_t is government expenditure, and T_t are tax revenues. Assuming the government keeps its debt constant by adjusting tax revenues, total tax revenues are:

$$\frac{P_{H,t}}{P_t}T_t = r_{t-1}B_{t-1} + \frac{P_{H,t}}{P_t}G_t \tag{27}$$

Monetary policy. We assume monetary policy follows a standard Taylor rule that targets price-index inflation:

$$i_t = r^* + \phi_\pi \pi_t \tag{28}$$

where r^* denotes the zero-inflation real rate and $\pi_t = \frac{P_t}{P_{t-1}} - 1$. Combining equation (28) with the Fisher equation, the real rate will be equal to:

$$(1+r_t) = \frac{(1+r^*+\phi_\pi\pi_t)}{(1+\mathbb{E}_t\pi_{t+1})}. \tag{29}$$

Current Account. The current account identity is defined as:

$$\begin{aligned} CA_t &= nfa_t - nfa_{t-1} = TB_t + r_{t-1}nfa_{t-1}, \\ TB_t &= \frac{P_{H,t}}{P_t}C^*_{H,t} - \frac{P_{F,t}}{P_t}[(1-\alpha)C^R_{F,t} + \alpha C^P_{F,t}] = EX_t - IM_t \end{aligned} \tag{30}$$

When all markets clear, the current account identity will also hold via Walras Law.[14]

[14] Appendix A.2 shows the derivation of the identity.

Equilibrium Definition. Given sequences of foreign prices $\{i_t^*, P_t^*\}$, a monetary policy rule given by $i_t = r^* + \phi_\pi \pi_t$, an initial wealth distribution $\mathcal{D}_0(a,e)$, and an initial capital level K_0, a competitive equilibrium is a path of policies for households

$$\left\{c_{H,t}^i(a,e), c_{F,t}^i(a,e), c_t^i(a,e), a_{t+1}^i(a,e)\right\}_{i \in FI,FE}$$

distributions $\mathcal{D}_t(a,e)$, prices $\{\mathcal{E}_t, \mathcal{Q}_t, P_t, P_{H,t}, P_{F,t}, W_t, p_t, i_t, r_t, r_t^k\}$ and aggregate quantities $\{C_t, C_{H,t}, C_{F,t}, CA_t, TB_t, K_t, I_t, Y_t, A_t, \text{nfa}_t\}$, such that all agents and firms optimize, and the domestic goods, labor, and asset markets clear:

$$\textit{Goods} \quad Y_t = C_{H,t} + C_{H,t}^* + G_t + I_t + \Xi_t, \tag{31}$$

$$\textit{Labor} \quad N_t = \int n_{i,t} e_{i,t} di = L_t, \tag{32}$$

$$\textit{Assets} \quad A_t = \int_{i \in Rich} a_{i,t} di = B_t + p_t + nfa_t = B_t + q_t K_{t+1} + nfa_t, \tag{33}$$

where $C_{Ht} \equiv \sum_e \pi_e \int c_{H,t}(a,e) \mathcal{D}_t(a,e)$ denotes aggregate consumption of home goods, and C_t, C_{Ft}, A_t are defined similarly. We focus on equilibria in which the long-run exchange rate returns to its steady state level, $\mathcal{Q}_\infty = \mathcal{Q}_{ss}$.

3 Quantitative Analysis

3.1 Calibration

Table 1 summarizes the parameters that we use to calibrate our model. Our goal is to be representative of a typical LIC. The time period is a quarter. β, the discount factor, is chosen to be consistent with an annual interest rate of 6%, much higher than what is usually used for the calibration of advanced economies.[15] σ and ϕ, the coefficients capturing the inverse of the elasticity of intertemporal substitution and of the Frisch elasticity, respectively, are set to 2, standard values in the literature. Labor disutility, ψ, is set to 7.04

[15]The real rate is obtained as the difference between the average nominal interest rate on domestic bonds and inflation in Ghana between 2009 and 2018. The series, taken from the IMF IFS Statistics, are: Monetary and Financial Accounts, Interest Rates, Securities Markets, Government Debt Securities, Government Bonds, Percent per Annum; Prices, Consumer Price Index, All items, Percentage change, Corresponding period previous year, Percent.

to normalize quarterly output to be equal to 1. To model idiosyncratic productivity risk, we follow the literature and assume household's labor productivity, e, follows an AR(1) process: $\log e_t = \rho_l \log e_t + \varepsilon_t$, with $\sigma_l = std(\varepsilon_t)$. We estimate the persistence and variance of the income process using data from the ECG-ISSER Ghana Socioeconomic Panel Survey (GSPS),[16] as explained in appendix C. For the domestic and foreign elasticities of substitution across goods we rely on Feenstra et al. (2018), and set $\eta = \eta^* = 1.01$. χ, the weight given to the domestically-produced good in the CES aggregator, is set to 0.484, consistent with the typical share of imports to GDP of 30% in LICs (and in line with the values reported by Melina and Portillo (2018)).

In order to calibrate $\bar{c}$, the subsistence level of imported goods consumption, we use the fact that consumption of imported staple goods accounts, on average, for 10% of the overall households' consumption basket in LICs. This is estimated by calculating the amount of staple foods needed at the country level to avoid under-nourishment and countries' dependence on imports of these food items, as explained in appendix B.[17] The parameter λ, the fraction of financially excluded households, is calculated from the ECG-ISSER Ghana Socioeconomic Panel Survey GSPS.[18] The borrowing constraint $\underline{a}$ is set to zero, implying that financially included households are unable to lend among themselves.

The parameters related to the firms in the model are standard in the literature. The capital share, α, is set to 0.33, while ϵ, is set to 11, implying a 10% steady-state markup. The slope of the Phillips curve, κ, is set to 0.1. The adjustment cost of capital, ζ, is set to 17, as in De Ferra et al. (2020). In order to match the estimate of the average annual marginal propensity to consume (MPC) of 0.632.[19] We set the capital to output ratio to 47%.[20]

[16]The survey is administered by the Economic Growth Center at Yale University, the Global Poverty Research Lab at Northwestern University, and the Institute of Statistical, Social, and Economic Research at the University of Ghana. Most studies are usually based on the empirical findings for the US economy of Floden and Lindé (2001) (e.g., Guerrieri and Lorenzoni, 2017).

[17]We rely on data from the Food and Agricultural Organization (FAO) of the United Nations Food Balances database and the World Bank's Consumption database. In line with Cravino and Levchenko (2017), our calibration implies a negative relation between the share of imported goods in the consumption basket and household's income.

[18]This is proxied by the fraction of households that declare to have only saved at home (i.e., not at a financial institution).

[19]We rely on Hong (2023)'s estimate from Peru, which is likely closer to the MPC in LICs than the more commonly used estimates for advanced economies.

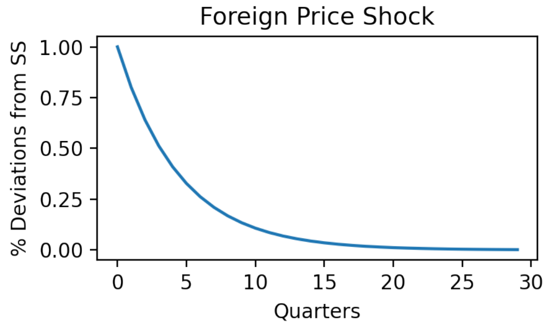
[20]The overall capital to output ratio is generally higher in LICs, nevertheless we use 47% in order to match the MPC estimated in the literature, as it is a key parameter in HANK models.

Table 1: Parameter Values

Parameter	Explanation	Value	Target/Source
Households			
β	Discount factor	0.955	Interest rate r = 6%
σ	Inverse EIS	2	Standard value
ϕ	Inverse Frisch	2	Standard value
ψ	Labor disutility coefficient	7.04	$Y = 1$
ρ_l	Persistence, labour productivity	0.97	Own calc. (see appendix C)
σ_l	St. deviation, labour productivity	0.14	Own calc. (see appendix C)
η	Elasticity of substitution across goods	1.01	Feenstra et al. (2018)
χ	Weight of home good in consumption	0.484	Melina and Portillo (2018)
$\bar{c}$	Subsistence foreign consumption	0.058	Own calc. (see appendix B)
λ	Financially excluded	33%	Findex Database (see appendix D)
$\underline{a}$	Borrowing constraint	0	Standard value
Foreign			
η^*	Elasticity of substitution across goods	1.01	Feenstra et al. (2018)
$(1-\chi^*)C^*$	Foreign demand shifter	0.32	Terms of trade = 1
Firms			
α	Capital share	0.33	Standard value
ϵ	Steady-state markup	11	De Ferra et al. (2020)
κ	Slope of Phillips curve	0.1	Standard value
ζ	Capital adjustment cost coefficient	17	De Ferra et al. (2020)
Government			
ϕ_π	Taylor rule coefficient	1.5	Standard value
G/Y	Government spending (% GDP)	15%	Melina and Portillo (2018)
Aggregates			
B/Y	Domestic debt (% GDP)	20%	Melina et al. (2016)
K/Y	Domestic capital (% GDP)	47%	Mean annual MPC = 0.632
nfa/Y	Net Foreign Asset Position (% GDP)	-35%	WEO and IFS databases (last year available)

Notes: See text for a discussion on the targets.

Figure 1: Exogenous increase in import prices.



Notes: The figure depicts the evolution of the shock to import prices ε_t, which follows a first order autoregressive process with persistence 0.8. The shock enters the model through $P_t^* = \mathcal{E}_t P_t^* (1 + \varepsilon_t)$. We calibrate the initial value of ε_t such that, if the nominal exchange rate were kept constant, there would be a one percent deviation from the steady state value of the foreign prices P_t^* on impact.

The Taylor rule coefficient, ϕ_π, is set to 1.5 in our benchmark framework, though we experiment with different values to evaluate the role of stringency of monetary policy reactions to inflation. The government expenditure to output ratio is set to 15%, in line with Melina and Portillo (2018). The ratio of debt to GDP is 20%, as in Melina et al. (2016). The ratio between NFA and output is set to -35%, equal to the LIC average, using the IMF's WEO and IFS databases.

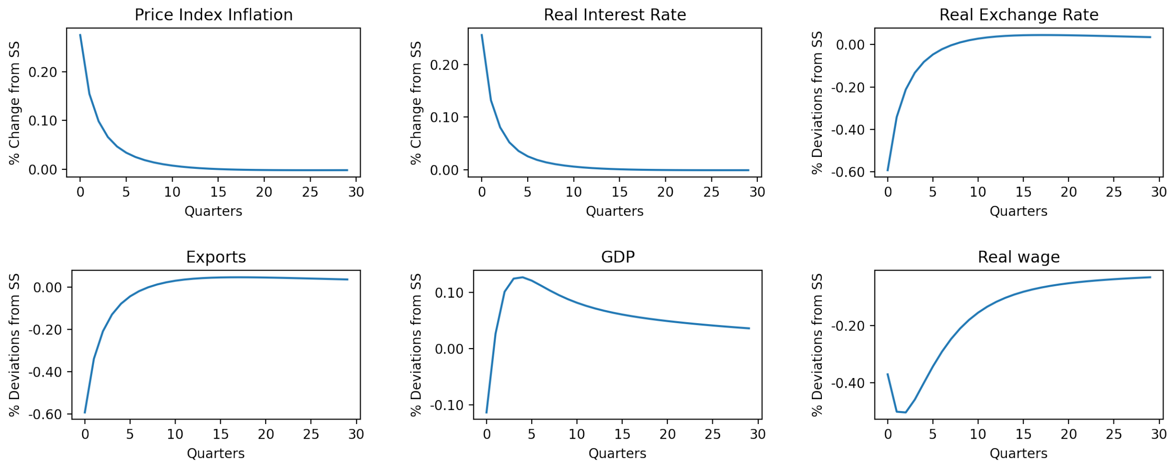
3.2 Positive Implications

A shock to import prices. We are interested in understanding how the increase in the price of staple foods, which took place with Russia's invasion of Ukraine, would affect LICs. Consequently, we simulate the impact of an exogenous increase in the imported good prices:

$$P_{F,t} = \mathcal{E}_t P_t^* (1 + \varepsilon_t) > \mathcal{E}_t P_t^*. \tag{34}$$

As shown in equation (34), the price of foreign goods expressed in domestic currency is increased by ε_t, which can be interpreted as a transportation cost. We model ε_t as an AR(1) process with persistence 0.8 and we calibrate it so that, if the exchange rate were kept constant, $P_{F,t}$ would increase by 1% relative to its steady-state value on impact. The

Figure 2: Response of aggregate variables



Notes: The figure depicts the response of aggregates, such as price index inflation π_t, real interest rate r_t, real exchange rate Q_t, exports EX_t, gross domestic product Y_t, real wage w_t, in deviations from the steady state after the shock to import prices.

dynamics of the shock ε are displayed in figure 1.[21,22]

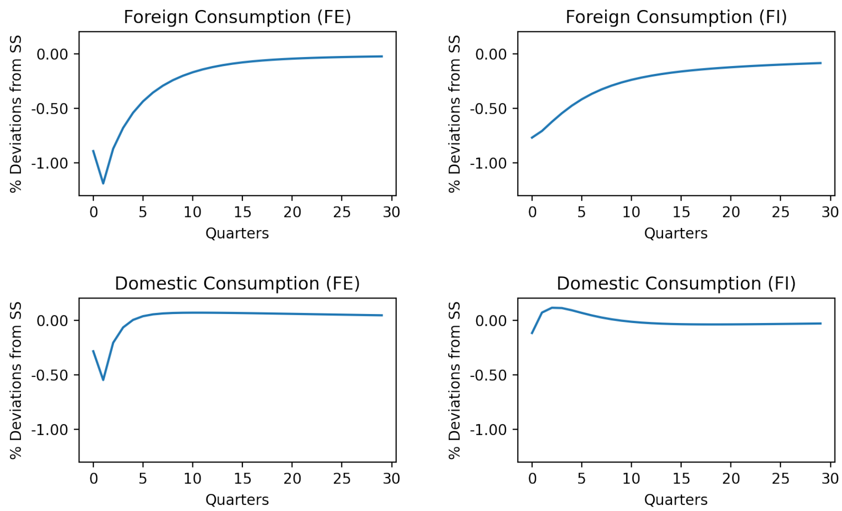
Equilibrium Responses: Aggregates. Figure 2 shows the response of some aggregate variables to the exogenous increase in import prices.[23] Higher import prices lead to an increase in domestic inflation, as expected based on equation (5). As a result, the central bank raises nominal interest rates, guided by the Taylor rule in equation (28). With a Taylor coefficient parameter, ϕ_π, of 1.5, the increase in nominal interest rates leads to a rise in the real interest rate. Higher domestic nominal rates do not trigger a response by foreign central banks, given the small open economy assumption. The real exchange rate $\mathcal{Q}$ appreciates, respecting the UIP condition in equation (24), triggering a contraction in external demand, and a decline in domestic exports. Because the government wants to keep debt constant, it raises taxes to cover higher interest payments, according to equation 27.

[21] We simulate shocks of up to 10 times larger than the baseline. Results are qualitatively similar, but with higher variation, as expected.

[22] These impulse responses are qualitatively consistent with the standard results for terms-of-trade shocks documented in Mendoza (1995b) and Schmitt-Grohé and Uribe (2018). The advantage of our framework is that it additionally allows us to assess the heterogeneous effects of the shock across the income distribution, as well as its welfare implications. An alternative shock to the UIP premium is considered in Appendix N.

[23] Appendix F provides information on the response of additional variables to the shock.

Figure 3: Consumption of different households



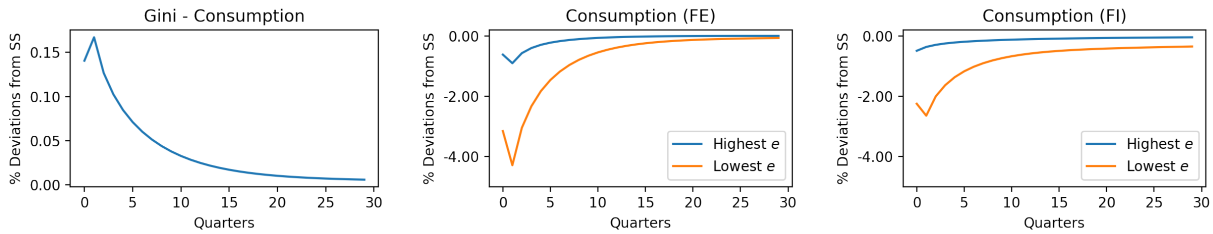
Notes: The figure depicts the evolution of consumption after the import price shock. The two left (right) panels depict the consumption of the foreign and domestic goods of the financial excluded (included) households.

