Aggregate Demand Effects of Factor Income Redistribution*

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Abstract

I study how factor income redistribution shapes the aggregate demand effects of supply shocks in a heterogeneous agent New Keynesian (HANK) model with sticky wages. When prices rise — due to markup increases, higher imported input prices, or tariffs — nominal wage rigidity compresses real wages, redistributing income from workers to profit recipients or the government. When marginal propensities to consume are higher for labor income earners than for wealthy households receiving capital and business income, this redistribution is contractionary. I provide empirical support for this channel.

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1 Introduction

The inflation surge of the early 2020s imposed a sharp decline in real wages across advanced economies. As shown in Figure 1, consumer prices rose faster than nominal wages in most European countries, compressing household purchasing power and prompting widespread concern about a ”cost-of-living crisis”.[1] This episode raises a fundamental question that existing frameworks are ill-equipped to answer: when prices rise due to a cost-push shock, how does the resulting redistribution of income across households affect aggregate demand?

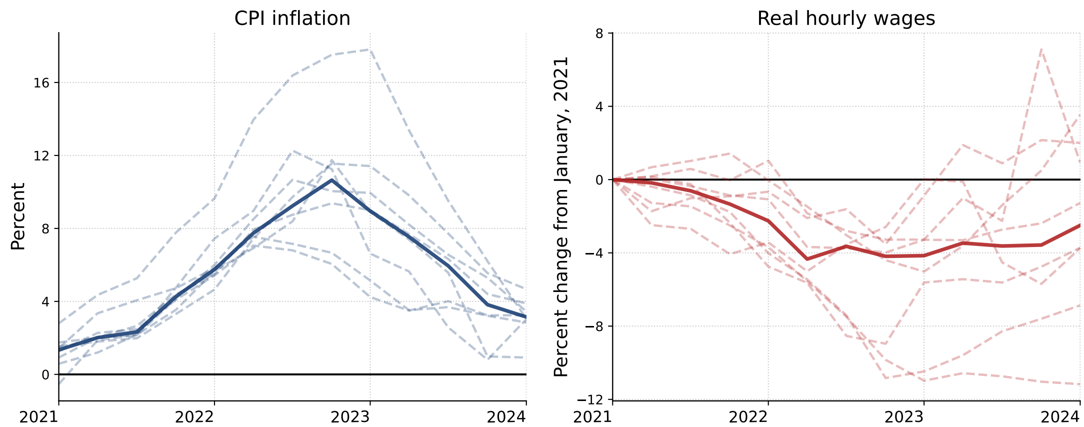


Figure 1: CPI inflation and real wages in advanced economies.

Left panel: Annual CPI inflation for selected countries obtained from the OECD. Right panel: Real hourly wages in manufacturing, defined as nominal hourly wages deflated by the consumer price index, both obtained from the OECD. Series indexed to 100 in January 2021. The countries used are Canada, Luxembourg, Italy, Netherlands, Great Britain, Slovenia, Poland and Sweden.

This paper provides a tractable, general equilibrium answer. I build a New Keynesian small open economy model with incomplete markets and heterogeneous households (Bewley 1986; Imrohoroğlu 1989; Huggett 1993; Aiyagari 1994) in which nominal wages are sticky. The model is rich enough to capture the full distribution of income and wealth, yet I exploit the sequence-space representation of the equilibrium to derive sharp analytical results. The central insight is simple: cost-push shocks — whether from domestic markups, imported material prices, or tariffs — compress real wages by raising prices against a rigid nominal wage. Because workers have higher marginal propensities to consume (MPCs) than the wealthy households who receive profit income, this redistribution reduces aggregate demand. The strength of this channel depends critically on who bears the income loss and on how the associated revenues are recycled through the economy.

I establish three main results. First, I consider a domestic markup shock under a constant real interest rate rule, which isolates the distributional channel by shutting down conventional monetary transmission. In the representative agent model, this

[1]See e.g. Schnabel (2022).

shock has no effect on output — the only transmission is through the monetary policy response to inflation (Bodenstein et al. 2013; Auclert et al. 2023a). I show analytically that in the HANK model, the same shock is contractionary if and only if the aggregate MPC out of labor income exceeds that out of profits. Since markups redistribute from workers to owners, and owners have lower MPCs, aggregate spending falls. This result has a clean corollary: the contractionary effect vanishes precisely when MPCs are equalized across the income distribution, confirming that heterogeneity — not market incompleteness per se — is the operative force.

Second, I study a foreign cost-push shock: a rise in the price of imported production inputs. This shock differs from the markup shock in one important respect — it transfers resources abroad rather than merely redistributing them domestically. It therefore depresses aggregate demand even when all domestic agents share identical MPCs. Nonetheless, I show that the dominant transmission channel in quantitatively realistic calibrations remains the real wage compression arising from factor income redistribution. When the imported material is instead owned by domestic households, the shock is isomorphic to a markup shock and the pure redistribution results apply exactly. Third, I examine tariff shocks. A tariff raises consumer prices, compressing real wages through the same mechanism as the domestic and foreign cost-push shocks, but the associated revenues accrue to the government rather than to firms. When tariff revenue is rebated in a manner analogous to profit distributions, the tariff shock closely resembles a markup shock, and the distributional results carry over directly. A key additional feature is that tariffs also generate a terms-of-trade effect on net exports, which has no counterpart in the domestic shocks and whose sign depends on the elasticity of foreign demand.

Taken together, these results establish factor income redistribution as a unifying mechanism behind the aggregate demand effects of cost-push inflation. Standard representative agent models miss this channel entirely. Existing HANK analyses of inflationary shocks either restrict attention to specific shocks or rely on numerical results (Auclert et al. 2023a; Bobasu et al. 2024). By exploiting the sequence-space structure, this paper delivers analytical characterizations that hold for the full wealth distribution, clarify the exact conditions under which each shock is contractionary, and reveal the common logic connecting markups, commodity prices, and tariffs within a single framework.

1.1 Related literature

This paper connects to four strands of literature.

HANK models. A large literature has documented the importance of household heterogeneity and high average MPCs for the transmission of monetary and fiscal shocks in closed economies (Kaplan et al. 2018; Hagedorn et al. 2019; Auclert et al. 2020; Luetticke 2021; Auclert et al. 2023b) and in open economies (De Ferra et al. 2020; Druedahl et al. 2022; Oskolkov 2023; Auclert et al. 2024c; Druedahl et al. 2025). I contribute to this literature by deriving analytical results for cost-push shocks using the sequence-space approach, and by identifying factor income redistribution as the central transmission mechanism.

Oil and energy prices in open economies. The effects of foreign price shocks on small open economies have been studied extensively using representative agent frameworks (Mendoza 1995; Kose 2002; Baqaee and Farhi 2024). Rotemberg and Woodford (1996) emphasize imperfect competition in a neoclassical growth model, while Blanchard and Gali (2007) introduce real wage rigidity into a New Keynesian framework to account for the differential US responses to oil shocks in the 1970s and 2000s. I extend this tradition to a HANK environment and show that distributional forces, absent from all representative agent treatments, are quantitatively central.

Inflationary shocks in HANK models. A small number of papers study cost-push shocks in heterogeneous agent models (Cravino et al. 2020; Yang 2022; Pieroni 2022; Diz et al. 2023). The most closely related paper is Auclert et al. (2023a), who study higher energy prices in a SOE HANK model with constant markups. My paper complements their analysis by providing analytical results, by allowing markups to vary, and by establishing the common redistributive logic across a broader class of cost-push shocks.

Tariffs in New Keynesian models. A new literature has emerged studying the macroeconomic effects of tariffs following the trade policy actions of the second Trump administration (see e.g. Auclert et al. 2025; Monacelli 2025; Bianchi and Coulibaly 2025; Guerrieri et al. 2025). These papers uniformly rely on representative agent frameworks. I extend the analysis to a full heterogeneous agent environment and show that the distributional consequences of tariff-induced inflation — which representative agent models ignore by construction — are a quantitatively important determinant of the aggregate demand response.

Sequence-space methods. Finally, my paper is related to a number of papers which use the sequence-space formulation to obtain analytical results for general HANK models without reducing them to tractable cases such as zero-liquidity limits or two-agent models. Auclert et al. (2021) lay out the general formulation for working in sequence-space, which has been widely used to study the Phillips-curve (Auclert et al. 2022), fiscal policy (Auclert et al. 2024d; Druedahl et al. 2025), multi-sector HANK dynamics (Schaab and Tan 2025), models with heterogeneous banks (Bellifemine et al.

2022), regional dynamics (Bellifemine et al. 2025) and long run optimal fiscal policy (Auclert et al. 2024a).

Roadmap. The rest of this paper is organized as follows. Section 2 develops the HANK model which is the central framework for the majority of the paper. Section 3 shows how markup shocks transmit in the heterogenous agent environment, and establishes analytically when heterogeneity amplifies the effects of the shock. Section 4 studies more general cost-push shocks and Section 5 studies tariff shocks. Finally Section 6 concludes.

2 Model

This section describes the baseline heterogeneous agent New Keynesian model used in the rest of the paper. I consider a small open economy inhabited by a continuum of households and firms. Households consume domestic and foreign tradeable goods and may save in foreign or domestic government bonds due to free capital flows similar to Obstfeld and Rogoff (2000) and Gali and Monacelli (2005), but are subject to idiosyncratic earnings risk and credit frictions as in Bewley (1986), Imrohoroğlu (1989), Huggett (1993) and Aiyagari (1994). Domestic firms produce a tradeable good using labor and materials subject to nominal price frictions. Unions have market power and decide on the labor supply of households subject to nominal wage frictions. There is no aggregate risk; only unanticipated aggregate shocks which materialize at date zero, after which all agents in the economy have perfect foresight with respect to aggregate variables (MIT shocks).

2.1 Households

Consumption-saving problem. While the analytical results I present in section 3 are general and require almost no structure on the household problem, it is useful to have a baseline model in mind for the numerical examples and the quantitative analysis. The economy consists of a continuum of households with unit measure. Households are subject to idiosyncratic income risk e (described in detail in the calibration section). Households can save in a domestic mutual fund but cannot insure against idiosyncratic risk due to incomplete credit markets. A household with existing asset position a and idiosyncratic earnings e chooses consumption c and savings a' optimally by solving the recursive problem:

$$V_t(e,a) = \max_{c,a'} u(c) - \xi(L_t) + \beta \mathbb{E}_t V_{t+1}(e',a') \tag{1}$$

s.t.

$$c + a' = (1 + r_t^a) a + Z_t e + g(e) \Pi_t - T(e), \tag{2}$$

$$\ln e_t = \bar{e} + \rho_e \ln e_{t-1} + \epsilon_t^e, \quad \epsilon_t^e \sim \mathcal{N}\left(0, \sigma_e^2\right), \tag{3}$$

$$a' \geq \underline{a}, \tag{4}$$

where $Z_t \equiv \frac{W_t L_t}{P_t}$ denotes real labor income (the product of the real wage W_t/P_t and labor supply L_t), r_t^a is the real return on assets, Π_t denotes real profits received from firms, and $T(e)$ denote a lump sum tax raised by the government. Profits in (2) are distributed according to a function $g(e)$ which depends on earnings e and integrates to 1, $\int g(e)\, d\mathcal{G}_t = 1$, where $\mathcal{G}_t$ denotes the time t endogenous distribution of households over states.[2]

The functional forms of the utility functions are given by:

$$u(c_t) = \ln c_t, \quad \nu(L_t) = \xi \frac{L_t^{1+\frac{1}{\varphi}}}{1+\frac{1}{\varphi}},$$

where ξ measures the disutility of supplying labor, and φ denotes the Frisch elasticity. Aggregates are defined by:

$$C_t = \int c_t(e,a)\, d\mathcal{G}_t(e,a), \qquad A_t = \int a_t(e,a)\, d\mathcal{G}_t(e,a) \tag{5}$$

Consumption basket. Consumption of goods C_t is a CES aggregate over foreign and domestic goods with elasticity of substitution η:

$$C_t = \left[\alpha^{\frac{1}{\eta}} C_{F,t}^{\frac{\eta-1}{\eta}} + (1-\alpha)^{\frac{1}{\eta}} C_{H,t}^{\frac{\eta-1}{\eta}}\right]^{\frac{\eta}{\eta-1}}.$$

The demand functions for $C_{H,t}, C_{F,t}$ are then given by:

$$C_{H,t} = (1-\alpha)\left(\frac{P_{H,t}}{P_t}\right)^{-\eta} C_t, \quad C_{F,t} = \alpha\left(\frac{(1+\tau_t) P_{F,t}}{P_t}\right)^{-\eta} C_t, \tag{6}$$

[2] In Section 3 I will vary the distributional rule $g(\bullet)$ to illustrate the role of profit incidence in the model.

where $P_{H,t}, P_{F,t}$ are the prices of domestic and foreign tradeables in domestic currency units, τ_t is a tariff on imports, and the CPI (P_t) is defined by:

$$P_t = \left[(1-\alpha)P_{H,t}^{1-\eta} + \alpha\left(\left(1+\tau_t\right)P_{F,t}\right)^{1-\eta}\right]^{\frac{1}{1-\eta}}. \tag{7}$$

I assume a law of one price such that $P_{F,t} = \mathcal{E}_t P_{F,t}^*$, where $P_{F,t}^*$ denotes foreign exports prices and $\mathcal{E}$ denotes the nominal exchange rate. Note that with this convention, an increase in $\mathcal{E}$ indicates a nominal *depreciation* as in Gali and Monacelli (2005).

2.2 Supply side

The supply side is mostly standard. Firms produce output Y_t using labor and materials subject to monopolistic competition. Materials may be either purchased domestically or imported from abroad.