The shock leads to an initial drop in GDP, a consequence of the decline in exports and domestic demand (see figure 3). GDP recovers as start growing, and domestic demand strengthens due to expenditure switching: as imported goods become relatively more expensive, domestic consumers tilt their consumption toward more domestically-produced goods. An important consequence of the movements of inflation and output is that the shock leads to a drop in the domestic real wage. The rise in inflation mechanically drives down the real wage. At the same time, the drop in aggregate output leads to a drop in demand for labor services, putting an additional downward pressure on real wages. Yet, given the stickiness of wages, the decline in nominal wages is gradual, leading to a hump-shaped response of the real wage.

Figure 3 shows the dynamics of consumption of FI and FE agents.[24] The shock to the relative price of imported goods leads to a drop in their demand, though given the assumption of subsistence level of foreign good consumption, the drop in demand is more muted (Appendix G shows counterfactuals with different subsistence parameter, including the case of no subsistence needs, e.g. zero $\bar{c}$l). Subsistence needs also means that, despite the lower demand for foreign goods in response to higher import prices, households still devote a

[24] Appendix E shows IRFs without the breakdown between foreing and domestic consumption.

Figure 4: Consumption inequality



Notes: The figure depicts the evolution of consumption inequality. The left panel depicts the evolution of the Gini Index of consumption in deviations from the steady state. The center (right) panel depicts the evolution of consumption for the highest and lowest productivity financially excluded (included) households in deviations from the steady state.

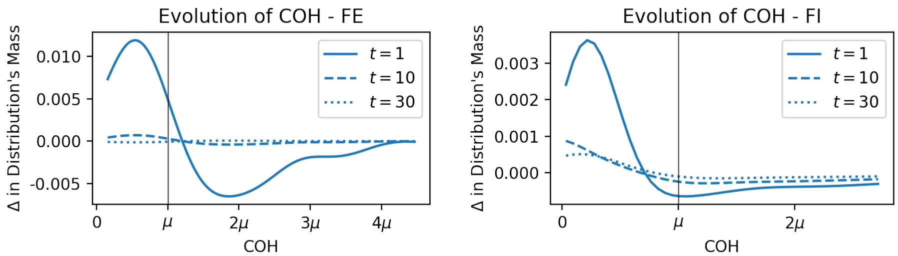
substantial amount of their resources to their consumption, reducing the income available for domestic goods consumption. Given the dynamics in prices, subsistence requirements also affect the conduct of monetary policy. For the same shock to relative prices, a higher increase in the policy rate is needed when there are subsistence needs compared to the case in which there are no differences in consumption baskets across households.

For all households, the shock leads to an initial drop in the consumption of domestic goods followed by a recovery. For FE households, the initial drop is the consequence of lower wages (which is particularly important for these households, since labor income is their only source of income), and the negative income effect due to higher import prices. The subsequent recovery is mostly due to the reduction in the prices of the imported good and expenditure switching. For FI households, the initial drop in consumption is much smaller in magnitude, given their access to saving instruments.[25]

Equilibrium Responses: Distributional Impacts. The shock to imported goods prices directly increases consumption inequality (Figure 4), which then slowly reverts back to its steady-state level. The middle and right charts in the figure provide the intuition behind this result by plotting the response of the overall consumption of FE and FI households

[25]The ability to run down assets is important given the various forces weighing on consumption: (i) higher interest rates provide households an incentive to save; (ii) the higher debt service of the government leads to a hike in the lump sum taxes imposed on FI households; (iii) the shock leads to a contraction in output, implying a drop in the value of the investment firm, negatively affecting the wealth and income of the FI agents.

Figure 5: Movements in the distribution



Notes: The figure depicts the change in the distribution of cash-on-hand (COH) relative to its steady-state value at different horizons after the shock ($t = 1, 10, 30$). The left (right) panel depicts this evolution for financially excluded (included) households. μ represents the steady-state average COH for financially excluded (left panel) and financially included (right panel) households.

with the lowest, and highest, idiosyncratic productivity levels. Lower productivity households are disproportionately affected by the shock. The reason for this is twofold. First, the shock leads to a drop in real wages, compressing labor income. Since lower productivity households make less labor income for a given amount of hours worked, their income drops more than that of more skilled agents. Second, for FI households, an additional channel is at play. Since lower productivity households tend to accumulate less assets over time, they have less resources to smooth out the shock once it hits the economy compared to higher productivity households. Nevertheless, their consumption is less affected by the shock relative to the financially excluded households as they can sustain consumption using part of their assets.

Finally, we examine the effect of the shock on the distribution of agents along their cash-on-hand (COH) levels (Figure 5) . In both charts, μ is the steady state average COH for FI and FE households. The different blue lines display the change in mass at different horizons since the shock hit (e.g., the solid blue line for $t = 1$ shows the change in mass after one period since the shock takes place). Immediately after the shock (solid blue line), the mass of agents with below-mean-steady-state COH level rises, while the mass ofagents with above mean steady-state COH declines. Over time, the distributions gradually return to their steady-state values.

Overall, our baseline simulation shows that an exogenous increase in the prices of imported goods leads to a rise in inflation and a contraction in output. Households, especially those with lower productivity and those unable to tap into savings, react by reducing their consumption. Consumption inequality increases and the number of households with below-average-steady-state COH rises.

3.3 Normative Implications

Thus far, our analysis has focused on the positive implications of an exogenous increase in the price of imported goods. This section moves to a normative analysis, highlighting the welfare effects of the shock on different households in the economy.

Welfare Criterion. We measure welfare, Λ, in terms of consumption equivalents. In particular, Λ solves the following equation:

$$\mathbb{E}_0\left[\sum_{t=0}^{\infty}\beta^t U\Big(c_t, n_t\Big)\right] = \mathbb{E}_0\left[\sum_{t=0}^{\infty}\beta^t U\Big((1+\Lambda)c_t^{ss}, n_t^{ss}\Big)\right]. \tag{35}$$

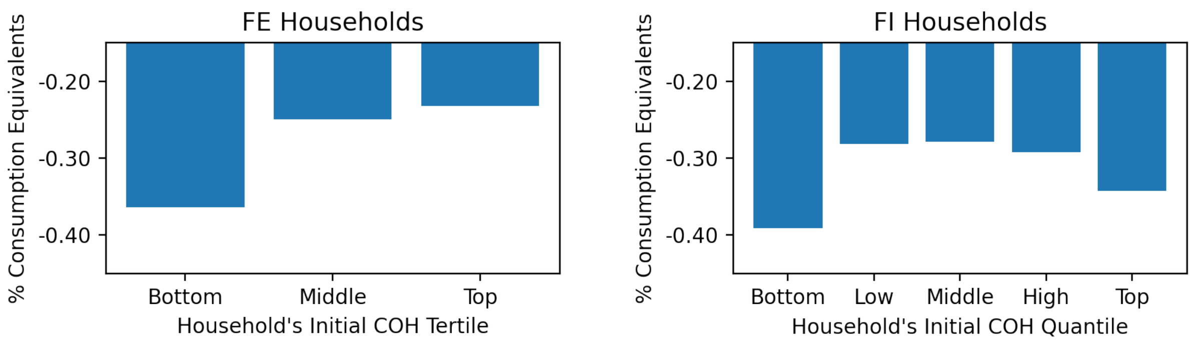
where c_t and n_t represent the consumption and hours worked in the periods after the shock, while c_t^{ss} and n_t^{ss} are the steady-state consumption and hours worked. According to this definition, Λ captures the percentage increase in steady-state consumption that is necessary for households to achieve the same lifetime utility that they obtain after the shock takes place, or alternatively, the fraction of lifetime consumption that they would be willing to forgo in other to avoid the shock. Negative values of Λ imply a negative impact of the shock on households' welfare.[26]

Welfare Effects of a Shock to Import Prices. Figure 6 displays the welfare effect of the shock on FE and FI households, both ranked based on their time-zero COH. For all households, regardless of their initial COH position, the shock reduces welfare.

However, the lower the initial COH level, the larger is the drop in welfare. The finding can be explained by the real wage movements (see figure 2). Since FE agents can only count on their labor income, the drop in wages that follows the shock negatively affects all of them. Nonetheless, households with lower initial COH positions are those with lower productivity levels, who are also the ones getting the lowest labor income for unit of hour

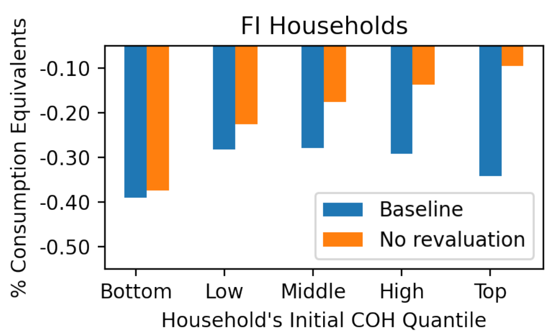
[26]Computationally, we approximate ∞ by computing the expected utility of households for $T = 50$ periods, since our calibrated value for β implies marginal weights attributed to later periods.

Figure 6: Welfare impact of the shock



Notes: The figure depicts the welfare effect (measured by Λ in equation 35) of the import price shock. Households are ranked based on their initial COH (tertiles in the left panel for financially excluded households, quantiles in the right panel for financially included households).

Figure 7: Counterfactual welfare effect: no revaluation

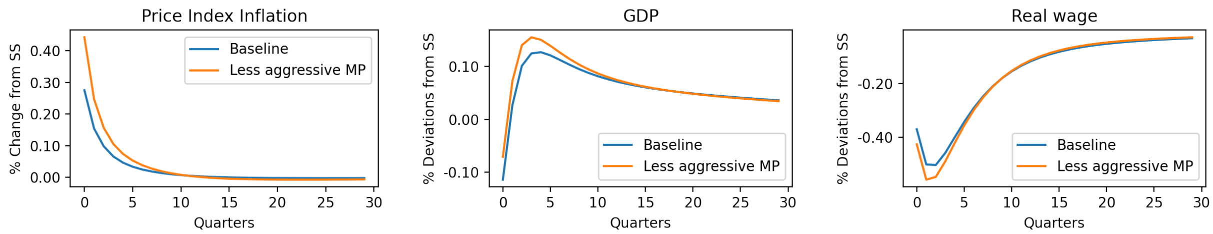


Notes: The figure depicts the baseline welfare effect (blue) and the counterfactual welfare effect (orange) of the shock under the assumption of no negative asset revaluation.

worked: their labor income is particularly negatively affected by the shock. Hence, low productivity FE households suffer the most from the shock.

The shock also affects negatively all FI households. Similarly, households at the bottom of the COH distribution suffer the most. The reasoning is similar to that of the FE households: low COH households tend to have low productivity. Their income source is similar to that of FE agents, with low assets and a major dependence on labor income. Interestingly, households at the top quantile of the COH distribution suffer slightly more than those in the high and middle quantiles. These households derive most of their resources from the return on their assets. Since the equity value of the investment firm declines

Figure 8: Response of aggregate variables - Less aggressive MP



Notes: The figure depicts the baseline (blue) and counterfactual (orange) responses of inflation (left), output (middle) and the real wage (right) in deviations from their steady-state levels. The counterfactual responses rely on a less aggressive monetary policy stance against inflation.

with the shock, their investment income is also negatively affected. To give a sense of the importance of this effect, figure 7 compares the welfare losses in the baseline with the case in which the shock does not affect the equity of the investment firm. If this were to be the case, the welfare losses are strictly higher the lower the initial COH position of the household.

3.4 Welfare Implications of Monetary Policy Rules

Different monetary policy aggressiveness. In the next three subsections, we conduct counterfactual scenarios under different assumptions regarding the conduct of monetary policy. We start by varying the aggressiveness with which the monetary authority responds to inflation, namely we change the coefficient, ϕ_π in the Taylor equation (28) from 1.5 to 1.15.

Relative to the baseline, inflation increases by more as the central banks responds to inflation less aggressively (Figure 8).[27] GDP drops by less since the smaller rise in policy rates provides less of an incentive for households to save, and, consequently, domestic demand decreases less. The real wage, on the other hand, experiences a larger decline in this scenario, mostly due to the stickiness of nominal wages and the larger increase in inflation.

A less aggressive monetary policy stance leads to a slightly lower welfare drop for house-

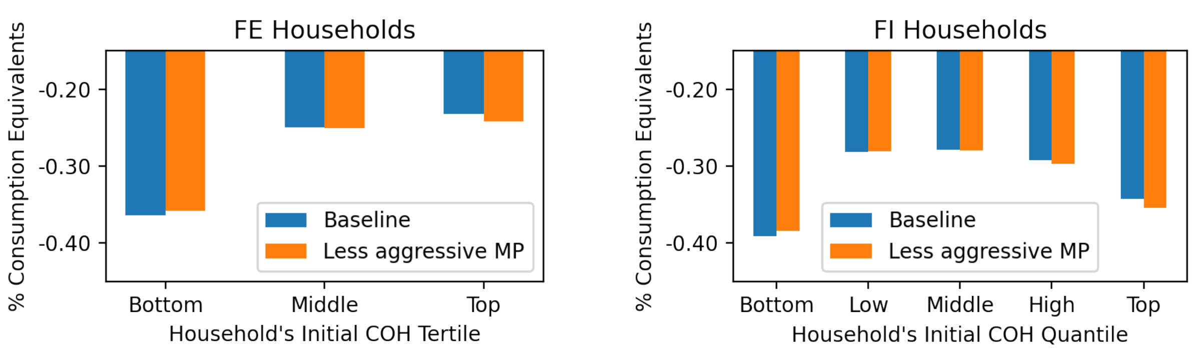
[27] Appendix H shows the impulse response functions of all variable under the counterfactual scenarios.

holds at the bottom of the COH distribution (figure 9). In terms of consumption equivalents, the welfare decline is only 0.005 percentage points smaller than in the baseline. At the same time, the negative impact of the shock is more pronounced for households with higher COH positions. This is due to two offsetting effects on households. On the one hand, real wages drop more as a consequence of the higher inflation; on the other the smaller decline in output is associated with a lower drop in hours worked.

Figure 10 isolates these two opposing effects. All households would have suffered less in the scenario with a less aggressive monetary policy, if it didn't imply a larger drop in real wages, as expected. If, instead of fixing real wages to the baseline, we fixed labor demand the effects would be more nuanced: low COH households would suffer more, while the opposite would be true for high COH households. The reason underlying this result is that, for low COH households, the positive gain out of higher income only marginally overcomes the negative effect from more hours worked. These households need as many resources as possible to sustain their consumption after the shock, unlike higher COH households. Hence, it is this differential impact of higher hours worked that explains the different welfare effects in figure 9.

Monetary policy with interest rate smoothing This section evaluates the counterfactual responses if the monetary authority followed an interest-rate smoothing rule, which im-

Figure 9: Comparison of the welfare impact of the shock - Less aggressive MP



Notes: The figure depicts the baseline (blue) and counterfactual (orange) welfare effect of the import price shock with a less aggressive monetary policy stance. Households are ranked based on their initial COH (tertiles in the left panel for financially excluded households, quantiles in the right panel for financially included households).