Representative competitive producer. There is a representative competitive producer who aggregates the output of a continuum of monopolistically competitive firms using CES technology with elasticity of substitution ϵ^p:

$$Y_t = \left[\int_0^1 Y_t\left(i\right)^{\frac{\epsilon^p-1}{\epsilon^p}} \mathrm{d}i\right]^{\frac{\epsilon^p}{\epsilon^p-1}}.$$

Optimization implies a standard demand curve for differentiated products:

$$Y_t\left(i\right) = \left(\frac{P_{H,t}\left(i\right)}{P_{H,t}}\right)^{-\epsilon^p} Y_t, \tag{8}$$

where $P_{H,t}$ is the price of home output.

Monopolistically competitive firms. The representative competitive producer purchases goods from a continuum of monopolistically competitive firms. In anticipation of a symmetric equilibrium, I drop the index i from here on out. The production technology of these firms is described by a CES function, where output Y_t is produced using labor L_t and materials X_t:

$$Y_t = \left[\alpha_L^{\frac{1}{\nu}} L_t^{\frac{\nu-1}{\nu}} + \left(1-\alpha_L\right)^{\frac{1}{\nu}} X_t^{\frac{\nu-1}{\nu}}\right]^{\frac{\nu}{\nu-1}}. \tag{9}$$

Labor is rented from unions at the nominal wage W_t, and materials are purchased at price $P_{X,t}$. The first-order conditions for input demands are:

$$L_t = \alpha_L \left(\frac{W_t}{MC_t} \right)^{-\nu} Y_t, \tag{10}$$

$$X_t = (1 - \alpha_L) \left(\frac{P_{X,t}}{MC_t} \right)^{-\nu} Y_t, \tag{11}$$

where MC_t denotes the nominal marginal cost of producers.

The material good X_t can come from either a domestic endowment (share ω) or be imported from the foreign economy (share $1 - \omega$). The price of the imported good in foreign currency is $P^*_{X,t}$. The law of one price then implies that the domestic-currency price of the imported good is

$$P_{X,t} = (1 + \tau_t)\, \mathcal{E}_t P^*_{X,t}, \tag{12}$$

where τ_t is a tariff levied on imports. In section 3 I will study a shock to the price of $P^*_{X,t}$ as a source of cost-push shocks.

Pricing friction. Firms choose prices and quantities subject to the demand function (8) and subject to a price adjustment cost à la Rotemberg (1982) given by $\frac{\theta^P}{2} \pi^2_{H,t} Y_t$. Optimization yields a New Keynesian Phillips-curve relating inflation $\pi_{H,t}$ to real marginal costs $mc_t = MC_t / P_t$ and markups:

$$\pi_{H,t} (1 + \pi_{H,t}) = \kappa^P \left(mc_t - \frac{P_{H,t}}{P_t} \frac{1}{\mu} \right) + \beta \pi_{H,t+1} (1 + \pi_{H,t+1}), \tag{13}$$

where $\kappa^P \equiv \frac{\epsilon^P}{\theta^P}$ denotes the slope of the Phillips-curve, and μ is the steady state markup.

Profits. Profits maximized by domestic firms - measured in units of the CPI - are given by:

$$\widetilde{\Pi}_t = \frac{P_{H,t}}{P_t} Y_t - \frac{W_t}{P_t} L_t - \frac{P_{X,t}}{P_t} X_t - \frac{\theta^P}{2} \pi^2_{H,t} Y_t \tag{14}$$

whereas total dividends (which also include the payment to the endowment of tradeable inputs) paid out to domestic households are:

$$\Pi_t = \widetilde{\Pi}_t + \omega \frac{P_{X,t}}{P_t} X_t$$

2.3 Labor supply and wage setting

Labor supply is determined by unions as in Erceg et al. (2000), Schmitt-Grohé and Uribe (2005). There is a continuum of unions, and each household i provides $\ell^k_{i,t}$ hours of work to union k. Total labor supply of household i is then $\ell_{i,t} = \int \ell^k_{i,t}\,\mathrm{d}k$. Each union assembles individual labor supply to a union-specific task $L^k_t = \int e_{i,t}\ell^k_{i,t}\,\mathrm{d}i$, and aggregate labor supply is assembled from these union-specific tasks using a CES technology:

$$L_t = \left(\int \left(L^k_t\right)^{\frac{\epsilon^W-1}{\epsilon^W}} \mathrm{d}k\right)^{\frac{\epsilon^W}{\epsilon^W-1}},$$

where $\epsilon^W > 0$ is the elasticity of substitution between labor types. Union k maximizes the discounted sum of future utility of its members, less a virtual Rotemberg adjustment cost on nominal wages:

$$\sum_{t=0}^{\infty}\beta^t\left(\int\left\{\frac{u\left(c_t\left(e,a\right)\right)}{\xi^{Wealth}_t} - \xi\left(L_t\right)\right\}\mathrm{d}\mathcal{G}_t\left(e,a\right) - \frac{\theta^W}{2}\left(\frac{W^k_t}{W^k_{t-1}} - 1\right)^2\right).$$

where ξ^{Wealth}_t is an endogenous preference shifter as in Galí et al. (2012), which serves the purpose of eliminating implausibly large wealth effects on labor supply. The problem yields a symmetric solution such that all unions choose the same wage, and all households supply the same amount of labor within each sector. The solution is characterized by the following New Keynesian wage Phillips curve:

$$\pi^W_t\left(1+\pi^W_t\right) = \kappa^W\left\{\frac{\xi'\left(L_t\right)}{w_t}\mu^W - 1\right\} + \beta\pi^W_{t+1}\left(1+\pi^W_{t+1}\right), \tag{15}$$

where the wage markup is $\mu^W \equiv \frac{\epsilon^W}{\epsilon^W-1}$, and the slope is defined as $\kappa^W = \frac{\epsilon^W}{\theta^W}$.

2.4 Financial assets and capital flows

The assets of domestic households are administrated by a mutual fund which invests in either government domestic bonds B in fixed supply or foreign bonds B^* in infinite supply. The foreign bond pays i^*_t in foreign currency units whereas domestic bonds pay i_t which is the nominal rate set by the domestic central bank. Free capital flows then implies a nominal UIP condition $1 + i_t = (1 + i^*_t)\frac{\mathcal{E}_{t+1}}{\mathcal{E}_t}$. Defining the real exchange rate $Q_t = \frac{\mathcal{E}_t}{P_t}$ we may rewrite this as the real UIP condition:

$$1 + r_t = (1 + i^*)\frac{Q_{t+1}}{Q_t}, \tag{16}$$

where $r_t = \frac{1+i_t}{1+\pi_{t+1}} - 1$ is the ex-ante real interest rate. Note that equilibrium in the asset market implies $A_t = B_t^* + B$. I define the net foreign asset position as the difference between domestic asset A_t and the supply of domestic bonds B, $NFA_t = A_t - B$, which also implies $NFA_t = B_t^*$.

2.5 Monetary policy

The domestic central bank controls the nominal interest rate i_t, which is related to the ex-ante real interest rate through the Fisher relation $1 + r_t = \frac{1+i_t}{1+\pi_{t+1}}$. In the baseline analysis I assume a neutral monetary policy stance which aims to keep the domestic ex-ante real rate constant, $r_t = r$ (see Auclert et al. 2023b for a similar approach). This may be interpreted as a Taylor rule with coefficient 1 on expected inflation.

2.6 Government

The government supplies bonds B and raise revenues from import tariffs τ_t to pay interest on issued bonds and to pay lump-sum transfers T_t to domestic households. The budget constraint is given by:

$$\tau_t \left(\frac{P_{F,t}}{P_t} C_{F,t} + \frac{P_{X,t}}{P_t} (1 - \omega) X_t \right) + B_t = T_t + (1 + r_t) B_{t-1}$$

2.7 Exports

Foreign demand for domestic goods $C_{H,t}^*$ is a standard Armington demand function:

$$C_{H,t}^* = \alpha^* \left(\frac{P_{H,t}^*}{P_{F,t}^*} \right)^{-\eta}. \tag{17}$$

I assume a law of one price such that $P_{H,t}^* = \frac{P_{H,t}}{\mathcal{E}_t}$.

2.8 Market clearing and equilibrium

Market clearing in the economy is given by:

$$Y_t = C_{H,t} + C_{H,t}^* + \frac{P_t}{P_{H,t}} \frac{\theta^P}{2} \pi_{H,t}^2 Y_t. \tag{18}$$

The general equilibrium of the model is defined as follows:

Definition 1 (Equilibrium in the small open economy.). *Given a sequence of shocks $\{\mu_t, P_{X,t}^*, \tau_t\}$, an initial household distribution over assets and earnings $\mathcal{G}_0(a, e)$, and an initial portfolio allocation between foreign and domestic bonds, a competitive equilibrium in the domestic economy* *is a path of household policies $\{c(a,e), a'(a,e)\}$, distributions $\mathcal{G}_t(a,e)$, prices:*

$$\{\mathcal{E}_t, Q_t, P_t, P_{H,t}, P_{F,t}, W_t, P_{X,t}, i_t, r_t\}$$

and quantities:

$$\{C_t, C_{H,t}, C_{F,t}, A_t, Y_t, X_t, L_t, \Pi_t, NFA_t, B_t^*\}$$

such that all households and firms optimize, the central bank sets monetary policy according to the chosen rule, and the goods market clearing condition eq. (18) *holds, while the asset market clearing condition $A_t = B_t^* + B$ holds residually by Walras's law.*

2.9 Representative agent economy

I compare my results for the HANK model to those obtained with a textbook representative agent model. Here aggregate consumption follows the Euler equation:

$$u'(C_t) = \beta(1 + r_t) u'(C_{t+1})$$

with $\beta = \frac{1}{1+r}$ in steady state.

2.10 Calibration

I calibrate the model to the average small open economy in the OECD.[3] Table 1 displays the calibration.

Households. For the household block the Frisch elasticity of labor supply is set to a standard value of 0.5. In the idiosyncratic income process, I fix the standard deviation of innovations (σ_e) to 0.13, and the persistence (ρ_e) to 0.966, following the estimates in Floden and Lindé (2001). This yields an income process which is similar to the ones commonly used in the HANK literature (e.g., McKay et al. 2016, Guerrieri and Lorenzoni 2017).

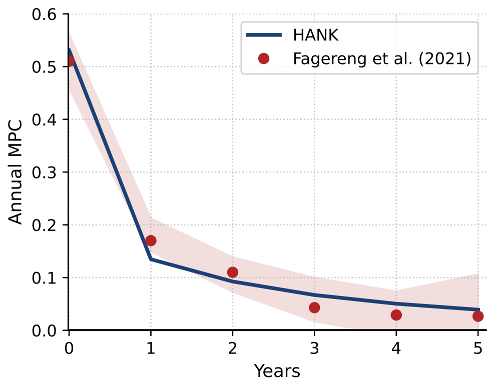
The discount factor β is calibrated to match an aggregate MPC out of a uniform lump sum transfer of 0.51 following Fagereng et al. (2021) at an annual steady state real interest rate of 4%. In Figure 2a I plot the dynamic MPCs in the model following a one time unexpected transfer against the estimated MPCs from Fagereng et al. (2021). The model overall replicates the empirical evidence well. In Figure 2b I plot the corresponding dynamic MPCs following an increase in aggregate *real labor income* Z. The first-year MPC is slightly lower than the transfer-MPC at 0.38 because Z loads more on

[3]The sample used is described in detail in Druedahl et al. (2022).

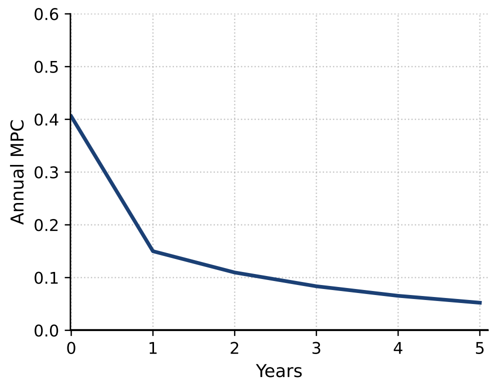
rich households who have lower MPCs. The MPC out of labor income will be a central object in the analysis in the remainder of the paper.
For the profits incidence function I assume a simple function form:

$$g(e_{i,t}) = \frac{e_{i,t}^{\vartheta}}{\int e_{i,t}^{\vartheta}\, \mathrm{d}\mathcal{G}} \tag{19}$$

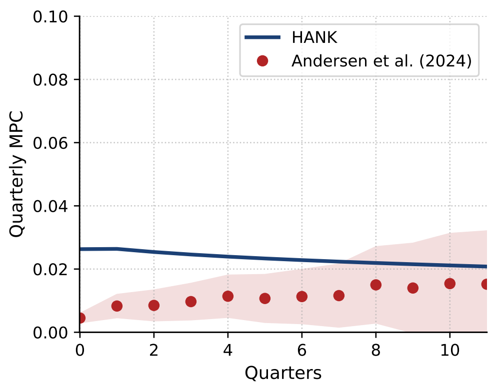
I calibrate the parameter ϑ, which determines how skewed the distribution of profits is in the population, to match an aggregate, annual MPC out of profits of 4%. Chodorow-Reich et al. (2021) estimate an annual MPC out of stock returns of 3.2% using US data. This yields $\vartheta = 15$ Andersen et al. (2024) estimate an annual MPC of 4% using Danish data. Figure 2c plots the aggregate quarterly MPC out of a one-time increase in profits against the estimated, dynamic response from Andersen et al. (2024). The overall response is relatively flat because rich households - who are the ones that have claims on firm profits - act as permanent income households, and thus smooth consumption extensively. Overall, this fits the empirical evidence well.