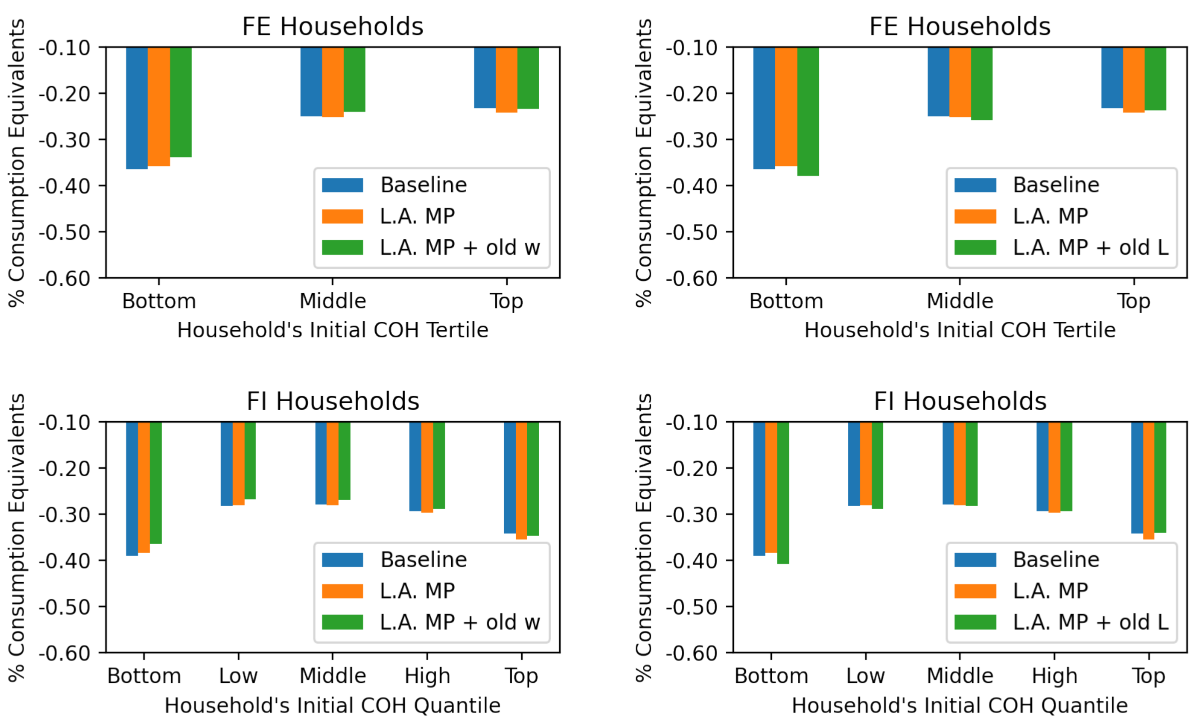
plies a gradual response to changes in the inflation rate. We capture this behavior with the following Taylor rule:

$$i_t = \rho i_{t-1} + (1-\rho)[r^* + \phi_\pi \pi_t] \tag{36}$$

where ρ, set to 0.5 in the calibration, dictates the degree of smoothness. Relative to the baseline and the previous exercise, the central bank is now slower to respond, albeit as aggressive as in the baseline scenario.

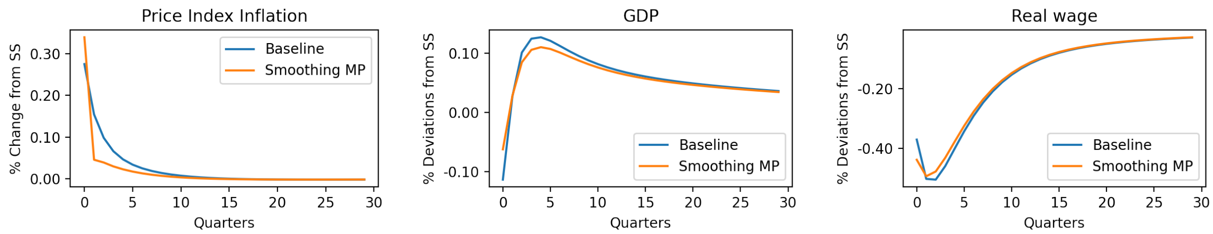
With interest rate smoothing, inflation increases more than in the baseline on impact, but declines faster (see figure 11 and Appendix I). The reason for the higher inflation on impact is the slower response of the central bank, which allows inflation to spike. The subsequent faster decrease in inflation is due to the shifts in the timing of aggregate demand movements. Households do not decrease their consumption as much as in the baseline on impact, though the consumption decline is more pronounced in subsequent periods.

Figure 10: Counterfactual effect of the shock - Less aggressive MP



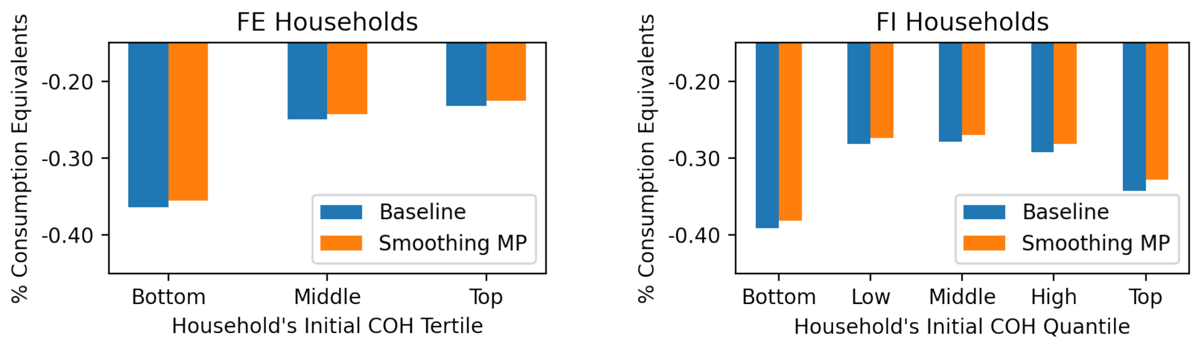
Notes: The figure depicts the baseline (blue) and counterfactual (orange) welfare effect of the import price shock with a less aggressive monetary policy stance. The green bars show the counterfactual welfare effect that would materialize if there had been a less aggressive monetary policy response together with the same movement in real wages (left-side charts) or labor (right-side charts) as in the baseline scenario.

Figure 11: Response of aggregate variables - MP with rate smoothing



Notes: The figure depicts the baseline (blue) and counterfactual (orange) responses of inflation (left), output (middle) and the real wage (right) in deviations from their steady-state levels. The counterfactual responses rely on the monetary policy rule entailing interest rate smoothing as expressed in equation 36.

Figure 12: Comparison of the welfare impact of the shock - MP with rate smoothing

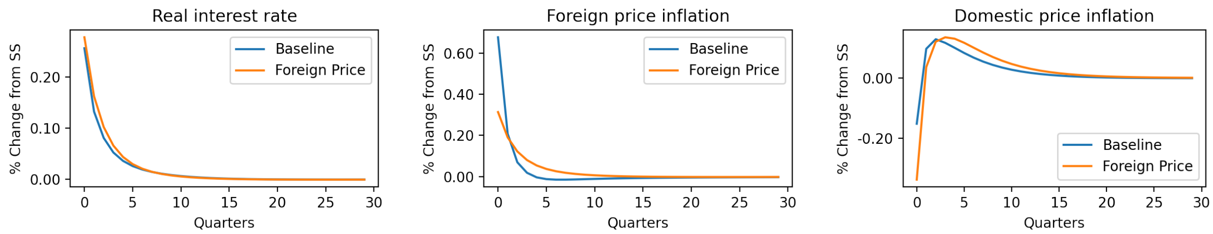


Notes: The figure depicts the baseline (blue) and counterfactual (orange) welfare effect of the import price shock with an interest rate smoothing monetary policy rule. Households are ranked based on their initial COH (tertiles in the left panel for financially excluded households, quantiles in the right panel for financially included households).

This mechanism explains the movements in inflation and in GDP, which drops by less on impact and has a more muted rebound in subsequent periods. Finally, the response of the real wage mirrors the dynamics of inflation: it drops more on impact, when inflation is higher, but recovers faster thanks to the lower inflationary pressures in the following periods.

Compared to the baseline, the decline in the welfare of all agents is smaller under the interest rate smoothing rule (Figure 12). The reason is the behavior of the real wage, which tends to benefit all households and, for FI agents, the lower drop in output and, hence, the lower decline in equity value, which benefits the high COH households.

Figure 13: Response of aggregate variables I - MP with foreign price inflation target



Notes: The figure depicts the baseline (blue) and counterfactual (orange) responses of the real interest rate (left), foreign price inflation (middle) and domestic price inflation (right) in deviations from their steady-state levels. The counterfactual responses rely on the monetary policy rule that targets foreign price inflation as in equation 37.

Monetary policy targeting imported goods price inflation. This section evaluates the case in which the central bank targets the source of inflationary pressures, namely imported goods prices. The Taylor rule in this scenario is:

$$i_t = r^* + \phi_\pi \pi_{F,t} \tag{37}$$

where $\pi_{F,t} = P_{F,t}/P_{F,t-1} - 1$ is foreign price inflation.

Under this rule, the central bank hikes the policy rate by more in response to the shock in order the contain the most affected part of the price index (see figure 13 and Appendix J). Consequently, foreign goods price inflation increases significantly less compared to the baseline, while domestic price inflation declines more. Due to higher increase in the real rate, the central bank triggers a deeper recession, leading to a larger decrease in the demand for home-produced goods.

Since the inflation rate of domestic goods declines, while the inflation of imported goods rises, inflation is mostly unchanged on impact, and only increases in subsequent periods. Output drops more in this scenario since the central bank has to depress demand by a larger amount to contain the rise in import prices. Finally, despite the larger drop in labor demand, which leads to lower wages, the smaller rise in inflation in the immediate aftermath of the shock leads to an lower decline in the real wage.

With the central bank targeting foreign goods inflation, the shock generally leads to larger welfare losses compared to the baseline (Figure 15). As shown in Appendix L, *FE* households benefit from the new dynamics of real wages, but the drop in labor demand is particularly harmful to those with low COH. For high COH, FI households, two opposing effects keep welfare losses similar to those in the baseline. On the one hand, they face larger decline in equity values. On the other hand, the real interest rates are relatively higher. As a result, their investment income is pretty much unchanged compared to the baseline.

Monetary policy targeting domestic price inflation. Finally, we evaluate the case in which the monetary authority targets only domestic prices, according to the following Taylor rule:

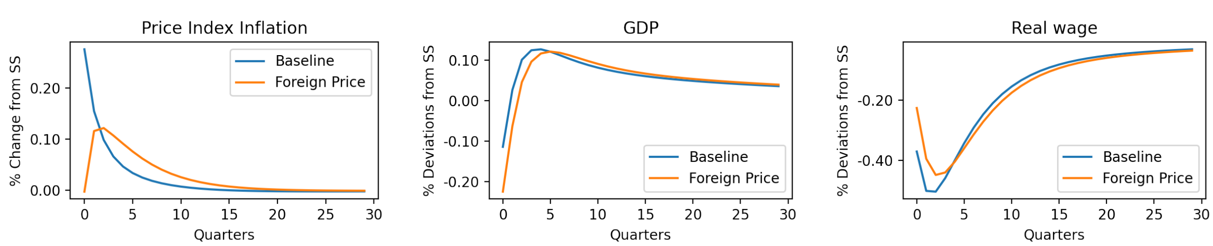
$$i_t = r^* + \phi_\pi \pi_{H,t} \tag{38}$$

with $\pi_{H,t}$ following the usual definition.

This analysis allows us to compare our findings with those of the literature on monetary policy and subsistence. In the representative agent context analyzed in Portillo et al. (2016), optimal policy calls for the stabilization of sticky prices non-food inflation, roughly correspondent to core inflation, even in the presence of subsistence. In our model, given that imported goods can be interpreted as food, the stabilization of "core" prices would correspond to monetary policy targeting only domestic prices.

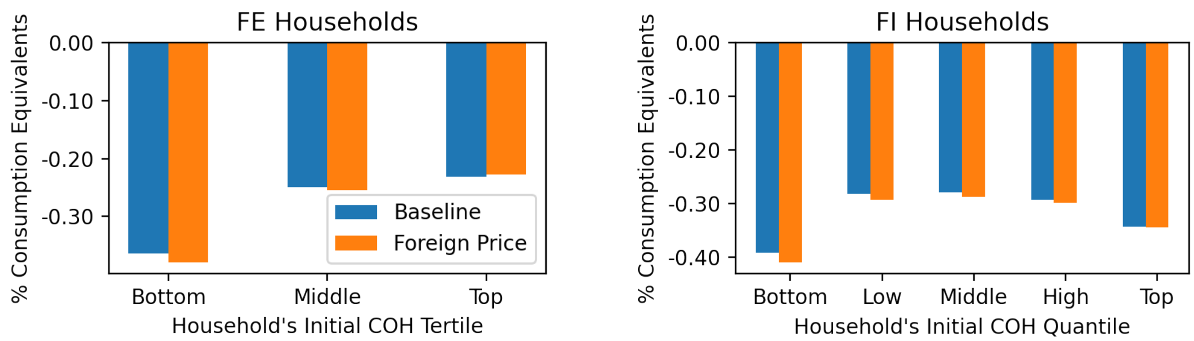
With the monetary authorities responding to domestic inflation, the path of interest rates is smoother than in the baseline as the central bank "sees through" the imported goods price shock and reacts to potential contamination of "core" inflation (see figure 16 and Appendix K). This shapes the dynamics of other key variables, with the economy taking a

Figure 14: Response of aggregate variables II - MP with foreign price inflation target



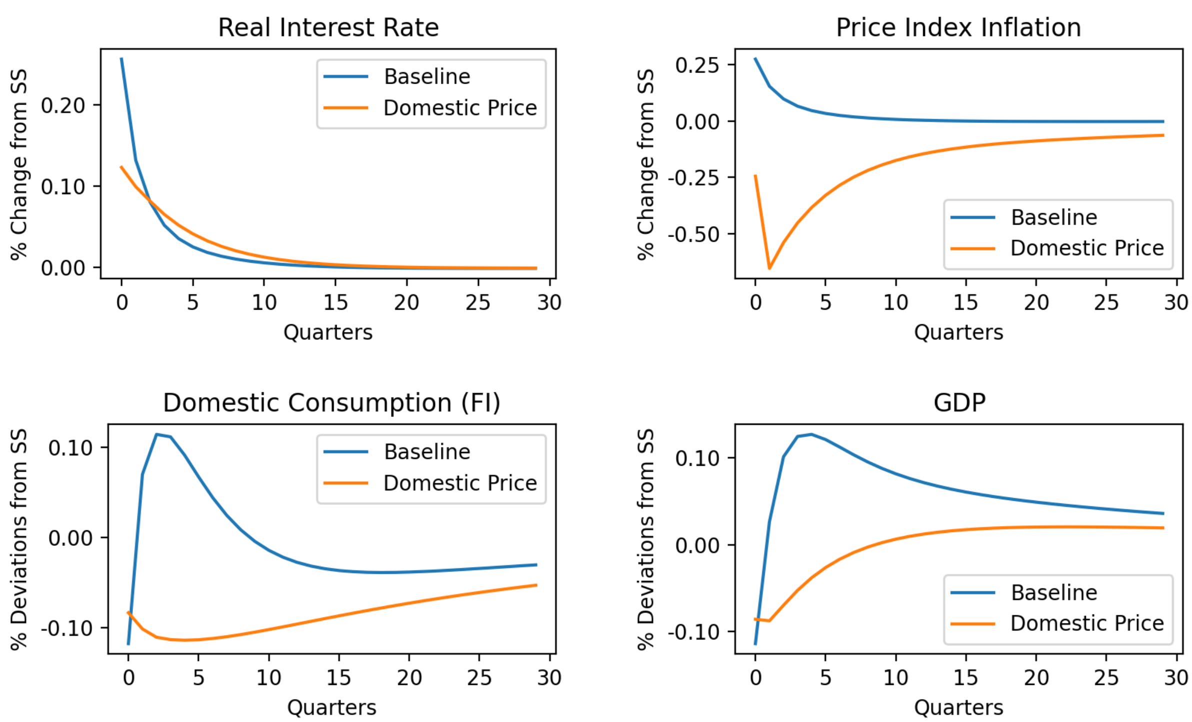
Notes: The figure depicts the baseline (blue) and counterfactual (orange) responses of inflation (left), output (middle) and the real wage (right) in deviations from their steady-state levels. The counterfactual responses rely on the monetary policy rule that targets foreign price inflation as in equation 37.

Figure 15: Comparison of the welfare impact of the shock - MP with foreign price target



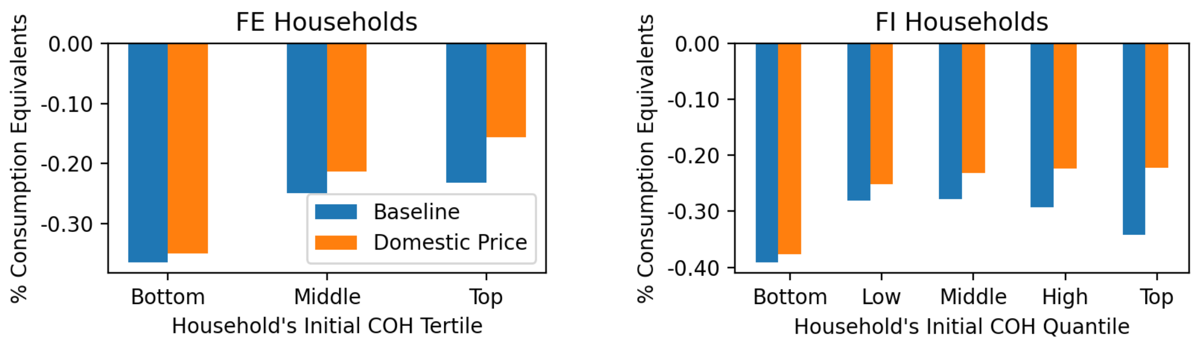
Notes: The figure depicts the baseline (blue) and counterfactual (orange) welfare effect of the import price shock with a monetary policy rule that targets import price inflation. Households are ranked based on their initial COH (tertiles in the left panel for FE households, quantiles in the right panel for FI households).

Figure 16: Response of aggregate variables - MP with domestic price inflation target



Notes: The figure depicts the baseline (blue) and counterfactual (orange) responses of inflation (left), output (middle) and the real wage (right) in deviations from their steady-state levels. The counterfactual responses rely on the monetary policy rule that targets domestic price inflation as in equation 38.

Figure 17: Comparison of the welfare impact of the shock - MP with domestic price target



Notes: The figure depicts the baseline (blue) and counterfactual (orange) welfare effect of the import price shock with a monetary policy rule that targets domestic price inflation. Households are ranked based on their initial COH (tertiles in the left panel for FE households, quantiles in the right panel for FI households).

smoother path. The lower initial increase in interest rates leads to a smaller intertemporal substitution of the domestic goods, especially by FI households, leading to a smaller drop in GDP.

The rule achieves a smaller welfare loss for all households compared to the baseline (see Figure 17). While the paths of GDP and domestic consumption should imply decreases in utility, the fact that consumers are able to smooth their consumption more increases their welfare, and consumption of the foreign good is higher. This is associated with higher real wages for FE agents and higher interest rates, which benefit returns on assets of FI agents.

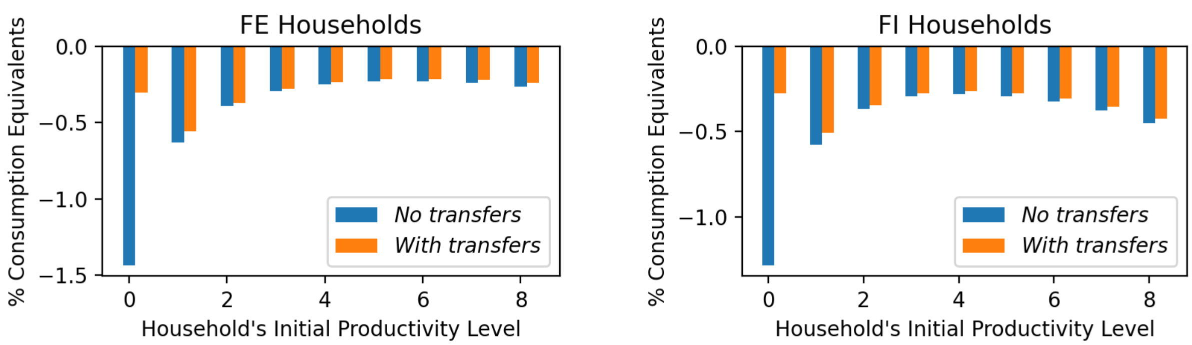
3.5 The Role of Transfers

While the previous sections focused on monetary policy, fiscal policy could be another tool to alleviate welfare loss for households in the bottom of the distribution of income in response to a shock to imported goods prices.[28] In our model, the lowest COH households

[28] It is well established that fiscal policy is better suited than monetary policy to address inequality, given its ability to directly redistribute resources through taxation and transfers and, within the context of HANK models, given its ability to provide insurance across households (Del Negro et al., 2022; Bhandari et al., 2021; Heathcote et al., 2020; Bénabou, 2000). The analysis presented in this section confirms these results within the context of a LIC subject to an external shock.

suffer greater welfare losses when imported goods prices rise. We simulate a scenario in which, in addition to monetary policy behaving as in the baseline exercise, the government collects the same amount of taxes to sustain a zero deficit. However, instead of taxing households of all income levels according to their productivity, it provides positive transfers to those at the bottom of the income distribution, financed by higher taxes to the richer households. While the result for macroeconomic variables is almost the same as in the baseline, the government is able to offset a large part of the shock to those in the bottom of the distribution of income.[29] Because of general equilibrium effects, this policy seems to be Pareto improving, given that the other groups also present a reduced loss of consumption equivalents.[30,31]

Figure 18: Using transfers to offset distributional effects of shocks



Notes: The figure depicts the baseline (blue) and counterfactual (orange) consumption equivalent by productivity distribution after a shock to foreign prices. In the baseline, all households are taxed according to their productivity, while in the counterfactual households at the bottom of the productivity distribution receive positive transfers (negative taxes).

[29]This result echoes findings in International Monetary Fund (2023).

[30]Transfers increase consumption among lower-income households and reduce savings among higher-income households. In general equilibrium, these effects result in a smaller decline in output and real wages, benefiting households across the income distribution, as displayed in Appendix M.

[31]While our analysis is theoretical, its relevance to LICs must be interpreted with care since, in many of these economies, the feasibility of implementing finely targeted transfers is limited by structural constraints. These include large informal sectors, narrow tax bases, and weak administrative capacity, all of which restrict the state's ability to reach the poorest households (Bastagli et al., 2015). Consequently, our transfer experiments underscore the importance of improving the targeting capacity of fiscal systems in LICs.

4 Conclusion

In this paper we present an open economy HANK model with two relevant features for LICs. First, in addition to limited insurance of income shocks, a fraction of poor households have no access to financial markets. Second, poorer households spend a larger share of their resources on imported food items, which we model as a subsistence level of consumption for tradable goods. These characteristics are incorporated into the model to study monetary policy alternatives in response to a shock to imported goods prices. The use of complex HANK models allows us to study the role of the various sources of heterogeneity at the household level, which shape the macroeconomic effects of shocks in addition to bringing important distributional considerations. An additional contribution is calibrating the model to an average LIC, which differs in many ways from the usual calibrations from AEs or EMEs.

By analyzing the effects of a shock to external prices on macro aggregates and inequality, and how these can be mitigated by alternative monetary and fiscal policy responses through the lens of our model, three key findings emerge. First, the shock causes a consumption-led recession, an increase in inflation and a drop in real wages. Importantly, consumption inequality increases because poor households cannot insure against the shock and are more exposed to fluctuations in import prices because of subsistence consumption needs.

Second, monetary policy can shape the macroeconomic effects of the imported food price shock, to some extent. However, none of the alternative monetary policy reactions we analyze can meaningfully affect its distributional consequences. We explore several scenarios, such as a less aggressive monetary policy stance, targeting import or domestic prices instead of the whole price index, and smoothing the reaction of the central bank. These alternative reactions do not disproportionately protect poorer households by much, given their offsetting effects on real wages and labor demand. A possible exception is targeting domestic prices, which, in our model, corresponds to core inflation. The benefit of targeting core inflation has been documented in previous studies, under alternative modeling assumption. That said, while targeting core inflation is associated with the smallest welfare losses and increases in inequality among the alternatives considered, the poorer still suffer the most. Third, we find that a more effective policy tool for addressing distributional concerns might be beyond monetary policy. Fiscal transfers to the poorer seem to work well, without major decrease in the welfare of other income groups.

LICs have many idiosyncratic characteristics, including several that our model does not incorporate, such as informality and incomplete markets. Here we chose to focus on two key characteristics that we believe are the main source of economic frictions: limited financial market participation and subsistence preferences. Beyond LICS, our framework is applicable to all economies, that may face similar constraints as those featured in the model. In many cases, the main difference between LICs and emerging market economies could be reflected by different calibration. Further studies would provide a deeper understanding of differences between groups of countries, but his works already provides insights on the specificity of monetary policy in LICs, including elements of the transmission mechanism outside the control of policymakers. One additional important topic for future research is a full treatment of fiscal policy, including the possibility of fiscal dominance, which is a perennial issue in LICs and emerging economies.

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A Model and Solution Method

A.1 Quantitative Implementation: Transitional Dynamics

After we send a shock into the model, the algorithm proceeds in the following manner to find a solution:

1. Guess a path for Y_t, π_t, K_t
2. Given a path for π_t, we can use monetary policy (29) to back out a path for the real rate r_t
3. Given a path for r_t and one for i_t^*, which is exogenous in our framework, the UIP condition (24) gives us a path for the real exchange rate, $\mathcal{Q}_t$
4. Given a path for $\mathcal{Q}_t$, we can back out a path for $\frac{P_{H,t}}{P_t}, P^*_{H,t}, \frac{P_{F,t}}{P_t}$ using equations (18), (19), (20)
5. Given a path for $\frac{P_{H,t}}{P_t}$ and one for π_t, we can back out the path of domestic goods inflation, π_t^H
6. Given a path for r_t and $\frac{P_{H,t}}{P_t}$, the tax rule (27) gives us a path for T_t (importantly, we keep G_t fixed to its steady state level)
7. Given a path for Y_t, π_t^H, K_t, we can back out a path for the marginal product of capital r_t^k, the real wage w_t, and labor demand L_t using equations (11), (12) and the firm's Cobb-Douglas production function
8. Given a path for π_t and w_t, we can solve for the path of π_t^W using the definition of the real wage
9. Given a path for K_t we can back out a path for investment I_t using the law of motion of capital, a path for the investment firm's adjustment cost using its definition, and a path for q_t using equation (22)
10. Given a path for $r_t, w_t, \frac{P_{H,t}}{P_t}, \frac{P_{F,t}}{P_t}, T_t$, we can solve the household problems and obtain paths of A_t, C_t and IM_t[32]

[32]To solve the household problems we need to make an assumption about how taxes are levied on differ-

11. Given a path for $P^*_{H,t}$, equation (14) gives us a path for $C^*_{H,t}$
12. Given a path for r_t and TB_t, equation (30) allows us to back out a path for nfa_t
13. Finally, given a path for C_t, L_t, π^W_t, w_t, we can check whether the NKPC (10) holds.

Following these steps, we obtain all variables that are necessary to check whether the assets market in equation (33) hold, together with the NKPC (10) and the investment firm's optimality condition (23) (by Walras' law, the goods market will clear as well). If the equations hold, our guesses for Y_t, π_t and K_t were correct. If this is not the case, we update the guesses following a Newton's method as specified in Auclert et al. (2021), which lets the code converge in a few steps.

A.2 Current Account

This appendix shows that Walras' law implies, in our setting, that the CA identity will hold. To see this, start by aggregating up the budget constraints of financially included and excluded households:

$$\alpha\left(\frac{P_{H,t}}{P_t}C^P_{H,t} + \frac{P_{F,t}}{P_t}C^P_{F,t}\right) + (1-\alpha)\left(\frac{P_{H,t}}{P_t}C^R_{H,t} + \frac{P_{F,t}}{P_t}C^R_{F,t} + A^R_t\right) =$$
$$(1+r_{t-1})A_{t-1} + w_t\int n_{i,t}e_{i,t}di - \frac{P_{H,t}}{P_t}Tax_t$$

Assets market clearing implies:

$$\alpha\left(\frac{P_{H,t}}{P_t}C^P_{H,t} + \frac{P_{F,t}}{P_t}C^P_{F,t}\right) + (1-\alpha)\left(\frac{P_{H,t}}{P_t}C^R_{H,t} + \frac{P_{F,t}}{P_t}C^R_{F,t}\right) + B_t + nfa_t + q_tK_t =$$
$$(1+r_{t-1})(B_{t-1} + nfa_{t-1} + q_{t-1}K_{t-1}) + w_t\int n_{i,t}e_{i,t}di - \frac{P_{H,t}}{P_t}Tax_t$$

Moreover, the government's budget constraint (26), labor markets clearing, and the production function, imply:

$$\alpha\left(\frac{P_{H,t}}{P_t}C^{FE}_{H,t} + \frac{P_{F,t}}{P_t}C^{FE}_{F,t}\right) + (1-\alpha)\left(\frac{P_{H,t}}{P_t}C^{FI}_{H,t} + \frac{P_{F,t}}{P_t}C^{FI}_{F,t}\right) + (1+r_{t-1})B_{t-1} + \frac{P_{H,t}}{P_t}G_t$$
$$-\frac{P_{H,t}}{P_t}Tax_t + nfa_t = \quad (1+r_{t-1})(B_{t-1} + nfa_{t-1}) + w_tL_t - \frac{P_{H,t}}{P_t}Tax_t$$

ent households. We assume that these are allocated proportionally to an agent's idiosyncratic productivity level, $e_{i,t}$. As a consequence, more productive households pay higher taxes.

Additionally, the firm's zero-profits condition implies that: $w_t L_t = \frac{P_{H,t}}{P_t} Y_t - \frac{P_{H,t}}{P_t} r_t^K K_{t-1}$. Substituting this and the firm's FOC into the previous equation, we get:

$$\alpha\left(\frac{P_{H,t}}{P_t}C^{FE}_{H,t} + \frac{P_{F,t}}{P_t}C^{FE}_{F,t}\right) + (1-\alpha)\left(\frac{P_{H,t}}{P_t}C^{FI}_{H,t} + \frac{P_{F,t}}{P_t}C^{FI}_{F,t}\right) + (1+r_{t-1})B_{t-1} + \frac{P_{H,t}}{P_t}G_t - \frac{P_{H,t}}{P_t}Tax_t +$$

$$nfa_t + q_t K_t =$$

$$(1+r_{t-1})(B_{t-1} + nfa_{t-1} + q_{t-1}K_{t-1}) + \frac{P_{H,t}}{P_t}Y_t - \frac{P_{H,t}}{P_t}r_t^K K_{t-1} - \frac{P_{H,t}}{P_t}Tax_t$$

Simplifying:

$$\alpha\left(\frac{P_{H,t}}{P_t}C^{FE}_{H,t} + \frac{P_{F,t}}{P_t}C^{FE}_{F,t}\right) + (1-\alpha)\left(\frac{P_{H,t}}{P_t}C^{FI}_{H,t} + \frac{P_{F,t}}{P_t}C^{FI}_{F,t}\right) + \frac{P_{H,t}}{P_t}G_t + nfa_t + q_t K_t =$$

$$(1+r_{t-1})(nfa_{t-1} + q_{t-1}K_{t-1}) - \frac{P_{H,t}}{P_t}r_t^k K_{t-1} + \frac{P_{H,t}}{P_t}Y_t$$

Substituting goods market clearing:

$$\alpha\left(\frac{P_{H,t}}{P_t}C^{FE}_{H,t} + \frac{P_{F,t}}{P_t}C^{FE}_{F,t}\right) + (1-\alpha)\left(\frac{P_{H,t}}{P_t}C^{FI}_{H,t} + \frac{P_{F,t}}{P_t}C^{FI}_{F,t}\right) + \frac{P_{H,t}}{P_t}G_t + nfa_t + q_t K_t =$$

$$(1+r_{t-1})(nfa_{t-1} + q_{t-1}K_{t-1}) + \frac{P_{H,t}}{P_t}\left(C_t + C^*_{H,t} + G_t + I_t + \Xi_t\right) - \frac{P_{H,t}}{P_t}r_t^k K_{t-1}$$

Re-arranging and simplifying:

$$\underbrace{\alpha\left(\frac{P_{F,t}}{P_t}C^{FE}_{F,t}\right) + (1-\alpha)\left(\frac{P_{F,t}}{P_t}C^{FI}_{F,t}\right)}_{IM_t} + nfa_t + q_t K_t =$$

$$= (1+r_{t-1})(nfa_{t-1} + q_{t-1}K_{t-1}) + \underbrace{\frac{P_{H,t}}{P_t}C^*_{H,t}}_{EX_t} - \frac{P_{H,t}}{P_t}r_t^k K_{t-1} + \frac{P_{H,t}}{P_t}(I_t + \Xi_t)$$