(a) MPC out of uniform transfer



(b) MPC out of labor income



(c) MPC out of profits

Figure 2: Marginal propensities in the calibrated model

For the tax function $T_t(e)$ I posit that households are taxed in proportion to total income (both labor and profits):

$$T_t(e) = T_t \frac{g(e)\Pi_t + eZ_t}{\int (g(e)\Pi_t + eZ_t)\,\mathrm{d}\mathcal{G}_t}.$$

I calibrate the amount of steady state government bonds B to equal assets demanded by households A and steady state taxes T then clears the government budget.

Firms. On the supply side I fix the steady state markup at a standard value of 20%, as is common in the literature. I follow Nakamura and Steinsson (2008) in setting the slope of the price Phillips-curve to $\kappa^P = 0.1$. For the elasticity of substitution in production I follow the estimates in Boehm et al. (2019), who find evidence of little substitution between factors in the short run following a supply shock. This leads me to set the elasticity of substitution between labor and materials to their preferred estimate $\nu = 0.03$. This rather low value is consistent with related papers that study inflationary shock such as Auclert et al. (2023a), Chan et al. (2024). Regarding the cost-structure I calibrate the input share of labor α_L to match the average cost-share of labor in the sample OECD countries. This yields residually spending on total materials X_t.

Unions. For the unions I fix the slope of the wage Phillips-curve to $\kappa^W = 0.01$ following Sbordone (2006) and Schmitt-Grohé and Uribe (2006), reflecting relatively sluggish nominal wage adjustment. The wage markup is set equal to the markup of firms (20%) as in Smets and Wouters (2007).

Trade. The remaining parameters of the model concern trade. I set the elasticity of import/export demand η to 2, which is standard in the literature. I calibrate the size of foreign economy α^* such that steady state exports amounts to 42% of GDP. I assume the net-foreign asset position (and net exports) are 0 in steady state. I fix the share of imports in domestic household's consumption basket at 25%, $\alpha = 0.25$ following Christiano et al. (2011). The share of imported materials by firms is then calculated residually such that aggregate imports constitute 42% of GDP. This yields $\alpha_L = 0.77$.

3 Transmission of Inflationary Shocks

In this section I show how the relative effects of wage/price stickiness and the interaction with limited insurance and high MPCs transmit to aggregate demand. For tractability in the derivation of analytical results, I focus on a special case where labor and materials are perfect complements, $\nu \to 0$. Given the estimates from Boehm et al. (2019), which underlie the calibration used, this is not an extreme approximation when focusing on short-run dynamics. These simplifying assumptions are only used

Parameter	Description	Value	Source/Target
Households			
φ	Frisch	0.5	Chetty et al. (2011)
β	Discount factor	0.981	MPC = 0.51 (Fagereng et al. (2021))
ρ^e	Persistence of idiosyncratic shocks	0.966	Floden and Lindé (2001)
σ^e	Std. dev of idiosyncratic shocks	0.13	Floden and Lindé (2001)
$\underline{a}$	Borrowing limit	0	Standard value
ϑ	Distribution of profits	15	MPC out of capital gains
Firms			
μ	Firm markup	1.2	Standard value
μ^W	Wage markup	1.2	Standard value
κ^P	Slope of Phillips curve	0.1	Nakamura and Steinsson (2008)
κ^W	Slope of wage Phillips curve	0.01	Sbordone (2006) and Schmitt-Grohé and Uribe (2006)
ν	EOS between labor and materials	0.03	Boehm et al. (2019)
α_L	Spending on labor	0.83	Imports = 42% of GDP (OECD average)
Trade			
α	Imports of final goods	0.25	Christiano et al. (2011)
α^*	Exports	0.42	$NX = 0$ in steady state
η	EOS between foreign and domestic goods	2.0	Standard

Table 1: Calibration

in the analytical derivations, and do not apply in any of the numerical illustrations and figures, which use the full quantitative model from Section 2.[4]

Shocks. I focus on three separate shocks which turn out to be closely related: i) A domestic markup shock as often studied in the New-Keynesian literature[5], ii) A shock to material prices (i.e. a *cost-push shock*), and iii) A tariff shock.

3.1 Markup shocks

Transmission. I start by considering a markup shock, which corresponds to a shock to the Phillips-curve in the standard New-Keynesian model. Recall that the model assumes a neutral stance of the domestic central bank such that the domestic real rate is constant (as in Auclert et al. 2023b; Angeletos et al. 2024) at the steady state level, $r_t = r$.[6] In the standard 3-equation New-Keynesian model the entire transmission of markup shocks to the real economy derives from the response of the central bank to inflation.[7] This is because domestic demand is driven entire by intertemporal substitution, or what Kaplan et al. (2018) call the "direct effect" of monetary policy. Hence the

[4] All analytical results apply approximately in the full model, reflecting that these assumptions constitute only a minor deviation from the quantitative model.

[5] See Smets and Wouters (2003), Smets and Wouters (2007), Del Negro et al. (2015).

[6] In the standard NK model a real rate rule of this kind results in indeterminacy. Following Auclert et al. (2023b) determinacy can be restored by assuming that the central bank switches to an active Taylor rule sufficiently far out in the future.

[7] This is true to first-order. At second-order or higher inflation generates a resource loss from adjustment (Rotemberg) or misallocation (Calvo) depending on the specification of the pricing friction which affects the equilibrium.

assumption of a constant real rate eliminates the main transmission channel present in the standard NK model to more clearly highlight the distributional dynamics which are the focus here.

Sequence-space representation. The analysis is centered around the goods market clearing condition (18). Linearizing and applying the assumption of a constant real interest rate, which implies a constant real exchange rate $Q_t = Q$ by the real UIP condition (16), yields that changes in domestic output equals the change in domestic consumption spend on home goods:[8]

$$dY_t = (1-\alpha)\, dC_t, \tag{20}$$

where $dx_t = x_t - x$ represent deviations from steady state for some variable x. Given a constant real rate the aggregate consumption function $\mathcal{C}_t$ depends only on the sequences of real labor income $\{Z_s\}_{s=0}^{\infty} = \left\{\frac{W_s}{P_s} L_s\right\}_{s=0}^{\infty}$ and profits $\{\Pi_s\}_{s=0}^{\infty}$, i.e. $C_t = \mathcal{C}_t\left(\{Z_s, \Pi_s\}_{s=0}^{\infty}\right)$. Stacking variables in vectors $d\mathbf{C} = (dC_0, dC_1, \ldots)$ the linearized consumption function can be written as $d\mathbf{C} = \mathbf{M}^Z d\mathbf{Z} + \mathbf{M}^{\Pi} d\mathbf{\Pi}$ where $\mathbf{M}^Z, \mathbf{M}^{\Pi}$ are the sequence-space Jacobians of aggregate consumption w.r.t labor income and profits respectively:[9]

$$\mathbf{M}^Z = \begin{bmatrix} \frac{\partial C_0}{\partial Z_0} & \frac{\partial C_0}{\partial Z_1} & \cdots \\ \frac{\partial C_1}{\partial Z_0} & \frac{\partial C_1}{\partial Z_1} & \cdots \\ \vdots & \vdots & \ddots \end{bmatrix}, \quad \mathbf{M}^{\Pi} = \begin{bmatrix} \frac{\partial C_0}{\partial \Pi_0} & \frac{\partial C_0}{\partial \Pi_1} & \cdots \\ \frac{\partial C_1}{\partial \Pi_0} & \frac{\partial C_1}{\partial \Pi_1} & \cdots \\ \vdots & \vdots & \ddots \end{bmatrix}.$$

Here the entry $M_{0,0}^Z$ corresponds to the quarterly MPC out of labor income and so forth. Note that the conventional MPC estimated in the literature is the change in consumption given a one-time unexpected lump-sum transfer (e.g. Shapiro and Slemrod 2003; Johnson et al. 2006; Fuster et al. 2021; Fagereng et al. 2021). As we shall see the relative level of $\mathbf{M}^Z, \mathbf{M}^{\Pi}$ will have important implications for the transmission of markup shocks.

Keynesian cross. Combining the linearized consumption function with the definition of profits and goods market clearing I obtain the following proposition:

Proposition 1 (Equilibrium relationship between output and profits)**.** *Given a sequence*

[8] See appendix A.1 for the derivation.

[9] See Auclert et al. (2023b) for more details on the existence of the consumption function, and the sequence-space Jacobians.

of markup shocks $\{\mu_s\}_{s=0}^{\infty}$ *the equilibrium relation between output and profits is given by:*

$$\frac{\boldsymbol{I}}{1-\alpha}d\mathbf{Y} = \underbrace{\mathbf{M}^Z d\mathbf{Y}}_{\textit{Multiplier}} - \underbrace{\left[\mathbf{M}^Z - \mathbf{M}^\Pi\right] d\mathbf{\Pi}}_{\textit{Distributional channel}} \tag{21}$$

Proof: appendix A.2.

Proposition 1 implies that the response of output to a markup shock depends on a multiplier term and a distributional term relating to changes in profits. Given a constant real rate the distribution effects are the fundamental source of propagation following the shock. In particular, with a representative agent - which typically features $\mathbf{M}^Z = \mathbf{M}^\Pi$ - the distributional effect is zero, and the solution to (21) is $d\mathbf{Y} = \mathbf{0}$. Hence the proposition highlights exactly why a markup shock has no effects (besides the effect through monetary policy) in the basic NK model featuring a representative agent. The same insight holds in more general HANK models which features an equal incidence of labor income and profits across the population. In this case the marginal propensities may be positive $\mathbf{M}^Z > 0, \mathbf{M}^\Pi > 0$ but to the extent that they are equal, $\mathbf{M}^Z = \mathbf{M}^\Pi$, redistribution is neutral in the aggregate, and the markup shock has no effect on aggregate demand. This is summarized in corollary 1:

Corollary 1. *If the model features an equal incidence of labor income and profits, and therefore delivers equal marginal propensities to consume out of labor income and profits,* $\mathbf{M}^Z = \mathbf{M}^\Pi$*, the markup shocks have no effect on real output,* $d\mathbf{Y} = \mathbf{0}$*, under a neutral monetary policy stance,* $d\mathbf{r} = \mathbf{0}$*.*

Moving onto the more general case where $\mathbf{M}^Z \neq \mathbf{M}^\Pi$, we see that if the MPC out of labor income is greater than that of profits, as the data suggests, $\mathbf{M}^Z > \mathbf{M}^\Pi$, an increase in firm markups, which increase profits $d\mathbf{\Pi} > 0$, will suppress aggregate demand and generate a contraction in terms of domestic output, $d\mathbf{Y} < 0$.

Figure 3 displays the responses to a markup shock that increases inflation by 1% on impact in a baseline RANK, permanent-income type model ($\mathbf{M}^Z = \mathbf{M}^\Pi$) model, and a HANK model with unequal incidence (the baseline model - $\mathbf{M}^Z > \mathbf{M}^\Pi$). Specifically, the Figure plots the responses of real labor income Z, aggregate output Y, inflation π and real profits Π. For both the RA and HA model the increase in desired markups causes firms to raise prices further above marginal costs hence generating inflation. Given nominal wage frictions, this drives down the real wage and increases firm profits. The two models then differ in how aggregate demand and output respond to these changes. In the RA model (left panel) with a neutral monetary policy stance aggregate consumption and output does not respond since the MPC out of transitory income changes is zero. If we consider the empirically realistic case where the aggregate MPC out of labor income is greater than that of profits (right panel) the redistribution caused by inflation is not demand-neutral and the model therefore delivers a significant drop in domestic demand and output, i.e. stagflation.

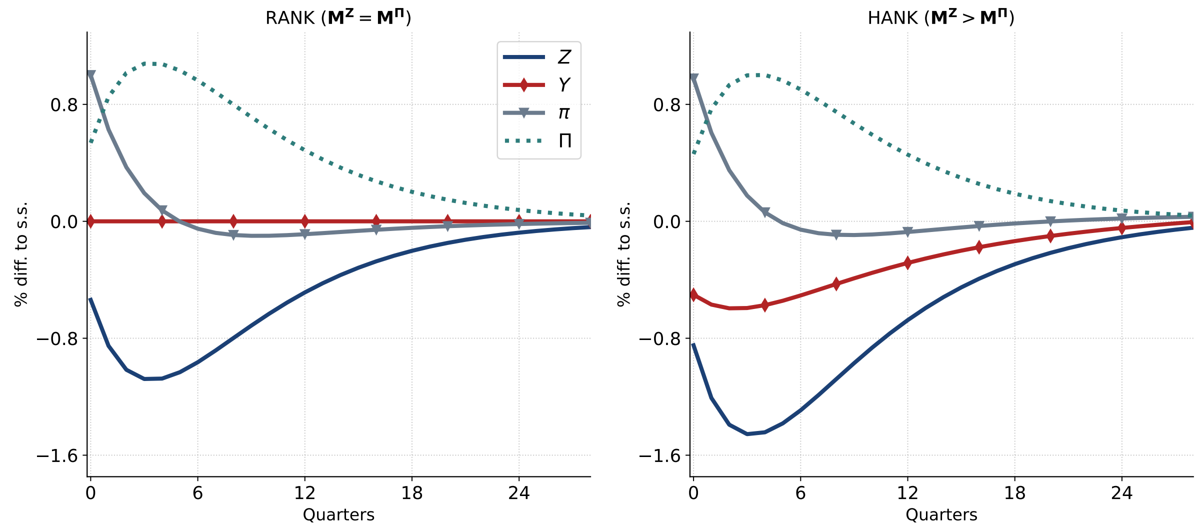


Figure 3: Effect of markup shock in RANK and HANK

Note: Impulse responses to an AR(1) shock to the domestic markup with persistence 0.8. The shock is normalized such that inflation increase 1% on impact. The Figure shows real labor income Z (red), real output Y (dark blue), CPI inflation π (grey) and real profits Π (orange).

Two-agent model. The transmission occurring through factor income redistribution is very clear in the case of a two-agent model à la Galí et al. (2004) where the matrices $\mathbf{M}^Z, \mathbf{M}^\Pi$ have closed form solutions. Assume that a share λ of households are financially constrained with the remaining $1-\lambda$ share being permanent-income type households (implying an aggregate MPC of λ). Constrained households receive a share δ of aggregate profits such that $\delta = \lambda$ implies an equal incidence of profits across the population. These assumptions imply $\mathbf{M}^Z = \lambda \mathbf{I}$ and $\mathbf{M}^\Pi = \frac{\delta}{\lambda}\lambda \mathbf{I} = \delta \mathbf{I}$. Equation (21) then takes the simple form:

$$\frac{1}{1-\alpha} d\mathbf{Y} = \lambda d\mathbf{Y} - [\lambda - \delta]\, d\mathbf{\Pi},$$

from which it is evident that $\lambda = \delta$ yields $d\mathbf{Y} = 0$ and $\lambda > \delta$ implies $d\mathbf{Y} < 0$ for $d\mathbf{\Pi} > 0$.

MPCs across the population. Additional intuition for the mechanisms present in eq. (21) can be provided by re-writing the distributional term in terms of covariances as follows:[10]

$$\frac{1}{1-\alpha} d\mathbf{Y} = \mathbf{M}^Z d\mathbf{Y} - \left[\mathbb{C}\text{ov}_i\left(\mathbf{M}_i, e_i\right) - \mathbb{C}\text{ov}_i\left(\mathbf{M}_i, g\left(e_i\right)\right)\right] d\mathbf{\Pi}, \tag{22}$$

[10]See appendix A.3 for the derivation.

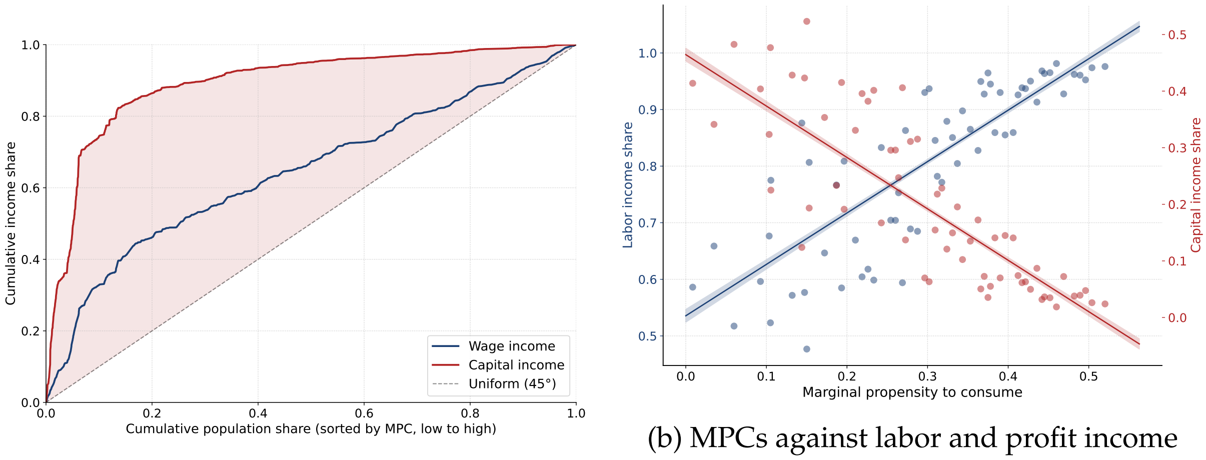
where $\mathbf{M}_i$ is the Jacobian of consumption w.r.t a uniform lump-sum transfer for individual i in the population.[11]

Each of the the terms in eq. (22) corresponds exactly to the terms in (21). Focusing on the second term on the right-hand side, eq. (22) shows that the differential $\mathbf{M}^Z - \mathbf{M}^\Pi$ corresponds exactly to the differential of two covariances: The population covariance between intertemporal MPCs $\mathbf{M}_i$ and idiosyncratic income e_i and the covariance between intertemporal MPCs $\mathbf{M}_i$ and the profit incidence function $g(e_i)$, since e_i and $g(e_i)$ determines the distribution of aggregate labor income and profits in the population. If profits tend to be distributed towards low MPC households more so than labor earnings, then eq. (22) implies that an increase in profits has contractionary short-run effects.

To investigate this empirically requires micro data on income and MPCs. I follow the general strategy from Patterson (2023) and Bellifemine et al. (2025) who estimate MPCs in one dataset (PSID and the NY FED's Survey of Consumer Expectations from Fuster et al. 2021), and apply these estimate to larger datasets through matching. I obtain MPC estimates from Fuster et al. (2021); specifically the \$500-loss treatment, in which respondents are asked how much of an unexpected \$500 expense they would finance out of reduced spending. I then combine these estimates with the 2013 wave of the Survey of Consumer Finances (SCF), which contain detailed data on household level labor income, capital income and business income.

The left panel in Figure 4 plots Lorenz-style concentration curves using this data: the cumulative income share of profits and labor income as a function of the cumulative population share sorted from lowest to highest predicted MPC. A curve above the 45 diagonal indicates that the income type is concentrated among low-MPC households. Both labor income and "profits" (capital income and business income) are more heavily skewed towards low MPC households, but profits much more so, implying $\mathbb{C}\text{ov}_i\left(\mathbf{M}_i, e_i\right) > \mathbb{C}\text{ov}_i\left(\mathbf{M}_i, g\left(e_i\right)\right)$.

[11]For the purpose of exposition, I assume that the covariance operator $\mathbb{C}\text{ov}\left(\mathbf{X}, y\right)$ in (22) takes a matrix $\mathbf{X}$ and a scalar y as input, and gives as output a matrix which is simply the element-by-element covariances between $\mathbf{X}$ and y.



(a) Distribution of income

(b) MPCs against labor and profit income shares

Figure 4: Empirical evidence on labor income and profit MPCs

Left panel: Concentration curves showing the cumulative share of wage income and capital income (business, dividend, and capital gains income) as a function of the cumulative population share, sorted by predicted MPC from low to high. A curve above the 45° diagonal indicates that the income type is concentrated among low-MPC households. Right panel: Scatter plot of MPCs against labor income and capital income shares. Predicted MPCs are estimated following Patterson (2023) using the \$500-loss treatment from Fuster et al. (2021) and individual-level income data from the 2013 Survey of Consumer Finances.

The right panel plots the share of each income type received by households in each MPC decile. Both panels show that capital income is substantially more concentrated among low-MPC households than wage income. Figure 5 displays the effects on inflation, real wages and consumption by varying the covariance gap in (22), or equivalently, the difference between the Jacobians $\mathbf{M}^Z - \mathbf{M}^\Pi$ by changing the profit incidence function $g(e)$. As the profits become more equally distributed in the population the gap $\mathbf{M}^Z - \mathbf{M}^\Pi$ lessens, and the contractionary effect on consumption becomes smaller, converging to zero when $\mathbf{M}^Z = \mathbf{M}^\Pi$ as per corollary 1.

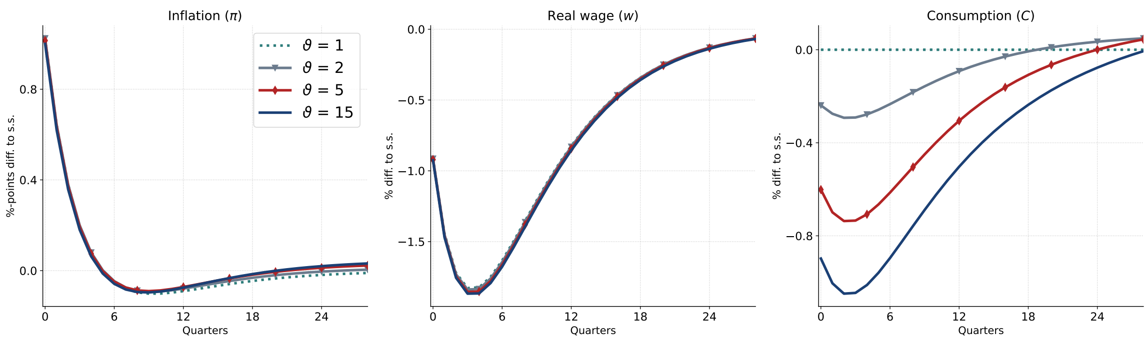


Figure 5: Responses to a markup shock with varying profit distribution across the population

The figure shows the response in the HANK model to a markup shock while varying the parameter ϑ, which determines the distribution $g(e_i)$ of profits in the population.

3.2 The role of price and wage stickiness

General equilibrium. So far I have taken the response of aggregate profits $d\mathbf{\Pi}$ as given. Solving the model for $d\mathbf{\Pi}$ and substituting into eq. (21) characterizes the full general equilibrium solution for output. This operation requires writing the New-Keynesian Phillips curve (13) and wage Phillips curve (15) in sequence-space:

$$d\mathbf{P_H} = \boldsymbol{\kappa}^P (d\mathbf{mc} + d\boldsymbol{\mu}) \tag{23}$$

$$d\mathbf{W} = \boldsymbol{\kappa}^W \left(\frac{w}{\phi} d\mathbf{L} - d\mathbf{w} \right), \tag{24}$$

where the bold letters $\boldsymbol{\kappa}^P, \boldsymbol{\kappa}^W$ are the Phillips curve pass-through matrices (Auclert et al. 2024b).[12] Note that even though these are matrices, they are proportional to the slopes of the respective Phillips curves and so $\kappa^P = 0 \Rightarrow \boldsymbol{\kappa}^P = \mathbf{0}$, $\frac{\partial \boldsymbol{\kappa}^P}{\partial \kappa^P} \geq \mathbf{0}$ etc. To compactly solve for the general equilibrium response of the model it is useful to define the *pass-through matrix of markup shocks to markups* $\boldsymbol{\Theta}^\mu$ as well as the *pass-through matrix of employment to markups* $\boldsymbol{\Theta}^L$.

Definition 2. *The pass-through matrix of markup shocks to markups is defined by:*

$$\Theta^\mu \equiv \left[\mathbf{I} + \frac{1}{W} \boldsymbol{\kappa}^W + \alpha_L W \boldsymbol{\kappa}^P \right]^{-1} W \boldsymbol{\kappa}^P. \tag{25}$$

Similarly, the pass-through matrix of employment to markups is defined by:

$$\Theta^L \equiv \left[\mathbf{I} + \frac{1}{W} \boldsymbol{\kappa}^W + \alpha_L W \boldsymbol{\kappa}^P \right]^{-1} \frac{\alpha_L}{\phi} \boldsymbol{\kappa}^W, \tag{26}$$

where $\boldsymbol{\kappa}^P, \boldsymbol{\kappa}^W$ are the slopes of the Phillips curves (23)-(24), α_L is the share of labor used in production, ϕ is the Frisch elasticity, and W is the steady state wage rate.

The markup pass-through matrix $\boldsymbol{\Theta}^\mu$ captures the effect of an increase in desired markups μ (or equivalently, in marginal costs) on the markup (defined as prices over nominal marginal costs, $P_{H,t}/MC_t$) through the two Phillips curves (23)-(24). If we consider simple, static Phillips curves of the form $dW_t = \kappa^W \left(\frac{W}{\phi} dL_t - dw_t \right)$, $dP_t = \kappa^P dmc_t$ with only labor used as input $dmc_t = dw_t$, then the entries in $\boldsymbol{\Theta}^\mu$ are constant and given by $\frac{\kappa^P}{1+\kappa^W+\kappa^P}$. The numerator captures the direct effect on markups from an increase in μ (markups increase by the shock times the pass-through to prices κ^P), while the denominator captures the feedback loop occurring through the wage Phillips curve. When

[12] If the discount factors in the Phillips-curves equal 0 then these matrices are simply given by $\boldsymbol{\kappa}^P = \kappa^P \times \boldsymbol{U}, \boldsymbol{\kappa}^W = \kappa^W \times \boldsymbol{U}$ where $\boldsymbol{U}$ is a lower-triangular matrix with ones on and below the diagonal, and zeros above. The more general expressions are derived in appendix A.4. Note that to simplify notation the markup shocks $d\boldsymbol{\mu} = (d\mu_0, d\mu_1, \ldots)$ in (23) are defined as $d\mu_t = \frac{\mu_t - \mu}{\mu^2}$. This is just a matter of scaling given linearity.

prices go up due to the shock, this reduces the real wages appearing in the wage Phillips curve, thereby raising nominal wages by κ^W. This raises the marginal costs of firms, which causes firms to once again raise prices by κ^P. The fixed point of this interaction is exactly $\boldsymbol{\Theta}^\mu$. With fully flexible prices the pass-through is one, while with fully flexible wages the pass-through is zero. $\boldsymbol{\Theta}^L$ captures the same logic following an increase in labor supply.[13] An increase in labor supply puts upwards pressure on nominal wage growth by exactly κ^W/ϕ. This raises marginal cost of firms, who in turn raise their prices by κ^P. This causes a decline in the real wage, whereby unions raise nominal wages again. The fixed point of this interaction is exactly $\frac{\kappa^W/\phi}{1+\kappa^W+\kappa^P}$. Note that this is positive; it enters the multiplier with a negative sign, reflecting that with sticky prices an increase in inputs such as labor generates temporarily lower markups.