Substitute the law of motion for capital to get:

$$-TB_t + nfa_t + q_t K_t = (1+r_{t-1})(nfa_{t-1} + q_{t-1}K_{t-1}) - \frac{P_{H,t}}{P_t}r_t^k K_{t-1} + \frac{P_{H,t}}{P_t}\left(K_t - (1-\delta)K_{t-1} + \Xi_t\right)$$

Note that we can re-write the investment firm's FOC (23) as:

$$q_{t-1}(1-r_{t-1})K_{t-1} = \frac{P_{H,t}}{P_t}\left[r_t^K K_{t-1} - \Xi_t - K_t + (1-\delta)K_{t-1}\right] + q_t K_t$$

Substituting this into the previous equation, we obtain:

$$-TB_t + nfa_t = (1+r_{t-1})nfa_{t-1} \Rightarrow CA_t = nfa_t - nfa_{t-1} = TB_t + r_{t-1}nfa_{t-1}$$

A.3 Investment Firm

Per period profits and the adjustment cost are given by:

$$
\begin{aligned}
\Pi_t^{Inv} &= \left(r_t^k K_t - I_t - \Xi_t\right) \frac{P_{H,t}}{P_t},\\
\Xi_t(I_t, K_t) &= \frac{\zeta}{2}\left(\frac{(1-\delta)K_t + I_t}{K_t} - 1\right)^2 K_t,
\end{aligned}
$$

Define $R_t := \prod_{i=0}^{t} \frac{1}{1+r_i}$. The problem of the firm is given by

$$
\max_{\{I_t, K_{t+1}\}_{t=0}^{t=\infty}} \sum_{t=0}^{\infty} \frac{\left(r_t^k K_t - I_t - \Xi_t(K_t, I_t)\right) \frac{P_{H,t}}{P_t}}{R_t}
$$

subject to $K_{t+1} = (1-\delta)K_t + I_t$. The first order condition with respect to I_t is given by:

$$
q_t = \left[1 + \zeta\left(\frac{K_{t+1}}{K_t} - 1\right)\right] \frac{P_{H,t}}{P_t} = \left[1 + \frac{d\Xi_t(I_t, K_t)}{dI_t}\right] \frac{P_{H,t}}{P_t}.
$$

The first order condition with respect to K_{t+1} is given by:

$$
q_t = \frac{\frac{P_{H,t+1}}{P_{t+1}}}{(1+r_{t+1})}\left[\left(r_{t+1}^k - \frac{\zeta}{2}\left(\frac{K_{t+2}}{K_{t+1}} - 1\right)^2 - \zeta\left(\frac{K_{t+2}}{K_{t+1}} - 1\right)\left(\frac{-I_{t+1}}{K_{t+1}}\right)\right)\right] + \frac{q_{t+1}(1-\delta)}{(1+r_{t+1})}.
$$

which is exactly:

$$
q_t = \frac{\frac{P_{H,t+1}}{P_{t+1}}}{(1+r_t)}\left[\left(r_{t+1}^k - \frac{d\Xi_{t+1}(K_{t+1}, I_{t+1})}{dK_{t+1}}\right)\right] + \frac{q_{t+1}(1-\delta)}{(1+r_t)}.
$$

B Background for the calibration of the parameter $\bar{c}$ for subsistence

The calibration of the parameter $\bar{c}$ in our model is based on the relative imports of staple foods by LIDCs. According to our calculations (explained below), LIDCs' imports of staple foods is equivalent to 10% of their consumption basket, a similar figure to that of emerging markets (EMEs), but three times higher than for advanced economies (AEs).

The Food and Agricultural Organization of the United Nations (FAO) provides the minimal number of calories a person must consume to avoid undernourishment. Below this threshold, the average person is not achieving minimum dietary energy requirements to maintain a normal, active and healthy life. The FAO provides country-specific levels of minimum consumption of calories to avoid undernourishment, since the requirement vary with average age as well as genre composition of populations.

The FAO also publishes a Food Balances database, with detailed information on quantity of food items produced, imported and consumed by each country, as well as the number of calories provided by each item. The level of desegregation is rich and the database spans all the main food items from consumption baskets of the countries covered.

For each country, we rank food items according to their contribution to food intake for the period 2015-2019. We then check how many food items are necessary to achieve a level just above undernourishment. These items compose our country-specific baskets of staple foods, since they are the ones that the countries' populations need to overcome undernourishment. Figure 19 shows the main staples for each LIDC. As expected, some items are more important in different parts of the world, according to cultural traditions and local factors of production (such as rice in Asia), but rice, wheat and maize are relevant items for most countries. Countries such as Benin are less dependent on one specific staple food, having a more diversified diet, and in theory could be less vulnerable to shocks to the price of a specific food item.

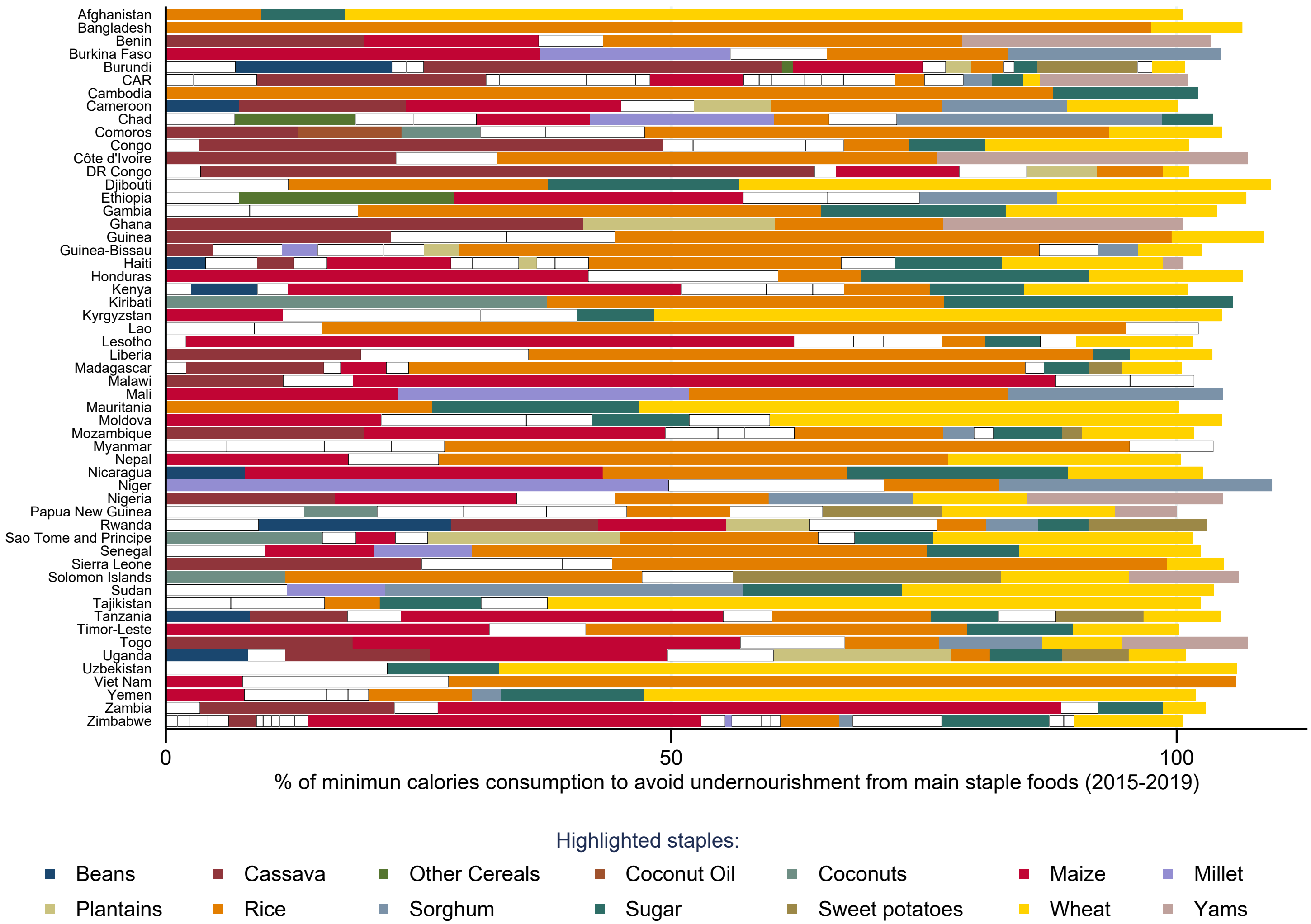


Figure 19: Main staple foods used to achieve consumption above undernourishment.

Notes: According to FAO, undernourishment means that a person is not able to acquire enough food to meet the daily minimum dietary energy requirements, over a period of one year. Source: FAOSTAT Food Balances and authors' calculations.

Using the information on what staples are relevant for each country, we then proceed to calculate how much countries import of those food items. Using the share of food as a percentage of their consumption basket (from the IMF's IFS), we calculate how much countries depend on the imports of staple foods (figure 20). AEs dependence on imports for staple foods is minimal, with an average of 2.5% of their consumption basket and most countries in this group import less than 10% of their needs (with just one exception). EMEs and LIDCs are much more dependent on imports, with averages (and medians) closer to 10% of their consumption basket. LIDCs are a particularly heterogeneous group, with at least 10% of the countries importing a quarter of their staple foods. We use the World Bank

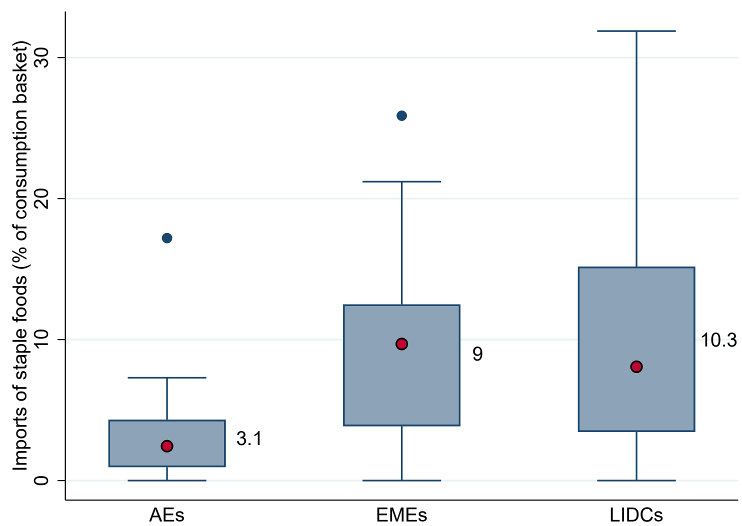


Figure 20: Import of staple food by country classification as % of their consumption baskets.

Notes: Floating numbers represent averages. Source: FAOSTAT Food Balances, WB Consumption Database and authors' calculations.

consumption database (for a more restricted sample of countries) to also analyze imports' dependence of staple goods by level of income within each group. The pattern is similar. Poorest households are the ones that depend more on imports for the consumption of staple foods required for subsistence. This is in sharp contrast with imports of luxury goods consumed by households in the top of the income distribution. The lowest level of income per capita in LIDCs imports the equivalent of 13% of their consumption basket in staple foods, in comparison to 5.5% of the same stratum in AEs. The higher level of income in LIDCs average imports of staple foods is equivalent to 4.8% of their consumption basket, in comparison to almost 2% for those in AEs. To further investigate the dependence of

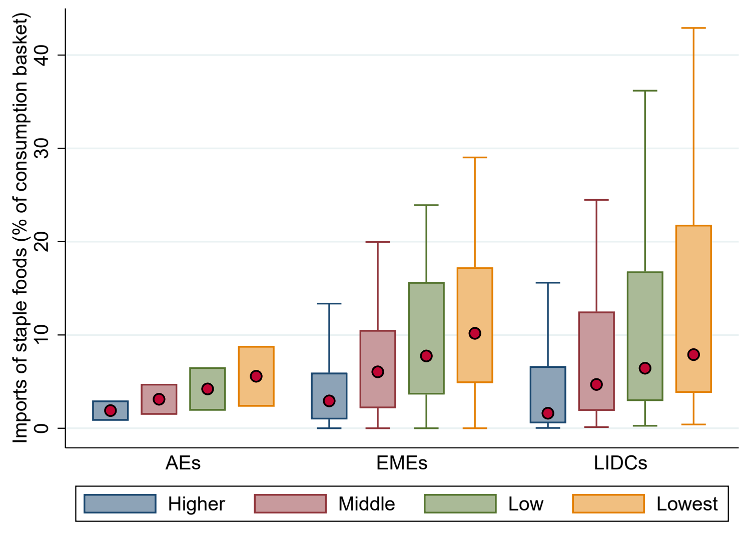


Figure 21: Import of staple food by country classification and income as % of their consumption baskets.

Notes: No outsides. The four levels of consumption used to segment the market in each country correspond to the rank of the global population by income per capita. 'Lowest' corresponds to 50th percentile and below; 'Low' to 51th–75th; 'Middle' to 76th–90th; and 'Higher' to 91st and above. The PPP$ thresholds per capita a day are: below 2.97 for 'Lowest', between 2.97 and 8.44 for 'Low', between 8.44 and 23.03 for 'Middle' and above 23.03 for 'Higher'. Source: FAOSTAT Food Balances, WB Consumption Database and authors' calculations.

staple food imports, we run regressions of the variable constructed above on a indicator variable for EMEs and LIDCs and progressively introduce controls that could explain why these countries are more dependent on imports for subsistence, testing if the new variables for each new specification are jointly significant. The coefficients of these regressions are represented in figure 22. Predictions based on the first specification without controls, as expected, show results similar to figure 20, with LICs dependence on imports three times higher than EMEs and around 10% of their consumption basket. The result does not change when the specification includes controls for population (in log) and for geographical characteristics: an indicator for small islands, percentage of land that is desert, average distance to nearest ice-free coast, and a population-weighted terrain ruggedness index. The last three indicators come from the database of Nunn and Puga (2012) (see also Unsal et al. (2022)). The ruggedness index is a proxy for the integration of domestic markets. In the case of food supply, it could help measure how difficult it is to transport food produced in one part of the country to other regions. All coefficients are significant at 5% levels and have the expected signs. Population works as a proxy for the size of the country, with a negative coefficient (measures of countries' area and density were not significant when included jointly with population). In the next step, we add an indicator variable for the African continent, meaning that the indicator variable for LIDCs covers only countries outside Africa. Results do not change by much and the African dummy is significant and positive: countries in Africa import on average more 3 percentage points of food for subsistence in their consumption basket. Results only change when the specification includes rule of law from the World Bank's Worldwide Governance Indicators database. When controlled for this variable, differences between group of countries, as represented by the indicator variable for LIDCs and EMEs, become non-significant. The channels by which rule of law can have an impact on the dependence of food imports are varied. Countries with lower levels of rule of law might be unable to adapt to new technologies to produce and distribute food more efficiently, leading to higher imports. Additionally, lower levels of rule of law might compromise availability of credit for agricultural production. Another channel might come from distorting taxes that are a consequence of governments' low fiscal capacity.

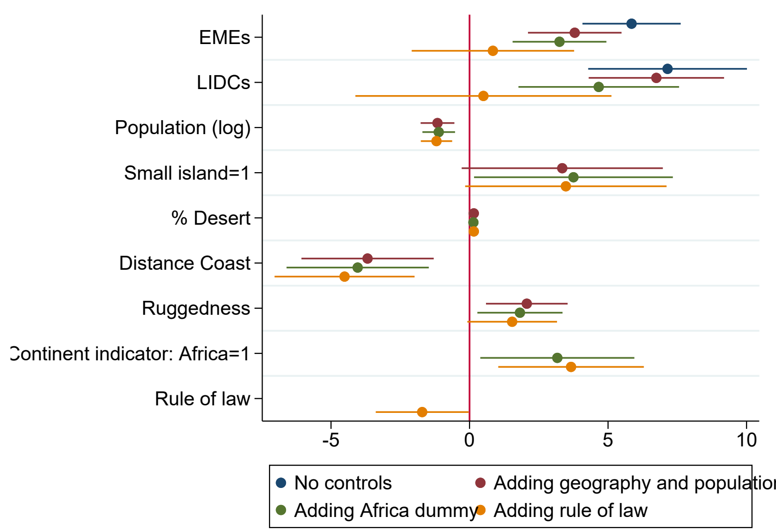


Figure 22: Coefficients of regressions using the import dependence of staple foods as dependent variable.