3.2.1 General equilibrium solution

With the notation from Definition 2 in place, the following proposition characterizes the full general equilibrium solution for output:

Proposition 2. *The equilibrium response of output $d\mathbf{Y}$ to a markup shock is:*

$$d\mathbf{Y} = -\mathcal{M}\left[\mathbf{M}^Z - \mathbf{M}^\Pi\right] \times \boldsymbol{\Theta}^\mu \times d\boldsymbol{\mu}, \tag{27}$$

where the Keynesian general equilibrium multiplier $\mathcal{M}$ is:

$$\mathcal{M} \equiv \left[\frac{\boldsymbol{I}}{1-\alpha} - \boldsymbol{M}^Z\left(1-(1-\omega)\left(1-\alpha_L\right)\right) - \left[\boldsymbol{M}^Z - \boldsymbol{M}^\Pi\right]\left[\Theta^L - \frac{\mu-1}{\mu} - \omega\left(1-\alpha_L\right)\right]\right]^{-1}$$

Proof: appendix A.5.

Proposition 2 highlights simultaneously the importance of the MPC differential $\mathbf{M}^Z - \mathbf{M}^\Pi$ discussed earlier as well as the importance of nominal price and wage frictions (captured in $\boldsymbol{\Theta}^\mu$) as they determine the response of profits $d\boldsymbol{\Pi}$.

More flexible prices ($\kappa^P \uparrow$) will lead to a larger pass-through from markups to prices. In the presence of nominal wage frictions ($\kappa^W < \infty$) this will lead to a decline in the real wage and higher profits (larger $\boldsymbol{\Theta}^\mu$). The drop in real wages suppress aggregate demand and output if $\mathbf{M}^Z > \mathbf{M}^\Pi$. Similarly, more flexible wages ($\kappa^W \uparrow$) will imply a small drop in real wages as any drop in real wages will be met by larger nominal wage increases according to the wage Phillips curve (15). This will stabilize aggregate demand since $\mathbf{M}^Z > \mathbf{M}^\Pi$ and output fluctuations will be dampened. These mechanisms are summarized in the following proposition:

Proposition 3 (Price and Wage flexibility)**.** *Consider the response of aggregate output (27) to a markup shock. If $\mathbf{M}^Z \geq \mathbf{M}^\Pi$ then:*

[13] In this stylized example the entries of $\boldsymbol{\Theta}^L$ are given by $\frac{\kappa^W/\phi}{1+\kappa^W+\kappa^P}$.

(i) Increasingly flexible prices amplify the output effects of the markup shock $\frac{\partial d\mathbf{Y}}{\partial \kappa^P} \leq 0$*, while rigid prices dampen the shock. In the limit with completely rigid prices we have* $\boldsymbol{\Theta}^\mu = \mathbf{0}$*, and the general equilibrium response of output is zero:*

$$\lim_{\kappa^P \to 0} d\mathbf{Y} = \mathbf{0} \times d\boldsymbol{\mu},$$

while with fully flexible prices there is full pass-through, $\boldsymbol{\Theta}^\mu = \boldsymbol{I}$*:*

$$\lim_{\kappa^P \to \infty} d\mathbf{Y} = -\mathcal{M}\left[\mathbf{M}^Z - \mathbf{M}^\Pi\right] \times d\boldsymbol{\mu}.$$

(ii) If prices are not completely flexible, $\kappa^P < \infty$*, increasingly flexible wages attenuate the output effects of the markup shock* $\frac{\partial d\mathbf{Y}}{\partial \kappa^W} \geq 0$*, while more rigid wages amplify the effects of the markup shock. In the limit with completely flexible wages we have* $\boldsymbol{\Theta}^\mu = \mathbf{0}$*, and the general equilibrium response of output is zero:*

$$\lim_{\kappa^W \to \infty} d\mathbf{Y} = \mathbf{0} \times d\boldsymbol{\mu}.$$

Proof: Appendix A.6.

Figures 6 and 7 illustrate Proposition 3 numerically. Figure 6 shows that a lower degree of price stickiness amplifies the markup shock by generating a larger inflation response, which for given nominal wages generates a larger real wage drop. Hence price flexibility amplifies the redistribution from workers to firm owners which suppresses aggregate demand. With sufficiently sticky prices, inflation does not move and the shock has no effect.

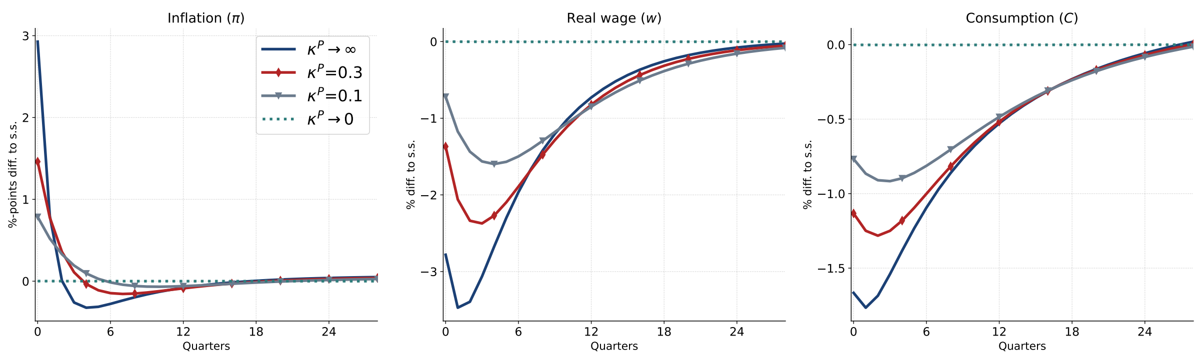


Figure 6: Transmission of markup shock with varying degree of price stickiness

Figure 7 correspondingly shows that a larger degree of wage flexibility attenuates the response to the shock. In the limit with completely flexible wages real wages remain unchanged even though the equilibrium outcome features a larger inflation response. Since real wages are unchanged the effect on aggregate demand is completely neutralized. Note that for wage flexibility to matter it is necessary that prices are not completely flexible $\kappa^P < \infty$, since in that case the change in the markup is exogenous. In this case wage flexibility cannot affect the cyclicality of markups, and even completely flexible wages will not be sufficient to stabilize the real wage.

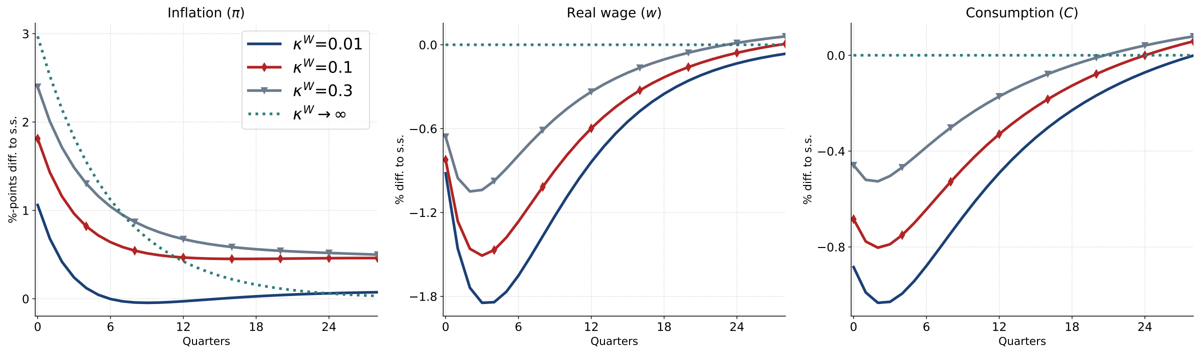


Figure 7: Transmission of markup shock with varying degree of wage stickiness

3.3 Extensions

Fisher effects. The baseline model assumes that households save in real assets, sidestepping the debt-revaluation channel that arises when nominal debt contracts are present (Fisher 1933; Auclert 2019; M. Brunnermeier et al. 2025). In Appendix C.4 I introduce nominal, long term government bonds such that surprise inflation affects returns in the first period of the shock. In the case with 1 year maturity of bonds, the change in aggregate consumption is given by:

$$d\boldsymbol{C} = \underbrace{\boldsymbol{M}^Z d\boldsymbol{Z}}_{\text{Labor income}} + \underbrace{\boldsymbol{M}^\Pi d\Pi}_{\text{Profits}} - \underbrace{\boldsymbol{M}^{r_0}\theta^n d\pi_0}_{\text{Fisher effects}}$$

where $\boldsymbol{M}^{r_0}$ is a vector capturing the effect on aggregate consumption $d\boldsymbol{C}$ following a change in the real rate of return at time 0, dr_0 and θ^n is the share of nominal bonds.[14] The vector $\boldsymbol{M}^{r_0}$ can be written as the product of an average effect and a covariance:

$$\boldsymbol{M}^{r_0} = \boldsymbol{M}_0 \times A^n + \mathbb{C}\text{ov}\left(\boldsymbol{M}_{i,0}, a_i^n\right)$$

stating that the effect on consumption from a surprise change in the rate of return is the sum of 1) MPC out of a lumpsum transfer at time $t = 0$ ($\boldsymbol{M}_0$) times the aggregate net nominal position A^n, 2) The covariance between MPCs in the population and net nominal position. Since borrowers in the model are more likely to be credit constrained, this covariance tends to be negative. Figure A.5a shows the effects of the markup shock with the Fisher effect active. On impact, the redistribution from creditors to debtors dampens the demand contraction, since impact MPCs of debtors exceed those of creditors, $\mathbb{C}\text{ov}\left(\boldsymbol{M}_{i,0}, a_i^n\right) < 0$. However, because creditors have larger intertemporal MPCs

[14] I only need to account for the effects of a rate change at time 0 on consumption, since monetary policy keeps the ex-ante real rate constant, and so $dr_t = 0$ for $t > 0$.

(i.e. they consumption smooth more), the negative consumption response is amplified in subsequent periods as the initial redistributional effect subsides and savers reduce consumption persistently. However, for a realistic covariance between MPCs and net nominal positions (Auclert 2019) the overall impact of these Fisher effects are minor.

Investment. The baseline model abstract from investment. This may matter as the low MPC out of profits imply a high marginal propensity to invest. In the baseline model these profits flow into unproductive bonds. To see the implications of this assumption, I introduce investment into the model. I consider two versions: 1) A standard approach where investment is paid for by firms out of profits subject to an adjustment cost, 2) A version with financial frictions where a fraction s of operating surplus is used to finance investment (Lian and Ma (2021) and Drechsel (2023)). In both cases total output Y is a Cobb-Douglas with capital and the CES aggregate containing L, X (see appendix C.1 for details). Figure A.3 shows the results. With unconstrained investment there is mild contraction in output in the RANK model, while the response of the HANK model are largely unchanged. In both models investment decline since a higher firm markup reduces the marginal product of capital. With financial constraints the overall surplus of firms instead determines the response investment. In this case the RANK model predicts an increase in output following the markup shock as the increase in profits flow into investment. The HANK model still predicts a decline due to the negative effect on consumption from lower real wages, though this can be overturned if the financial friction effect on investment is sufficiently strong.

3.4 Policy

Transfers. It is obvious that a targeted transfer to poorer households paid for by hiking taxes on wealthier households can fully neutralize the shock. However, in practice government which paid out stimulus to alleviate cost-of-living crises issues during the 2021–2023 inflation surge often did so using deficit financing (Dao et al. 2023). To investigate this, I consider a policy of this kind. I assume that the government provides a transfer dT_t that is exactly enough to stabilize the income loss from real wages in the baseline shock, and that this transfer is financed by a tax on rich households. The size of the tax is determined by the degree of debt issuing:

$$dB_t = \rho_B \left(dB_{t-1} - dT_t \right)$$

where $\rho_B = 0$ imply that the policy is perfectly balanced (i.e. the transfer equals the tax), and $\rho_B > 0$ imply that the policy is partially deficit financed. Figure A.2 shows the results for varying ρ_B in the baseline HANK model. With a fully balanced budget fiscal policy can perfectly stabilize consumption without causing excess inflation (i.e. inflation beyond the effects of the underlying markup shock). As the policy becomes increasingly deficit financed the response of private consumption becomes positive, reflecting that overall household income is now net positive: Real labor income is fully stabilized (funded by the government), while profit income is above steady state due to the markup shock itself. This causes excess inflation, which increases in the degree of deficit financing ρ_B.

Monetary policy. The baseline models features "passive" monetary policy ($dr_t = 0$), which imply that the markup shock has no effects in the representative agent model. Whether monetary policy should tighten or loosen is not obvious with a stagflationary supply shock if the central bank has a dual mandate, though historically the Fed has tightened in response to oil shocks, as has the ECB as they focus only on inflation stabilization. I investigate the implications of a tight monetary policy response by adding a Taylor rule $di_t = \phi^{\pi} d\pi_{t+1}$ where the $\phi^{\pi} = 1$ recovers the baseline where the ex-ante real rate is constant. Figure A.1 shows the 1st year response of real labor income, real wages and employment as a function of ϕ^{π}. aggregate real labor income Z declines more as the monetary policy response becomes more aggressive. Notably the *driver* of this decline changes with the monetary policy response: For a low ϕ^{π} the decline is caused by higher inflation, and lower real wages. As ϕ^{π} become larger inflation declines, real wages fall less, but overall employment declines more. The latter effect dominates, so total real labor income ultimately declines more with a more aggressive policy. This can potentially have import implications in model with a more realistic modelling of the labor market where not all households are equally affected by changes in real wages vs. employment (see e.g. Alves and Violante 2023).

Wage indexation. Proposition 3 highlights the importance of real wage dynamics for the transmission of cost-push shocks in models with distributional effects. A natural structural remedy is to index nominal wages to CPI inflation (Fischer 1976). In Appendix C.2 I solve the model with wage indexation and demonstrate that a higher degree of indexation dampens the output effects of the markup shock. Full indexation perfectly neutralizes the shock's aggregate demand effects, analogously to the flexible-wage case in Proposition 3.

4 General cost-push shocks

While the cost-push shock considered in section 3.1 is a very direct inflationary shock, it is also special in the sense that it per construction directly distorts the distribution of factor income. In this section I consider instead a more general cost-push shock corresponding to an increase in the price of materials used in production ($P^*_{X,t}$ in equation (12)). This shock resembles more closely the large inflationary shock which hit Europe in 2021-2023 through higher import prices.

Preliminaries. The baseline analysis assumes that the domestic central bank keeps the domestic real rate constant, implying that the real exchange rate is also constant given the real UIP condition (16). It turns out that if we consider a foreign inflation shock that increases foreign CPI and the price of foreign inputs equally, $dP^*_{F,t} = dP^*_{X,t}$ then the assumption of a constant real rate implies that the nominal exchange rate takes the entire adjustment of the shock and the domestic economy is entirely unaffected.[15]

This result can easily be broken by considering an asymmetric shock which features a larger increase in the price of foreign inputs compared to the foreign CPI, $dP^*_{X,t} > dP^*_{F,t}$. In this section I consider the special case where $dP^*_{F,t} = 0, dP^*_{X,t} > 0$ but given linearization the shock can be interpreted as an increase import prices over and above the increase in foreign CPI.

Analysis Consider now a shock which raises the price of materials, $P^*_{X,t} > 0$. The difference between this shock and the markup shock can be seen in the following proposition, which generalizes eq. (21):

Proposition 4 (Equilibrium relationship between output and profits with cost-push shocks). *Given a sequence of material price shocks* $\left\{dP^*_{X,t}\right\}_{s=0}^{\infty}$ *the equilibrium relation between output and profits is given by:*

$$\frac{\boldsymbol{I}}{1-\alpha}d\mathbf{Y} = \underbrace{\alpha_L \mathbf{M}^Z d\mathbf{Y}}_{Multiplier} - \underbrace{\left[\mathbf{M}^Z - \mathbf{M}^\Pi\right] d\mathbf{\Pi}}_{Distributional\ channel} - \underbrace{(1-\omega)\,(1-\alpha_L)\,\mathbf{M}^Z d\mathbf{P}^*_{\mathbf{X}}}_{Direct\ effect} \tag{28}$$

Proof: appendix D.2.

Proposition 4 shows that even with an equal incidence of labor income and profits $\mathbf{M}^\Pi = \mathbf{M}^Z$, the cost-push shock has a contractionary effect on domestic output to the extent that MPCs are positive, $\mathbf{M}^\Pi = \mathbf{M}^Z > \mathbf{0}$. In this case the dynamics of the real wage and profits do not matter because both have the same effect on aggregate demand, and one can solve for the GE output response independently of the Phillips curves:

Corollary 2. *If there is equal incidence of labor income and profits,* $\mathbf{M}^\Pi = \mathbf{M}^Z$, *then the output response to a cost-push shock is:*

$$d\mathbf{Y} = -\left[\boldsymbol{I} - (1-\alpha)\,\alpha_L \mathbf{M}^\Pi\right]^{-1} (1-\alpha_L)\,(1-\omega)\,\mathbf{M}^\Pi d\boldsymbol{P}^*_{\mathbf{X}}$$

and thus contractionary if $\mathbf{M}^\Pi = \mathbf{M}^Z > \mathbf{0}$ *and* $\omega < 1$.

Corollary 2 suggests that, unlike markup shocks, cost-push shocks produce contractionary effects in any model with $\mathbf{M}^\Pi = \mathbf{M}^Z > 0$, including the representative

[15] See Appendix D.1.

agent case ($\mathbf{M}^Z = \mathbf{M}^\Pi$). This is because, whenever $\omega < 1$, some resources leave the domestic economy as domestic firms must pay more for foreign inputs, making the contractionary effects unavoidable.

Figure 8 illustrates this in the quantitative model. The left panel shows that for the RANK model - which features permanent income type behaviour - there is a small but persistent effect on output coming from the direct effect. The right panel shows that the HANK model, which features the additional distributional channel from endogenous markups, shows pronounced amplification. The decline in output over the first year is 3 times larger in the HANK model compared to the RANK model.

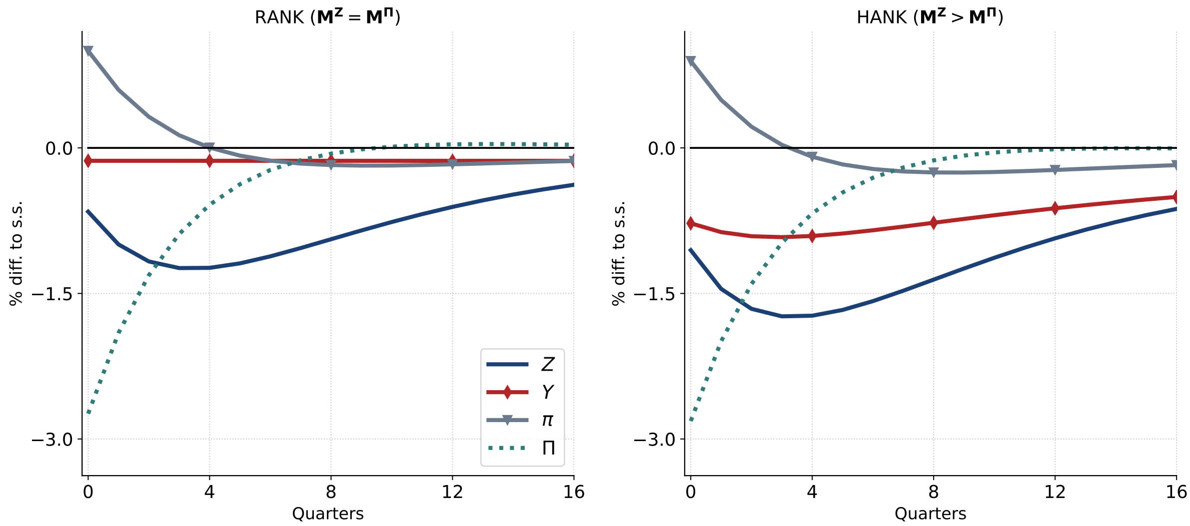


Figure 8: Effect of cost-push shock in RANK and HANK

Note: Impulse responses to an AR(1) shock to the import prices with persistence 0.8 when imports are fully owned by foreigners, $\omega = 0$. The shock is normalized such that inflation increase 1% on impact. The Figure shows real labor income Z (red), real output Y (dark blue), CPI inflation π (grey) and real profits Π (orange).

It is worth noting that domestic GDP (measured in units of the CPI), $GDP_t = \frac{P_{H,t}}{P_t} Y_t - \frac{P_{X,t}}{P_t} X_t$, declines persistently in both models due to the mechanical effect from higher material prices $\frac{P_{X,t}}{P_t}$. I here focus on the effect on output as a measure of internal propagation and amplification.[16]

For completeness proposition 5 shows the equilibrium response of output to the cost-push shock. The solution reveals that the direct effect is proportional to the MPC out of profits (and not $\mathbf{M}^Z$ as prop. 4 might lead one to think), and therefore relatively weaker than the contribution coming from the indirect, factor income distribution effect.

Proposition 5 (Equilibrium output response to cost-push shocks). *Given a sequence of*

[16] A similar measure would be domestic employment, which is often used as a measure of the business cycle by the FED.

cost-push shocks $\left\{dP^*_{X,t}\right\}_{s=0}^{\infty}$ *the equilibrium response of output is:*

$$d\boldsymbol{Y} = -\mathcal{M}\left[\boldsymbol{M}^Z - \boldsymbol{M}^\Pi\right](1-\alpha_L)\,\Theta^\mu d\boldsymbol{P}^*_{\boldsymbol{X}} - \mathcal{M}\boldsymbol{M}^\Pi(1-\omega)\frac{(1-\alpha_L)}{\alpha_L}d\boldsymbol{P}^*_{\boldsymbol{X}} \tag{29}$$

where the multiplier is defined by:

$$\mathcal{M} \equiv \left\{\frac{\boldsymbol{I}}{1-\alpha} - \boldsymbol{M}^Z\left(1-(1-\omega)(1-\alpha_L)\right) - \left[\boldsymbol{M}^Z - \boldsymbol{M}^\Pi\right]\left[\Theta^L - \frac{\mu-1}{\mu} - \omega(1-\alpha_L)\right]\right\}^{-1}$$

Proof: appendix D.2.

Empirical evidence. Unlike markup shocks, empirical estimates of the effects of foreign cost-push shocks are available in the existing literature, the most prominent type being oil shocks. Most of the literature find that oil shocks are contractionary and produces stagflation (Kilian 2008; Känzig 2021). Of course the empirical effects of oil supply shocks also induce an endogenous response of monetary policy, and therefore the observed contractionary effects can be consistent with both the RANK and HANK models. In a recent contribution Broer et al. (2025) investigate the effects of euro area oil shocks under a counterfactual, neutral monetary policy using the method from Sims and Zha (2006). They find that the negative effects oil shocks remain, consistent with the HANK model.

Markup shock equivalence. The cost-push shock and markup shock differ because the former involves a transfer to foreign households through higher import prices. Assuming that stock of materiels is entirely owned by domestic households, $\omega = 1$ nullifies this effects, and the two shocks are equivalent:

Proposition 6 (markup shock equivalence)**.** *When the endowment X is entirely owned by domestic households, $\omega = 1$, markup shocks $d\boldsymbol{\mu}$ and cost-push shocks $d\boldsymbol{P}^*_{\boldsymbol{X}}$ are equivalent up to a constant scaling factor given by $1-\alpha_L$. Proof: The result follows immediately from setting $\omega = 1$ in* (21) *and* (29).

Figure 9 illustrates this in the quantitative model.

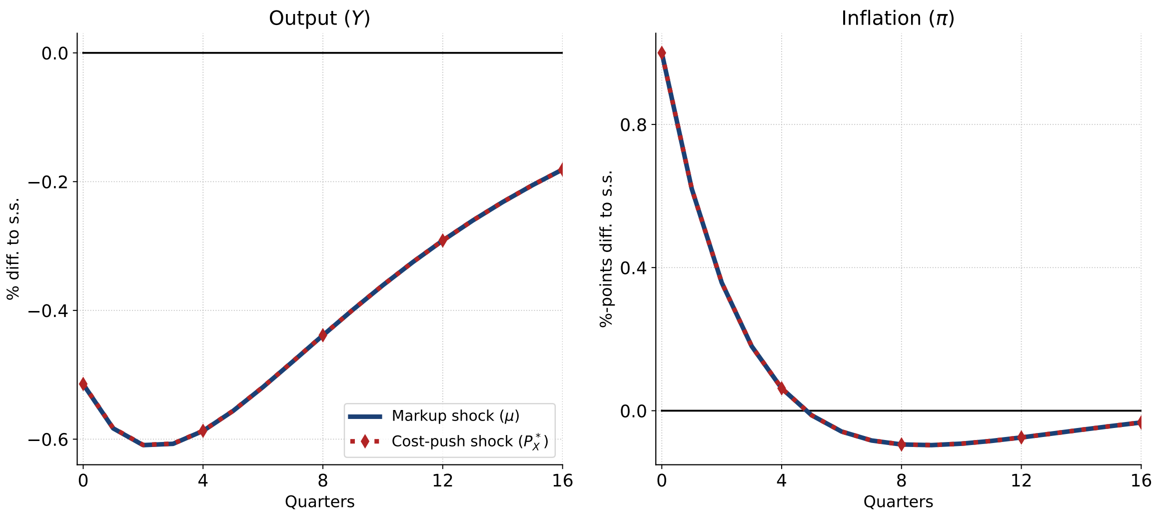


Figure 9: Equivalence between markup shocks and cost-push shocks

Note: The figure shows the response of output and inflation to a markup shock and to a cost-push shock for $\omega = 1$. The shocks are scaled to increase inflation in the first period by 1%.

4.1 Substitution in production

The analytical results assume zero substitution between production inputs. Figure 10 shows how the transmission of the markup shock (left panel) and cost-push shock (right panel) changes with the degree of substitutability. With an elasticity of zero the two shocks are equivalent (prop 6) and both generate a large decline in output. As the elasticity becomes larger firms respond to the increase in import prices by substituting away from materials towards labor, which is relatively cheap due to sticky nominal wages. This increases employment thereby stabilizing real labor income and consumption. This effect is much stronger for the cost-push shock since this directly changes the relative price of materials vs. labor. Thus a necessary condition for the amplification of the cost-push shock is the presence of sticky wages *and* complementarity in factor inputs. A similar point was made in Lorenzoni and Werning (2023) and Auclert et al. (2023a). Note, however, that an implausibly high degree of substitutability is required for consumption and output to *increase* in response to the cost-push shock.