As a robustness exercise, we substitute the indicator variables for EMEs and LIDCs by GDP per capita and results are identical, in the sense that the higher the GDP, the lower is the dependence on food imports, even controlling by geographical characteristics and population. The exception, as in the basic specification above, is rule of law, which makes GDP per capita non-significant.

C Background for the calibration of the parameters ρ_l for persistence and σ_l for standard deviation of labour productivity.

As mentioned in the main text, in order to model idiosyncratic productivity risk, we follow the literature by assuming that the household's labor productivity, e, behaves accordingly to a AR(1) process $\log e_t = \rho_l \log e_t + \varepsilon_t$, with $\sigma_l = std(\varepsilon_t)$. Aggarwal et al. (2022a) mention that $\rho_l = 0.92$ and $\sigma_l = 0.6$ are typical estimates for these parameters, while aiming to calibrate the model for Mexico, an emerging market. Floden and Lindé (2001) seem to be the pioneers on estimating these parameters for the US and Sweden. Guerrieri and Lorenzoni (2017) also use the same estimates from the US, but transforming to quarterly frequency. Wöhrmüller et al. (2022) re-estimates Floden and Lindé (2001), but going beyond the wages of the head of the family. As far as our knowledge extends, there is no known estimation of these parameters for LICs.

We aim to fill this gap by using the ECG-ISSER Ghana Socieconomic Panel Survey (GSPS) to reproduce for Ghana the methodology of Floden and Lindé (2001). The survey was conducted in three waves in 2009/2010, 2013/2014, and 2017/2018, and follows individuals over time. Our measure of hourly wages derives from the variable *paid amount* and *paid other*, which refers to other types of payment. Because the amount received depends on the frequency of payment, we transform other frequencies of payment (such as quarterly and weekly) to hourly by dividing the amount by the number of weeks and days worked (these variables are available in the data set). In line with Floden and Lindé (2001), we assume that the lower bound for wages is 10% of the average wage and exclude all agents with less than 1000 work hours supplied. Table A1 shows the remaining values for wages in GHS (Ghanaian cedis) - $\overline{W}$ - as well as descriptive statistics for the constructed relative hourly wages w_t^i, which is agent i's hourly wage rate as a function of the average hourly wage rate in that wave. In comparison to the US and Sweden, the variability in the relative wages series is much larger and also increases more over time.

We follow the procedure of capturing permanent wage differences by individual specific characteristics such as age, education, and occupation. We regress the variable for (log of) hourly wages from the first wave on age, the square of age, a dummy variable for sex (equal to 1 if the individual's gender is male), and variables that are dummies for agents'

Table A1: Descriptive Statistics for Relative Wages

Statistic	Wave 1	Wave 2	Wave 3
$\overline{W}$	0.87	2.18	3.65
$Std(w^i)$	1.06	1.75	1.95
$Max(w^i)$	11.04	28.50	40.85
$Min(w^i)$	0.10	0.10	0.10

education levels and occupation. Results are in table A2. They are highly significant for age and sex and similar to those from the US and Sweden. For education, coefficients are positive, but those that refers to higher levels of education are more significant. Results for occupation are mixed, but generally positive coefficients are significant. The fit for both occupation and education are worse in comparison to Floden and Lindé (2001), maybe reflecting a smaller sample for the survey. Nonetheless, F-statistics are satisfactory and the adjusted r-square is reasonably high and similar to the regressions for Sweden and US. Results are similar when using robust standard erros, with significance improving substantially for all the coefficients of education levels.

Table A2: OLS Estimation Results for the Initial Relative Wage Level

	Initial Wage	
Variables	Estimate	Standard error
Age	0.0723***	(0.0139)
$Age^2/100$	-0.0675***	(0.0159)
Dmale	0.197***	(0.0595)
EDUC = 2	0.507	(0.751)
EDUC = 3	0.672	(0.749)
EDUC = 4	0.575	(0.745)
EDUC = 5	0.773	(0.748)
EDUC = 6	1.264*	(0.750)
EDUC = 7	1.321*	(0.747)
EDUC = 8	1.212	(0.747)
EDUC = 9	2.021*	(1.050)
EDUC = 10	1.770**	(0.755)
EDUC = 11	1.850**	(0.816)
OCC = 2	0.129	(0.125)
OCC = 3	0.506***	(0.138)
OCC = 4	0.431***	(0.154)
OCC = 5	-0.0192	(0.139)
OCC = 6	0.121	(0.185)
OCC = 7	0.331**	(0.137)
OCC = 8	-0.0158	(0.139)
OCC = 9	-0.187	(0.139)
Constant	-3.115***	(0.811)
Observations	847	
Adjusted R-squared	0.317	
F-test	19.69	
Prob > F	0.000	

Standard errors in parentheses

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

From the results of the regression in table A2, we calculate permanent wage component $\hat{\psi}^i = \hat{x}^i_{wave1}$ from the fitted values of the regression. The calculated variance of these differences (σ^2_{ψ}) is 0.1843, meaning that we find higher permanent wage differences between individuals in Ghana than Floden and Lindé (2001) find for the US. From there, we calculate $\tilde{x}^i_t \equiv x^i_t - \hat{\psi}^i$ for the the 3 waves. Summary statistics for the transformed variables are in table A3. In contrast to the US and Sweden, the variability actually increases in comparison to table A1. This means that in Ghana, after controlling for systematic factors, dispersion increases.

Table A3: Descriptive Statistics for Transformed Relative Wages

Statistic	Wave 1	Wave 2	Wave 3
$Std(w^i)$	1.20	4.76	3.84
$Max(w^i)$	15.63	59.55	53.62
$Min(w^i)$	0.11	0.05	0.06

We use $\tilde{x}^i_t$ to construct unconditional moment conditions (7) in Floden and Lindé (2001) and estimate ρ, σ^2_{ε} and σ^2_{ς} using the general method of moments. The three waves for the survey allows us to use 6 moments. Results are in table A4. The persistence of the series for hourly wage is high, precisely estimated, and not much different from the typical estimates from advanced economies in the literature. The variance of temporary shocks is higher than what is estimated in the literature for the US and Sweden, which might be expected in countries with less developed markets. The coefficient is not precise (p-value is 0.117).

As in Floden and Lindé (2001), over-identifying restrictions do not seem to hold. As mentioned by those authors, it is possible that the wage process we are using is too crude an approximation and that parameters are different for sub-samples of the population. As expected and showed above, heterogeneity across households should be even larger in LICs, and education premiums more pronounced. This could explain why the fit of the model is less precise than when estimating it with AE data. The main results are that, even thought the variance of wages and temporary shocks are somehow larger when estimating the model for LICs, persistence of wages is similar.

The estimates above are for annual the annual moments. To convert these to a quarterly AR(1) process, we use the expressions for the variance and covariance of the yearly average of a quarterly AR(1) process, as derived in Wöhrmüller et al. (2022).

Table A4: GMM Estimation Results for the Wage Process

Parameter	Estimate	Standard error
ρ	0.922***	(0.0377)
σ_{ε}^2	0.0503	(0.0321)
σ_{ξ}^2	0.135*	(0.0693)
χ_{obs}^2	18.38	
$p-value$	0.0004	

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

D Financial exclusion

Financial exclusion (λ) is a key parameter of the model, given the prevalence of limited financial market participation in Low-income Developing Countries (LIDCs). An analysis of the causes of financial exclusion is beyond the scope of this paper, but this appendix provides some background on what informed the calibration of the parameter λ. The Global Findex Database from the World Bank is the main source of information, as it is based on surveys with households in more than 160 countries. While the underlying microdata provides insights on different cleavages of the distribution of households, the aggregate indexes of financial inclusion are relevant to understand general patterns of financial inclusion.

Figure 23 below shows the distributions of countries classified by development level (advanced - AEs, emerging - EMEs, Low-Income Developing) in the 2024 Findex survey. The main question related to financial inclusion is if households have an account, which can be in a financial institution or in a mobile phone. As expected, advanced economies are very close to universal financial inclusion, with rates concentrated close to 100%. LIDCs are in the opposite extreme, with a median around 58%. The percentile 25% for LICDs is 43% while the percentile 75% is 63%. The use of 33% as the percentage of financially excluded households in the calibration of the model actually underestimates financial exclusion. One important aspect that might not be captured well in surveys is the widespread use of mobile accounts especially in Africa, which are responsible for the increase of financial inclusion in the last years. The median for households having a mobile account in LIDCs is 32%, but this can reach 87% in some countries. Figure 24 shows how financial inclusion increased in LIDCs in the several vintages of the Findex survey since 2011, with a major participation of mobile accounts.

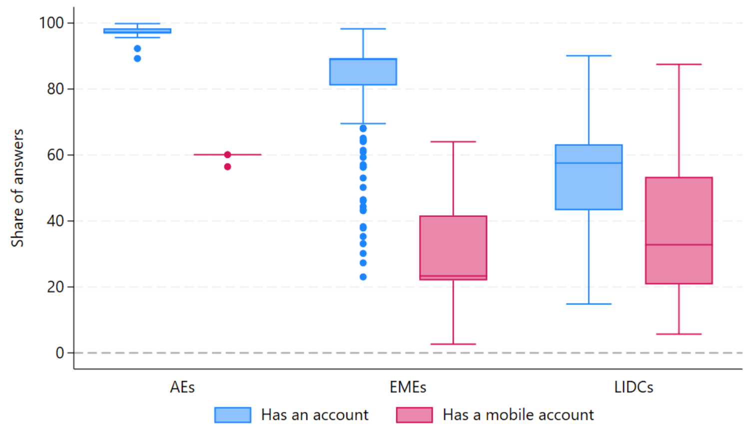


Figure 23: Share of respondents with an account in a financial institution and a mobile account in 2024.

Notes: Source: Global Findex Database and authors' calculations.

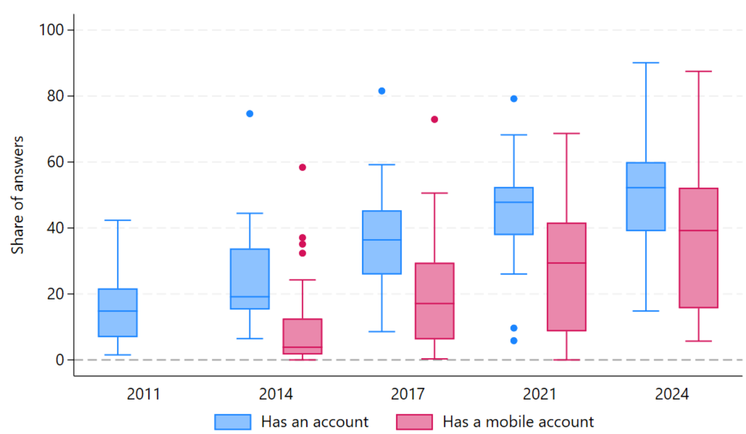
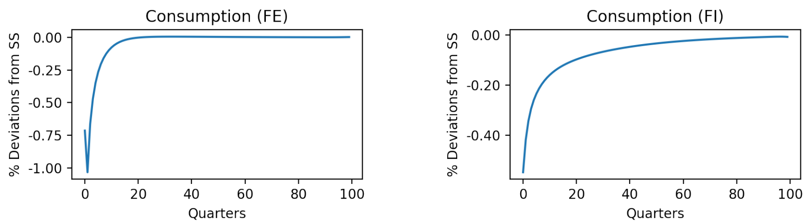


Figure 24: Share of respondents with an account in a financial institution and a mobile account in LIDCs.

Notes: Source: Global Findex Database and authors' calculations.

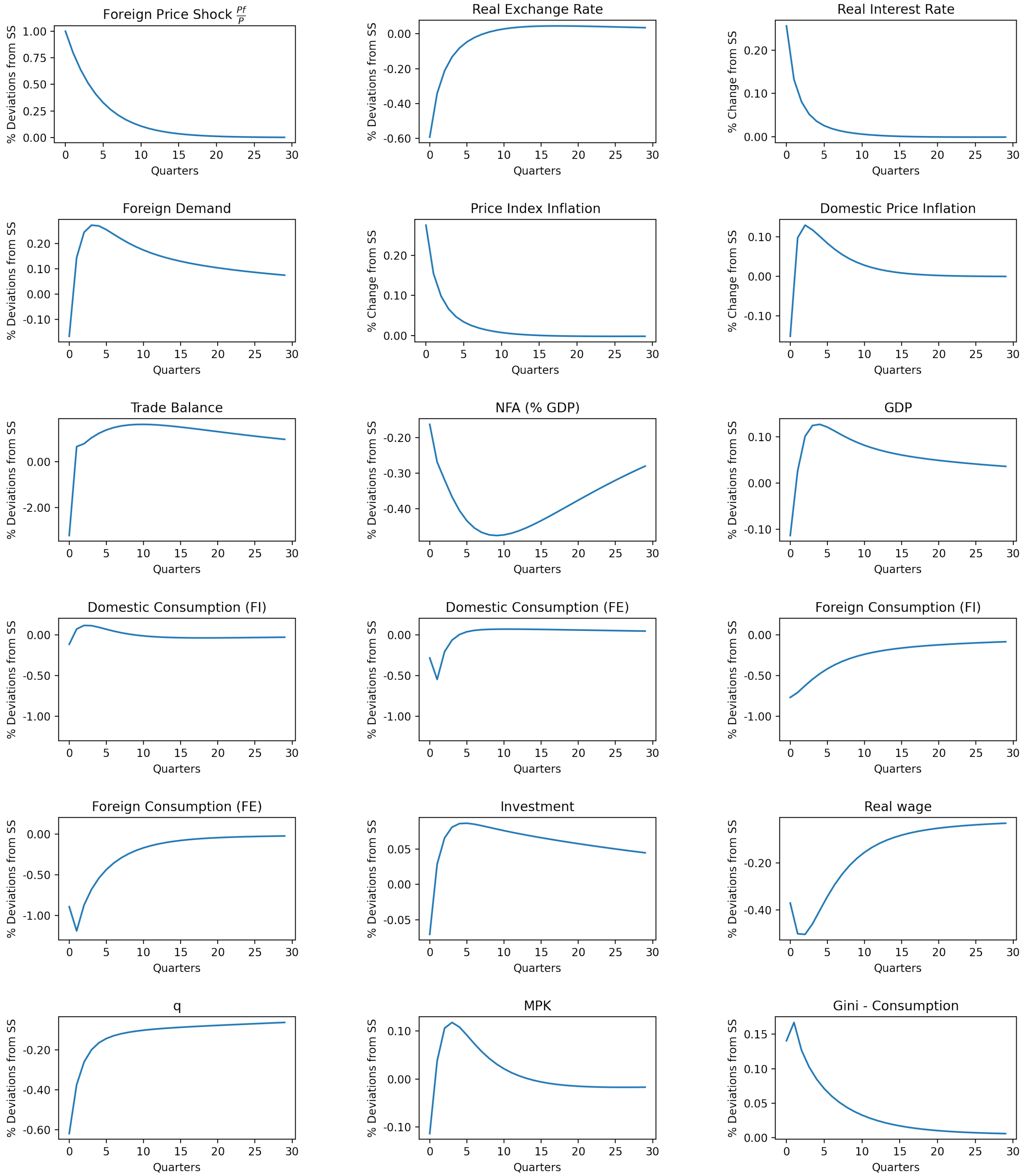
E IRFs of consumption for FI and FE households