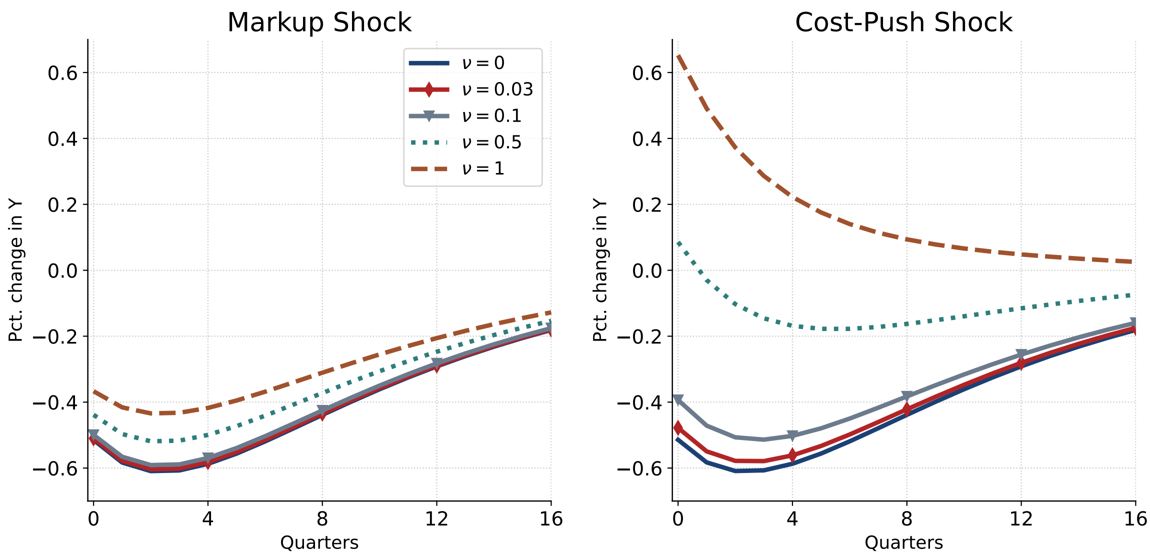


Figure 10: Importance of labor-materials substitution

Note: Impulse responses to a markup shock and a cost-push shock in HANK for different elasticities of substitution between labor and materials ν.

5 Tariffs

Lastly I study the effects of a hike in domestic tariffs τ imposed on goods imported by households and firms. Stirred by the tariffs imposed by US on many trading partners in 2025, several papers have studied the effects of tariffs on the macroeconomy in the short run, see e.g. Auclert et al. (2025), Monacelli (2025), Bianchi and Coulibaly (2025) and Guerrieri et al. (2025). Proposition 7 gives the equilibrium response of output under the assumption that the revenue from the tariffs is rebated to households under some general rule with (intertemporal) MPCs $\boldsymbol{M}^{\tau}$.[17] The proposition shows that the effect on output is determined by 3 distinct channels. Firstly, higher tariffs increase costs for firms as they pay more for imported materials, which induces a real wage channel as with the domestic markup shock and the cost-push shock studied earlier. Secondly, there is a *demand stabilization* effect as the revenue from the increase in tariffs is rebated to households which increases domestic demand by the MPC matrix $\boldsymbol{M}^{\tau}$. Lastly, higher tariffs also tweak the terms-of-trade by reducing the relative price of domestic vs. foreign goods, thereby inducing an expenditure switching effect which increases demand as agents substitute toward domestically produced goods.

Proposition 7 (Equilibrium output response to tariffs)**.** *Given a sequence of tariff shocks*

[17] For instance, if transfers are rebated similarly to labor income (proportionally to idiosyncratic income) we have $\boldsymbol{M}^{\tau} = \boldsymbol{M}^{Z}$, and if rebated similarly to profits we have $\boldsymbol{M}^{\tau} = \boldsymbol{M}^{\Pi}$.

$\{d\tau_t\}_{s=0}^{\infty}$ *the equilibrium response of output is:*

$$d\boldsymbol{Y} = \overbrace{-\mathcal{M}\left[\boldsymbol{M}^{Z} - \boldsymbol{M}^{\Pi}\right]\boldsymbol{\Theta}^{\mu}\left((\boldsymbol{\kappa}^{P})^{-1}\frac{\alpha}{1-\alpha} + (1-\alpha_L)\right)d\boldsymbol{\tau}}^{\text{Real wage effect}}$$
$$+\overbrace{\mathcal{M}\frac{1-\alpha_L(1-\alpha)}{\alpha_L}\left[\boldsymbol{M}^{\tau} - \frac{1}{1-\alpha}\boldsymbol{M}^{\Pi}\right]d\boldsymbol{\tau}}^{\text{Tax/transfer effect}}$$
$$+\overbrace{\mathcal{M}\frac{\alpha}{1-\alpha}\eta\left(1+\frac{\alpha^*}{1-\alpha}\right)d\boldsymbol{\tau}}^{\text{Terms-of-trade effects}} \tag{30}$$

Proof: appendix E.

The main difference between the tariff shock and the two prior shocks is in the expenditure switching effect. In particular if there is no expenditure switching, $\eta = \eta^* = 0$, then the shock has no effect on domestic output if agents behave identically $\boldsymbol{M}^{\Pi} = \boldsymbol{M}^{Z}$ and transfers are distributed to agents such that $\boldsymbol{M}^{\tau} = \frac{1}{1-\alpha}\boldsymbol{M}^{\Pi}$. The intuition for the two conditions is as follows. $\boldsymbol{M}^{\Pi} = \boldsymbol{M}^{Z}$ eliminates the real wage channel: the decline in demand from lower real wages is exactly offset by the increased income of profit recipients. $\boldsymbol{M}^{\tau} = \frac{1}{1-\alpha}\boldsymbol{M}^{\Pi}$ then ensures that the tariff rebate neutralises the remaining tax/transfer effect on demand.

In the absence of this knife-edge case the tariff shock can have either an expansionary or contractionary effect on the domestic economy depending on how strong the expenditure switching effect is vs. the drag on household demand. This is similar to the finding of Auclert et al. (2025) though they focus on a permanent-income household and so the transmission to domestic households' demand occurs primarily through intertemporal substitution instead of income effects.

Figure 11 shows the dynamic effects of the tariff shock in the RANK and HANK models. In the RANK model the real wage effect is zero, while the tax/transfer effect is negligible and so the expenditure switching effect causes a rise in output. Inflation spikes at the introduction of the tariff, which cause a persistent decline in real labor income. In the HANK model similar effects operate, but the effect on output is lower, due to the drag on domestic consumption caused by lower real labor income (and profits).

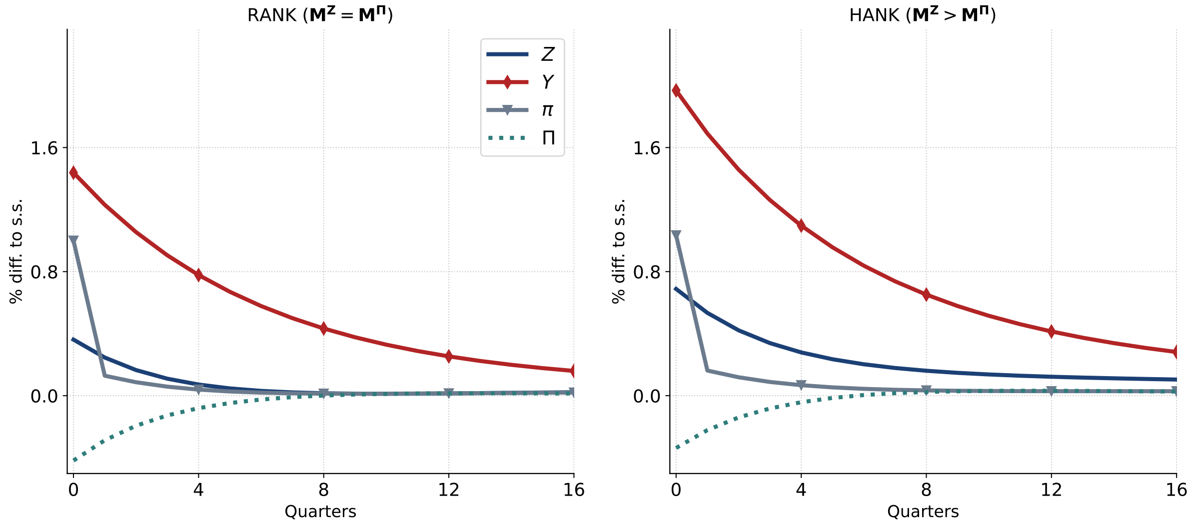


Figure 11: Effects of a temporary increase in tariff

Role of revenue rebate. As evident from proposition 7 the increase in tariffs have two opposing effects on domestic demand: 1) A sudden jump in the price level increases inflation and reduces real wages, 2) The increase in government revenue from tariffs on imports can potentially raise domestic demand depending on the policy of the government. Figure 12 shows the effects of the tariff shock on inflation, real wages and consumption assuming that the government debt rule of the form:

$$dB_t = \rho_B \left(dB_{t-1} - dR_t^\tau \right)$$

as in Auclert et al. (2023b), where R_t^τ is the revenue from tariffs and ρ_B determines the degree to which the revenue is used to payoff government debt. With $\rho_B = 0$ all tariff revenue is rebated to households immediately, whereas for a higher ρ_B the revenue is retained and used to temporarily pay off government debt. Figure 12 shows the IRFs in the HANK model with varying ρ_B. With $\rho_B = 0$ the entire revenue from tariffs are rebated to households, and this is sufficient to compensate from the drag on demand caused by declining real wages. Thus the domestic economy experiences an expansion driven by an increase in demand for domestic goods through expenditure switching, which through the Keynesian multiplier also increases domestic consumption. With a higher ρ_B the decline in real wages is not compensated through transfers, and domestic demand declines. The expenditure switching channel is not sufficiently strong to overcome this at a low trade elasticity (0.5 in the figure). Note that this result does not obtain in the corresponding RANK model since Ricardian equivalence prevails here, and the timing of transfers does not matter.

Figure 12: Tariff shock with varying financing

Role of expenditure switching. Figure 13 displays IRFs in the HANK model to the tariff shock for varying trade elasticities η, η^* in order to grasp the effect of the expenditure switching channel. For a low elasticity the effect on domestic consumption is dominantly negative as the drag from decline real wages outweighs the expansionary coming from expenditure switching. For a higher trade elasticity there is large surge in demand for domestic goods following the shock, which increases domestic employment and consumption.

Figure 13: Tariff shock with varying trade elasticities

6 Conclusion

This paper has analytically characterized the transmission of inflationary shocks in a heterogeneous-agent New Keynesian model, emphasizing the real wage channel through which cost-push shocks redistribute income from workers to firm owners. Using the sequence-space Jacobian framework, I derive closed-form expressions relating the output response to the cross-sectional distribution of marginal propensities to consume across income sources and to the degree of nominal price and wage rigidities. Across all three shocks studied — domestic markup shocks, foreign cost-push shocks, and tariffs — the HANK model generates substantially larger output contractions than the RANK benchmark, with the largest amplification arising for the foreign cost-push shock. Two structural features moderate the magnitude of the channel: more flexible prices amplify the real wage decline, while more flexible wages attenuate it, as nominal wages adjust to restore purchasing power.

Future research should extend the framework to settings where the inflation burden is not shared uniformly across workers, for instance through heterogeneous consumption baskets or labor supply schedules, to further assess the redistributive anatomy of price shocks.

References

Aiyagari, S. Rao. 1994. "Uninsured idiosyncratic risk and aggregate saving". Publisher: MIT Press, *The Quarterly Journal of Economics* 109 (3): 659–684.

Alves, Felipe, and Gianluca Violante. 2023. "Some Like it Hot: Monetary Policy Under Okun's Hypothesis".

Andersen, Asger Lau, Niels Johannesen and Adam Sheridan. 2024. "Dynamic spending responses to wealth shocks: Evidence from quasi-lotteries on the stock market". Publisher: CEPR Discussion Paper No. DP16338, *American Economic Review: Insights* Forthcoming.

Angeletos, George-Marios, Chen Lian and Christian K Wolf. 2024. "Can deficits finance themselves?" *Econometrica* 92 (5): 1351–1390.

Ascari, Guido, Efrem Castelnuovo and Lorenza Rossi. 2011. "Calvo vs. Rotemberg in a trend inflation world: An empirical investigation". Publisher: Elsevier, *Journal of Economic Dynamics and Control* 35 (11): 1852–1867.

Auclert, Adrien. 2019. "Monetary policy and the redistribution channel". Publisher: American Economic Association 2014 Broadway, Suite 305, Nashville, TN 37203, *American Economic Review* 109 (6): 2333–2367.

Auclert, Adrien, Bence Bardóczy, Matthew Rognlie and Ludwig Straub. 2021. "Using the Sequence-Space Jacobian to Solve and Estimate Heterogeneous-Agent Models". *Econometrica* 89 (5): 2375–2408.

Auclert, Adrien, Michael Cai, Matthew Rognlie and Ludwig Straub. 2024a. "Optimal long-run fiscal policy with heterogeneous agents". *Unpublished Manuscript, Harvard University.*

Auclert, Adrien, Hugo Monnery, Matthew Rognlie and Ludwig Straub. 2023a. *Managing an Energy Shock: Fiscal and Monetary Policy.* Technical report. Working Paper.

Auclert, Adrien, Rodolfo Rigato, Matthew Rognlie and Ludwig Straub. 2024b. "New Pricing Models, Same Old Phillips Curves?" Publisher: Oxford University Press, *The Quarterly Journal of Economics* 139 (1): 121–186.

Auclert, Adrien, Rodolfo D. Rigato, Matthew Rognlie and Ludwig Straub. 2022. *New Pricing Models, Same Old Phillips Curves?* Technical report. National Bureau of Economic Research.

Auclert, Adrien, Matthew Rognlie and Ludwig Straub. 2023b. "The Intertemporal Keynesian Cross".

Auclert, Adrien, Matthew Rognlie, Martin Souchier and Ludwig Straub. 2024c. "Exchange Rates and Monetary Policy with Heterogeneous Agents: Sizing up the Real Income Channel".

Auclert, Adrien, Matthew Rognlie and Ludwig Straub. 2020. *Micro jumps, macro humps: Monetary policy and business cycles in an estimated HANK model.* Technical report. National Bureau of Economic Research.

———. 2024d. "The Intertemporal Keynesian Cross". *Journal of Political Economy* 132, no. 12 (December): 4068–4121.

———. 2025. *The Macroeconomics of Tariff Shocks.* Technical report. National Bureau of Economic Research.

Baqaee, David Rezza, and Emmanuel Farhi. 2024. "Networks, Barriers, and Trade". *Econometrica* 92 (2): 505–541.