Figure 25: IRFs of consumption



F Additional IRFs for the baseline exercise

Figure 26: IRFs to an exogenous increase in import prices



G Levels of subsistence

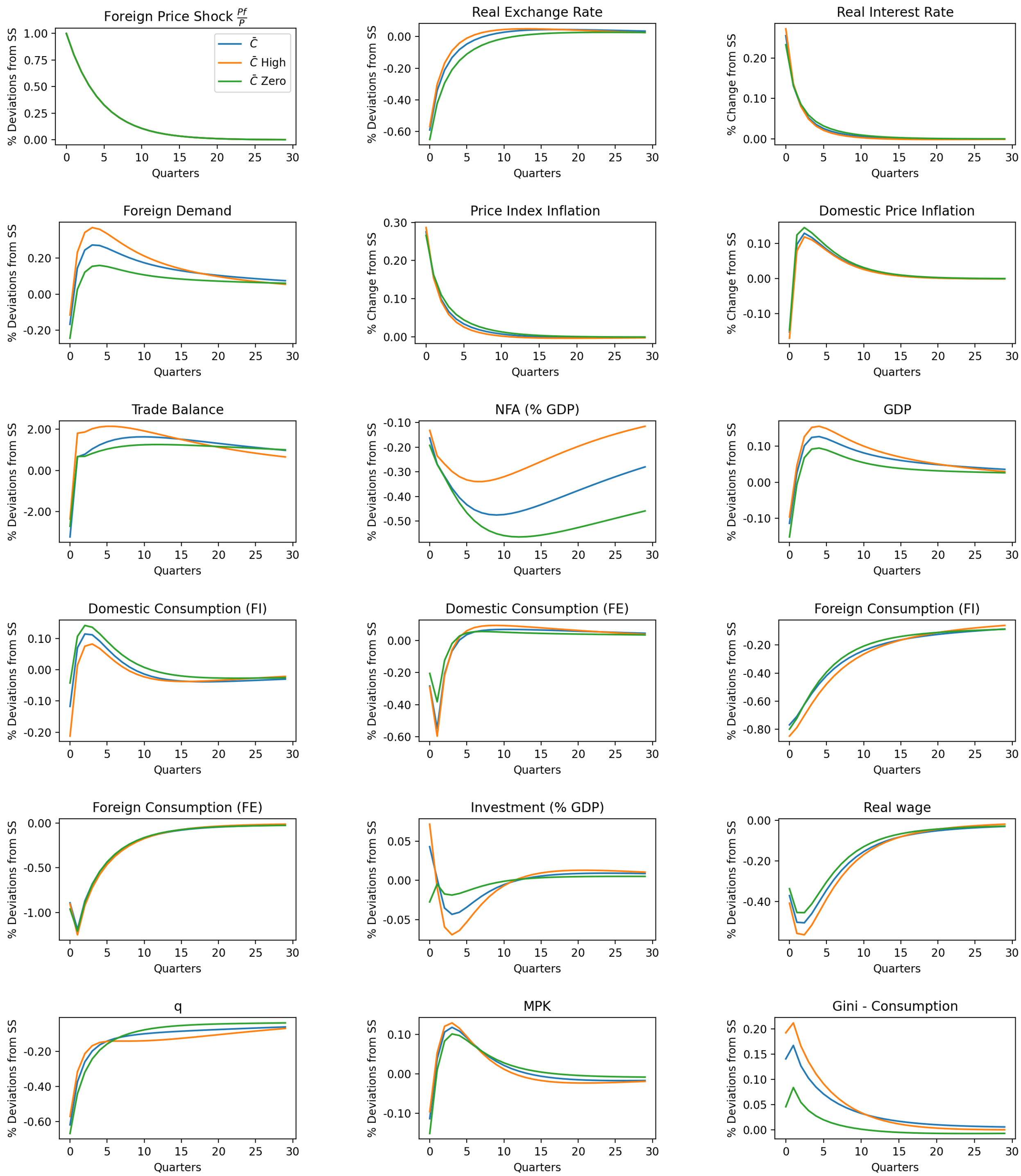
In this section, we analyse how the subsistence parameter $\bar{c}$ affects our baseline results. For this, in addition to the value of $\bar{c}$ used above (0.058), we present IRFs for a high $\bar{c}$ (0.068) and a $\bar{c}$ equal to zero.[33] The first one represents a society in which subsistence represents a higher of consumption. The case with a zero $\bar{c}$ corresponds to a society with no subsistence requirements. This allows us to analyze the importance of subsistence for the baseline results, as well as to compare those with models that do not contain that feature. These IRFs are in figure 27.

The direct effect of $\bar{c}$ on consumption is via two channels: disposable income and relative prices. When the subsistence requirement on the foreign good is loosened, it is natural that households will become more elastic to its consumption in comparison to the domestic good. At the same time, consumers' disposable income goes up, which means that households are able to consume more of both goods. As seen in the figure, when $\bar{c}$ is zero (i.e. lower subsistence level), financially excluded households switch between foreign and domestic goods - the fall in domestic good consumption by financially excluded households is less pronounced. Symmetrically, with a high $\bar{c}$, domestic consumption and domestic price inflation drop more on impact, with the associated lower prices leading to a lower drop in foreign demand/exports. These higher exports boost GDP after the first period. With lower levels of $\bar{c}$, the contribution of the external trade is weaker.

Given the dynamics in prices, the lower subsistence requirements are, the less the central bank needs to raise interest rates for the same shock on the price of the foreign good. This means that the presence of subsistence is a friction that decreases monetary policy power in a general equilibrium setting. The interest rate response, together with that of other variables, has a strong effect on investment. With higher levels of subsistence, investment is boosted in the first period and goes down subsequently. With lower levels of subsistence (we calculate that the threshold is around 0.03), investment becomes more stable, shrinking for most of the period.

[33]The value of $\bar{c}$ has an impact on the steady-state. This means that the different experiments presented in the charts start from different steady-states. To minimize differences, we used the same targets for all the relevant variables, such as debt/GDP ratio, fraction of financially excluded, average MPCs and others. But the fact that the different specifications have different starting point means that results can be counter-intuitive.

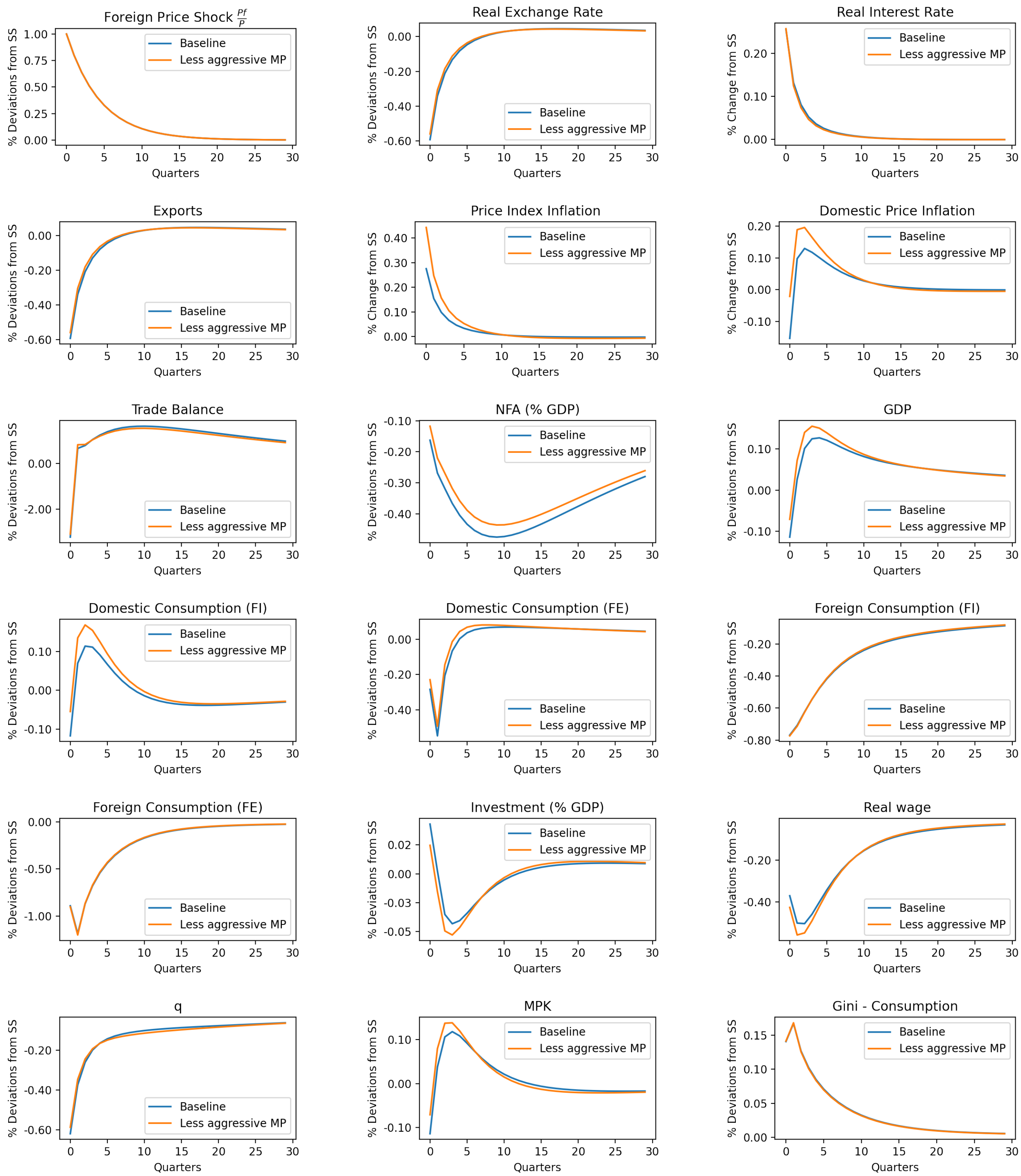
Figure 27: IRF comparison of different subsistence levels



In terms of inequality, when $\bar{c}$ is higher, the effect of inflation on real wages boosts the pattern of the distribution of labor income being compressed to the left, producing lower values of Gini. While labor income becomes less unequal, the boost in investment translates into higher dividends to rich households, increasing the Gini for cash-on-hand. The results for consumption Gini when $\bar{c}$ is higher represent a reversal compared to the baseline case. Because consumption of poor households is proportionally more exposed to imported goods, the adjustment to their overall consumption is much harsher than for rich households. This means that inequality increases dramatically from the first periods, remaining higher than in comparison to the baseline case in the long term. With $\bar{c}$ equal to zero, the rise on consumption inequality is much lower. This means that adding this friction to the model is relevant for the understanding of the dynamics of inequality.

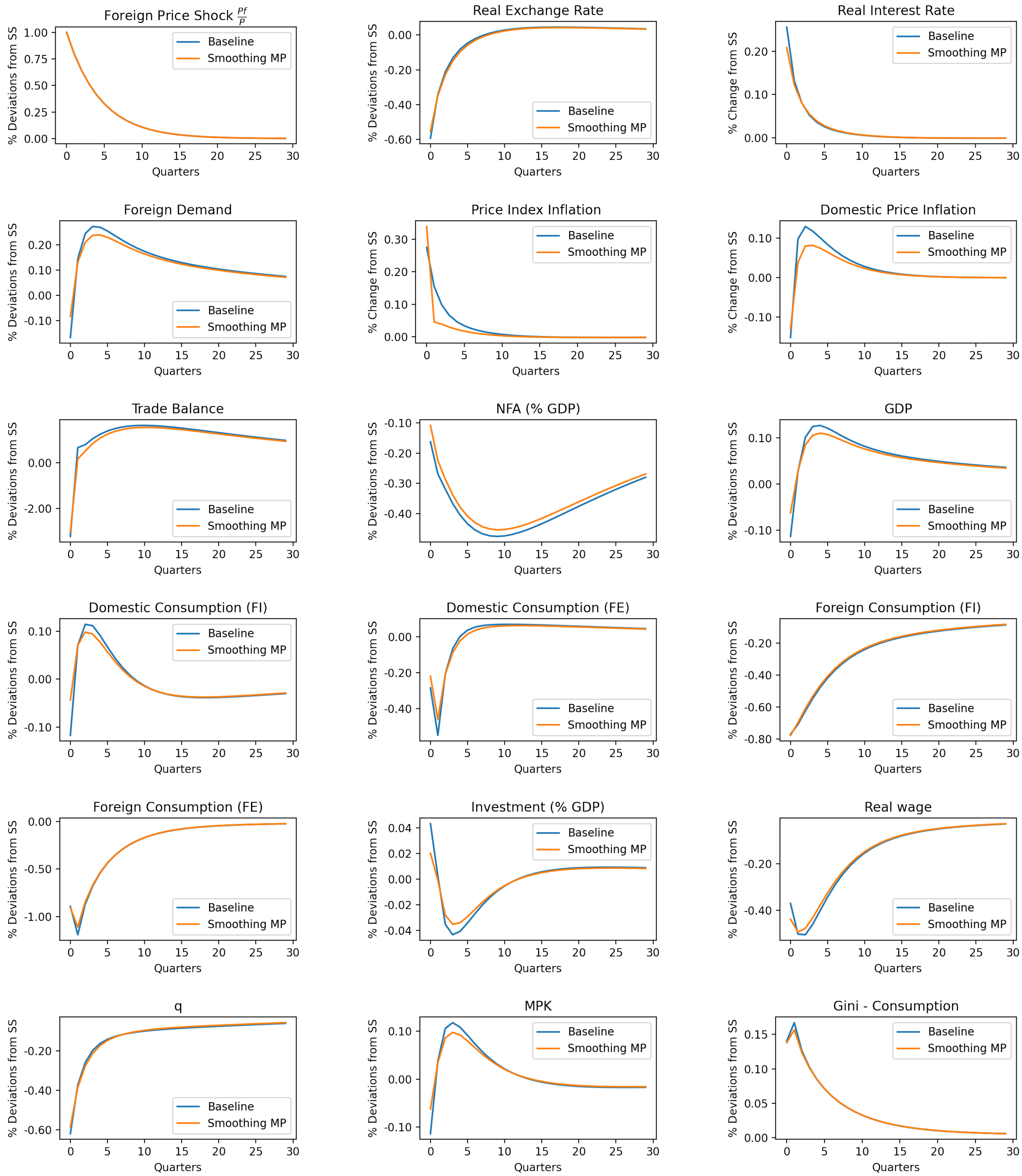
H Additional IRFs for the alternative MP exercise

Figure 28: Response of additional variables, alternative MP



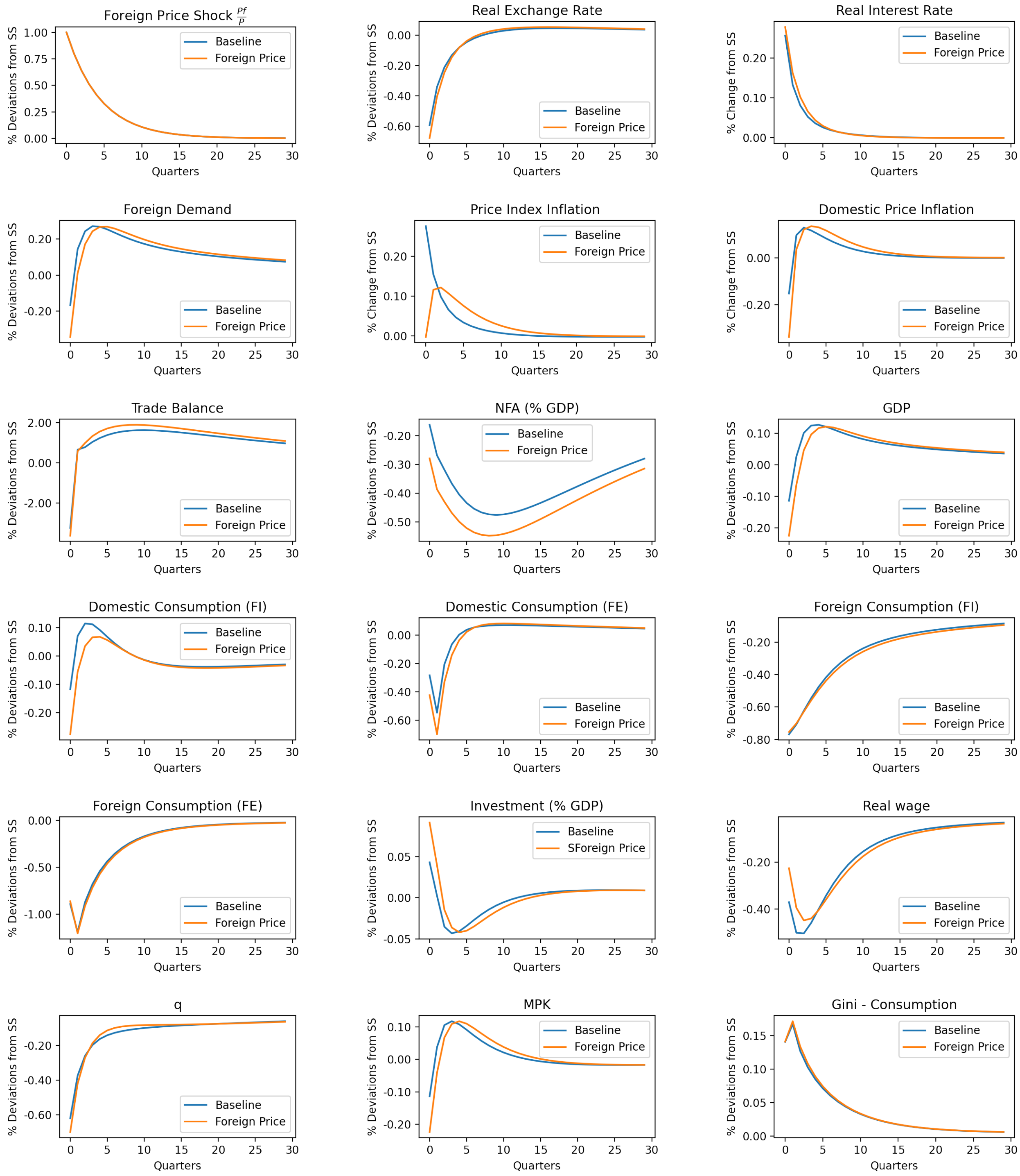
I Additional IRFs for the exercise with interest-rate smoothing

Figure 29: IRFs to an exogenous increase in import prices



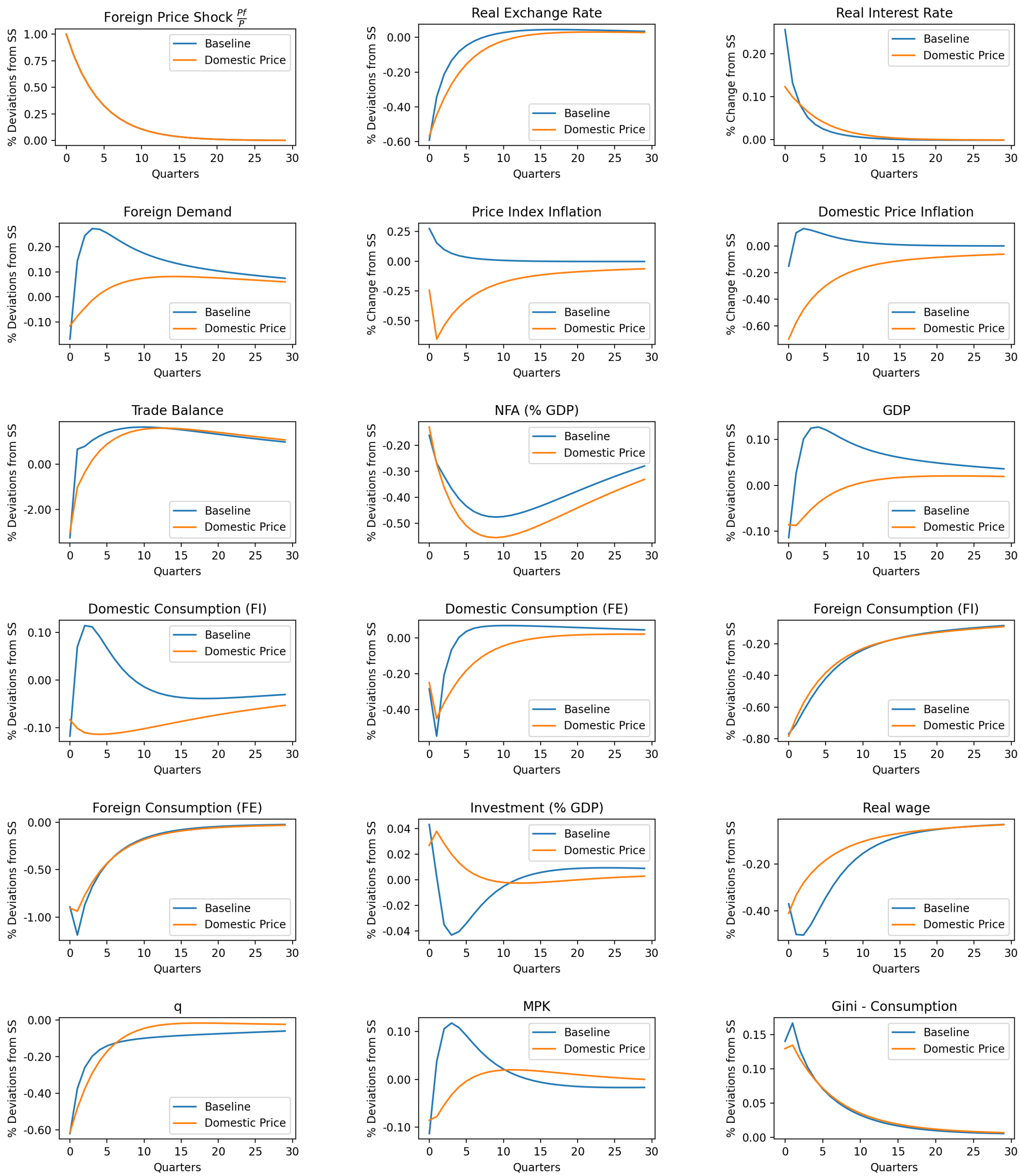
J Additional IRFs for the exercise with import inflation targeting

Figure 30: IRFs to an exogenous increase in import prices



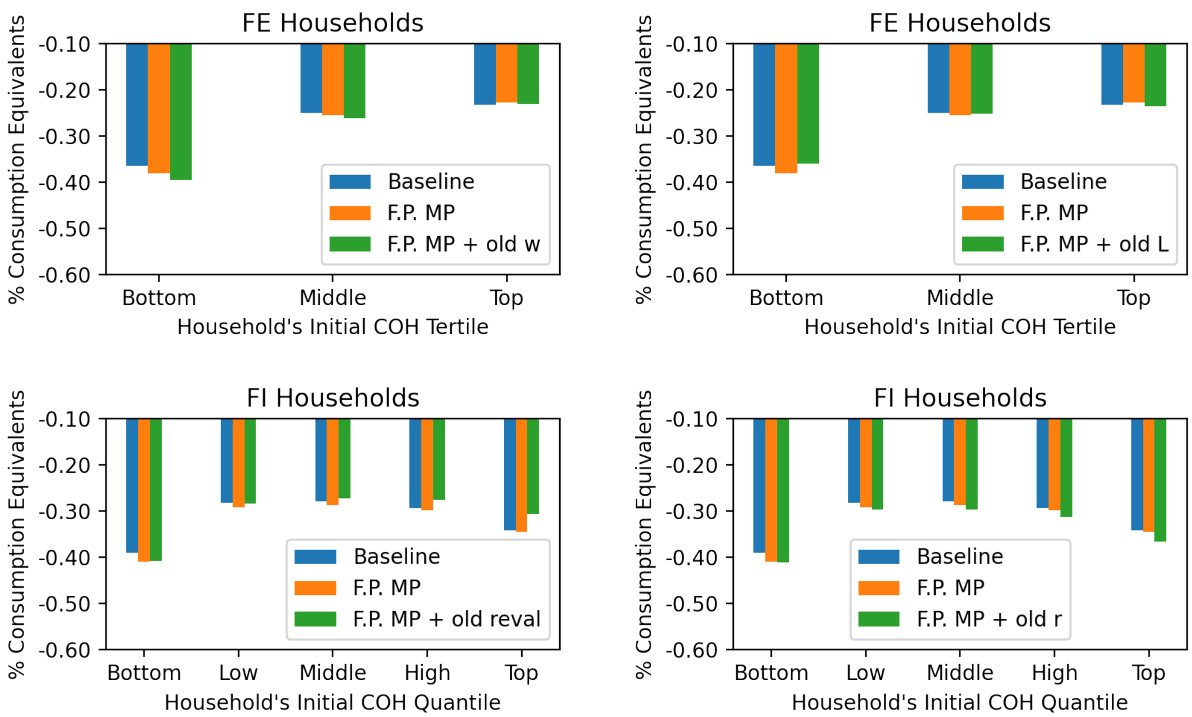
K Additional IRFs for the exercise with domestic inflation targeting

Figure 31: IRFs to an exogenous increase in import prices



L Counterfactual exercise with foreign price inflation target

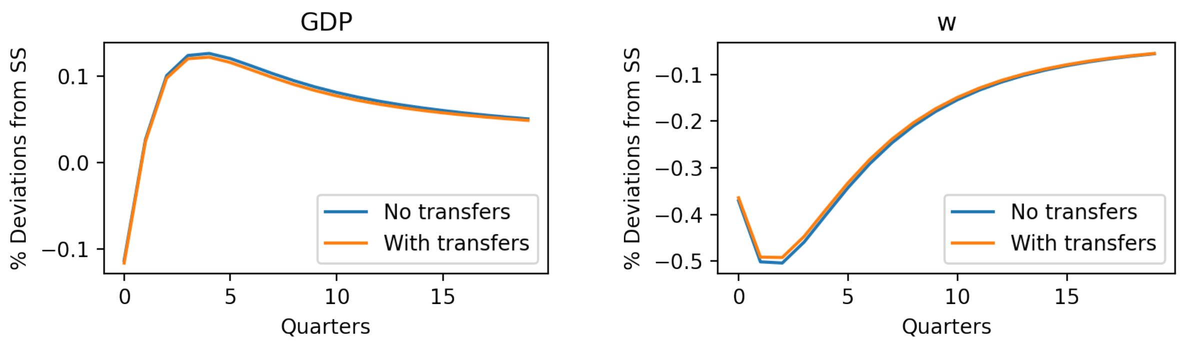
Figure 32: Counterfactual effect of the shock - MP with foreign price inflation target



Notes: The figure depicts the baseline (blue) and counterfactual (orange) welfare effect of the import price shock with monetary policy targeting foreign prices. The green bars in the top charts show the counterfactual welfare effect that would materialize if monetary policy had targeted import prices together with the same movement in real wages (left panels) or labor (right panels) as in the baseline scenario.

M IRFs of output and real wages with and without fiscal transfers

Figure 33: Counterfactual IRFs of output and real wages with fiscal transfers



Notes: The figure depicts the baseline (blue) and counterfactual (orange) effect of the import price shock with and without fiscal transfers, as discussed in section 3.5.

N Alternative shock to UIP premium

Figure 34 shows the IRFs of an alternative shock to the model: an increase in the UIP premium in equation 24:

$$(1+r_t) = (1+i_t^*)*(1+\varepsilon_t)\frac{\mathcal{Q}_{t+1}}{\mathcal{Q}_t} > (1+i_t^*)\frac{\mathcal{Q}_{t+1}}{\mathcal{Q}_t}, \tag{39}$$

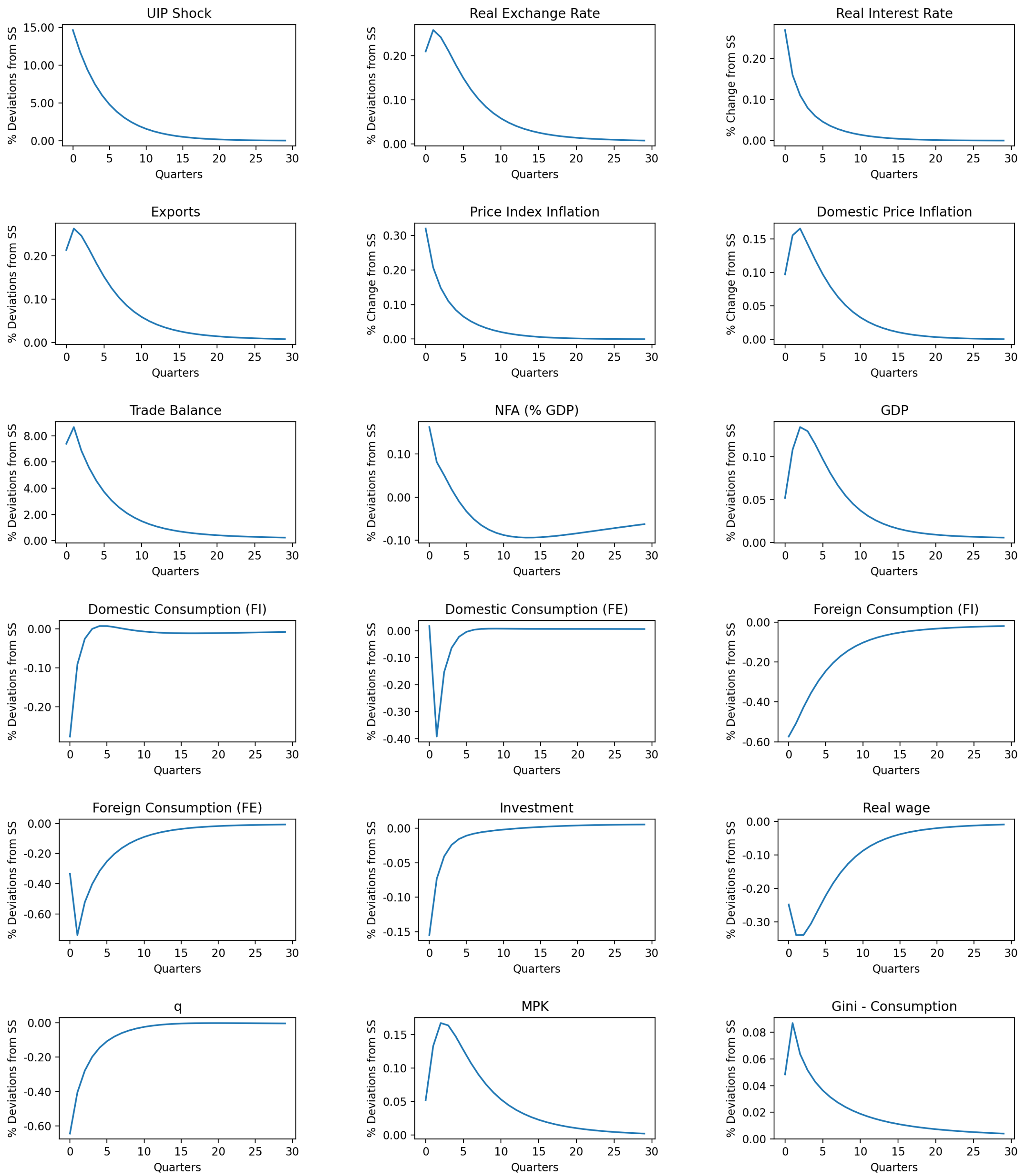
where ε_t is the shock to the UIP premium. In practical terms, the shock is the same as one for i_t^*, given that i_t^* does not affect other equations in the model. As is the case with prices for the imported good, we model ε_t as an AR(1) process with persistence 0.8 and we calibrate it so that the response of real interest rates is the same as is the main text for ease of comparison. The shock can be seen in the top LHS chart of figure 34.

The responses to the shock are as expected and different from the baseline in the main text. The central bank raises interest rates and partially offsets the increase in the risk premium. Despite this action, the real exchange rate depreciates, leading to a large surplus in the trade balance. Because of this, the GDP reacts positively, despite the dynamics of consumption.

In comparison to the shock to prices of the foreign good, the effects on consumption of the UIP shock are milder. Consumers are still facing higher prices for foreign goods, including by the effect of the exchange rate, but they seem to benefit from a higher income, given the impact of GDP on employment. In comparison to the dynamics of consumption in figure 3, we can see that the consumption of financially included households seems to be similar, while that of *FE* improves with respect to the baseline. Financially included households are smoothing consumption in all cases, but those excluded benefit from higher working hours when facing a UIP premium shock. The contrast with the main text is particularly striking when looking at domestic consumption for financially excluded households.

While the inequality of consumption increases, it does by half of the variation of the case considered in the main text. What does this imply for welfare? The calculation of consumption equivalents (not shown) indicates that all consumers fare better in comparison to the main text. For most COH groups, the coefficient calculated in equation 35 indicates losses of half the size of the ones in the main text. But the pattern of households in the bottom of the COH scale being hit harder is still present.

Figure 34: IRFs of a shock to UIP



PUBLICATIONS

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