Bellifemine, Marco, Adrien Couturier and Rustam Jamilov. 2025. "The Regional Keynesian Cross".

Bellifemine, Marco, Rustam Jamilov and Tommaso Monacelli. 2022. "Hbank: Monetary policy with heterogeneous banks".

Bewley, Truman. 1986. "Stationary monetary equilibrium with a continuum of independently fluctuating consumers". Publisher: North-Holland Amsterdam, *Contributions to mathematical economics in honor of Gérard Debreu* 79.

Bianchi, Javier, and Louphou Coulibaly. 2025. *The Optimal Monetary Policy Response to Tariffs.* Technical report. National Bureau of Economic Research.

Blanchard, Olivier J., and Jordi Gali. 2007. *The Macroeconomic Effects of Oil Shocks: Why are the 2000s so different from the 1970s?*

Bobasu, Alina, Michael Dobrew and Amalia Repele. 2024. "Energy price shocks, monetary policy and inequality". *Available at SSRN 4775771.*

Bodenstein, Martin, Luca Guerrieri and Christopher J. Gust. 2013. "Oil shocks and the zero bound on nominal interest rates". Publisher: Elsevier, *Journal of International Money and Finance* 32:941–967.

Boehm, Christoph E., Aaron Flaaen and Nitya Pandalai-Nayar. 2019. "Input linkages and the transmission of shocks: Firm-level evidence from the 2011 Tōhoku earthquake". Publisher: MIT Press One Rogers Street, Cambridge, MA 02142-1209, USA journals-info … *Review of Economics and Statistics* 101 (1): 60–75.

Broer, Tobias, John Kramer and Kurt Mitman. 2025. "The distributional effects of oil shocks". Publisher: JSTOR.

Brunnermeier, Markus, Sergio Correia, Stephan Luck, Emil Verner and Tom Zimmermann. 2025. "The Debt-Inflation Channel of the German (Hyper) Inflation". *American Economic Review* 115 (7): 2111–2150.

Brunnermeier, Markus K., Sergio A. Correia, Stephan Luck, Emil Verner and Tom Zimmermann. 2023. *The debt-inflation channel of the German hyperinflation.* Technical report. National Bureau of Economic Research.

Chan, Jenny, Sebastian Diz and Derrick Kanngiesser. 2024. "Energy prices and household heterogeneity: Monetary policy in a gas-tank". Publisher: Elsevier, *Journal of Monetary Economics,* 103620.

Chetty, Raj, Adam Guren, Day Manoli and Andrea Weber. 2011. "Are micro and macro labor supply elasticities consistent? A review of evidence on the intensive and extensive margins". *American Economic Review* 101 (3): 471–75.

Chodorow-Reich, Gabriel, Plamen T. Nenov and Alp Simsek. 2021. "Stock market wealth and the real economy: A local labor market approach". Publisher: American Economic Association 2014 Broadway, Suite 305, Nashville, TN 37203, *American Economic Review* 111 (5): 1613–1657.

Christiano, Lawrence J., Mathias Trabandt and Karl Walentin. 2011. "Introducing financial frictions and unemployment into a small open economy model". Publisher: Elsevier, *Journal of Economic Dynamics and Control* 35 (12): 1999–2041.

Cravino, Javier, Ting Lan and Andrei A. Levchenko. 2020. "Price stickiness along the income distribution and the effects of monetary policy". Publisher: Elsevier, *Journal of Monetary Economics* 110:19–32.

Dao, Mai, Allan Dizioli, Chris Jackson, Pierre-Olivier Gourinchas and Mr Daniel Leigh. 2023. *Unconventional fiscal policy in times of high inflation.* International Monetary Fund.

De Ferra, Sergio, Kurt Mitman and Federica Romei. 2020. "Household heterogeneity and the transmission of foreign shocks". Publisher: Elsevier, *Journal of International Economics* 124:103303.

Del Negro, Marco, Marc P. Giannoni and Frank Schorfheide. 2015. "Inflation in the great recession and new keynesian models". Publisher: American Economic Association 2014 Broadway, Suite 305, Nashville, TN 37203-2425, *American Economic Journal: Macroeconomics* 7 (1): 168–196.

Diz, Sebastian, Mario Giarda and Damián Romero. 2023. "Inequality, nominal rigidities, and aggregate demand". Publisher: Elsevier, *European Economic Review* 158:104529.

Doepke, Matthias, and Martin Schneider. 2006. “Inflation and the redistribution of nominal wealth”. Publisher: The University of Chicago Press, *Journal of Political Economy* 114 (6): 1069–1097.

Drechsel, Thomas. 2023. “Earnings-based borrowing constraints and macroeconomic fluctuations”. *American Economic Journal: Macroeconomics* 15 (2): 1–34.

Druedahl, Jeppe, Søren Hove Ravn, Laura Sunder-Plassmann, Jacob Sundram and Nicolai Waldstrøm. 2025. “Fiscal Multipliers in Small Open Economies with Heterogeneous Households: J. Druedahl et al.” *IMF Economic Review*, 1–54.

Druedahl, Jeppe, Søren Hove Ravn, Laura Sunder-Plassmann, Jacob Marott Sundram and Nicolai Waldstrøm. 2022. “The Transmission of Foreign Demand Shocks”.

Erceg, Christopher J., Dale W. Henderson and Andrew T. Levin. 2000. “Optimal monetary policy with staggered wage and price contracts”. Publisher: Elsevier, *Journal of monetary Economics* 46 (2): 281–313.

Faccini, Renato, Seungcheol Lee, Ralph Luetticke, Morten O. Ravn and Tobias Renkin. 2024. *Financial frictions: Micro vs. macro volatility.* Technical report. Danmarks Nationalbank Working Papers.

Fagereng, Andreas, Martin B. Holm and Gisle J. Natvik. 2021. “MPC heterogeneity and household balance sheets”. *American Economic Journal: Macroeconomics* 13 (4): 1–54.

Fischer, Stanley. 1976. “Wage-indexation and macro-economic stability”. Publisher: Cambridge, Mass.: MIT Dept. of Economics.

Fisher, Irving. 1933. “The debt-deflation theory of great depressions”. Publisher: JSTOR, *Econometrica: Journal of the Econometric Society*, 337–357.

Floden, Martin, and Jesper Lindé. 2001. “Idiosyncratic risk in the United States and Sweden: Is there a role for government insurance?” Publisher: Elsevier, *Review of Economic dynamics* 4 (2): 406–437.

Fuster, Andreas, Greg Kaplan and Basit Zafar. 2021. “What would you do with $500? Spending responses to gains, losses, news, and loans”. Publisher: Oxford University Press, *The Review of Economic Studies* 88 (4): 1760–1795.

Gali, Jordi, and Tommaso Monacelli. 2005. “Monetary policy and exchange rate volatility in a small open economy”. Publisher: Wiley-Blackwell, *The Review of Economic Studies* 72 (3): 707–734.

Galí, Jordi, David López-Salido and Javier Vallés. 2004. *Rule-of-thumb consumers and the design of interest rate rules.*

Galí, Jordi, Frank Smets and Rafael Wouters. 2012. "Unemployment in an estimated New Keynesian model". Publisher: University of Chicago Press Chicago, IL, *NBER macroeconomics annual* 26 (1): 329–360.

Guerrieri, Veronica, and Guido Lorenzoni. 2017. "Credit Crises, Precautionary Savings, and the Liquidity Trap". Publisher: Oxford University Press, *The Quarterly Journal of Economics* 132 (3): 1427–1467.

Guerrieri, Veronica, Guido Lorenzoni and Iván Werning. 2025. *Tariffs as Cost-Push Shocks: Implications for Optimal Monetary Policy.* NBER Working Paper 31494. National Bureau of Economic Research.

Hagedorn, Marcus, Iourii Manovskii and Kurt Mitman. 2019. *The fiscal multiplier.* Technical report. National Bureau of Economic Research.

Huggett, Mark. 1993. "The risk-free rate in heterogeneous-agent incomplete-insurance economies". Publisher: Elsevier, *Journal of economic Dynamics and Control* 17 (5-6): 953–969.

Imrohoroğlu, Ayşe. 1989. "Cost of business cycles with indivisibilities and liquidity constraints". Publisher: The University of Chicago Press, *Journal of Political economy* 97 (6): 1364–1383.

Johnson, David S., Jonathan A. Parker and Nicholas S. Souleles. 2006. "Household expenditure and the income tax rebates of 2001". Publisher: American Economic Association, *American Economic Review* 96 (5): 1589–1610.

Känzig, Diego R. 2021. "The macroeconomic effects of oil supply news: Evidence from OPEC announcements". Publisher: American Economic Association 2014 Broadway, Suite 305, Nashville, TN 37203, *American Economic Review* 111 (4): 1092–1125.

Kaplan, Greg, Benjamin Moll and Giovanni L. Violante. 2018. "Monetary policy according to HANK". *American Economic Review* 108 (3): 697–743.

Kilian, Lutz. 2008. "Exogenous oil supply shocks: how big are they and how much do they matter for the US economy?" Publisher: The MIT Press, *The Review of Economics and Statistics* 90 (2): 216–240.

Kose, M. Ayhan. 2002. "Explaining business cycles in small open economies:'How much do world prices matter?'" Publisher: Elsevier, *Journal of International Economics* 56 (2): 299–327.

Lian, Chen, and Yueran Ma. 2021. "Anatomy of corporate borrowing constraints". *The Quarterly Journal of Economics* 136 (1): 229–291.

Lorenzoni, Guido, and Iván Werning. 2023. "Wage price spirals". *Forthcoming, Brookings Papers in Economic Activity.*

Luetticke, Ralph. 2021. "Transmission of monetary policy with heterogeneity in household portfolios". *American Economic Journal: Macroeconomics* 13 (2): 1–25.

McKay, Alisdair, Emi Nakamura and Jón Steinsson. 2016. "The Power of Forward Guidance Revisited". *American Economic Review* 106 (10): 3133–58.

Mendoza, Enrique G. 1995. "The terms of trade, the real exchange rate, and economic fluctuations". Publisher: JSTOR, *International Economic Review,* 101–137.

Monacelli, Tommaso. 2025. *Tariffs and Monetary Policy.* Technical report.

Nakamura, Emi, and Jón Steinsson. 2008. "Five facts about prices: A reevaluation of menu cost models". Publisher: MIT Press, *The Quarterly Journal of Economics* 123 (4): 1415–1464.

Nuño, Galo, and Carlos Thomas. 2022. "Optimal redistributive inflation". Publisher: JSTOR, *Annals of Economics and Statistics,* no. 146, 3–64.

Obstfeld, Maurice, and Kenneth Rogoff. 2000. "New directions for stochastic open economy models". Publisher: Elsevier, *Journal of international economics* 50 (1): 117–153.

Oskolkov, Aleksei. 2023. "Exchange rate policy and heterogeneity in small open economies". Publisher: Elsevier, *Journal of International Economics* 142:103750.

Patterson, Christina. 2023. "The Matching Multiplier and the Amplification of Recessions". *American Economic Review* 113, no. 4 (April): 982–1012.

Pieroni, Valerio. 2022. "Energy Shortages and Aggregate Demand: Output Loss and Unequal Burden from HANK". *European Economic Review.*

Rotemberg, Julio J. 1982. "Monopolistic price adjustment and aggregate output". Publisher: Wiley-Blackwell, *The Review of Economic Studies* 49 (4): 517–531.

Rotemberg, Julio J., and Michael Woodford. 1996. *Imperfect competition and the effects of energy price increases on economic activity.*

Sbordone, Argia M. 2006. "US wage and price dynamics: A limited information approach". *FRB of New York Staff Report,* no. 256.

Schaab, Andreas, and Stacy Yingqi Tan. 2025. "Monetary and Fiscal Policy According to HANK-IO".

Schmitt-Grohé, Stephanie, and Martin Uribe. 2005. "Optimal fiscal and monetary policy in a medium-scale macroeconomic model". Publisher: MIT Press, *NBER Macroeconomics Annual* 20:383–425.

———. 2006. *Comparing two variants of Calvo-type wage stickiness.*

Schnabel, Isabel. 2022. "Monetary policy in a cost-of-living crisis". *intervento al Panel su 'Fight Against Inflation'alla IV edizione del Foro La Toja, La Toja* 30.

Shapiro, Matthew D., and Joel Slemrod. 2003. "Consumer response to tax rebates". Publisher: American Economic Association, *American Economic Review* 93 (1): 381–396.

Sims, Christopher A, and Tao Zha. 2006. "Does monetary policy generate recessions?" Publisher: Cambridge University Press, *Macroeconomic Dynamics* 10 (2): 231–272.

Smets, Frank, and Rafael Wouters. 2003. "An estimated dynamic stochastic general equilibrium model of the euro area". Publisher: Oxford University Press, *Journal of the European economic association* 1 (5): 1123–1175.

———. 2007. "Shocks and frictions in US business cycles: A Bayesian DSGE approach". Publisher: American Economic Association, *American economic review* 97 (3): 586–606.

Yang, Yucheng. 2022. "Redistributive Inflation and Optimal Monetary Policy". *Available at SSRN 4275770.*

Appendix

A Derivations and Proofs

Initial steady state. For all the linearized derivations and proofs I assume that in the initial steady state net-exports and the NFA are 0 (balanced trade) and that aggregate consumption C is normalized to 1. Steady state output is then $\frac{1}{\alpha_L} > 1$, labor is $L = 1$, material use is $\frac{1-\alpha_L}{\alpha_L}$. Prices are normalized to 1 except for the wage rate which is $W = \frac{\frac{1}{\mu}-(1-\alpha_L)}{\alpha_L}$. For future use, total imports are $\frac{1}{\alpha_L} - (1-\alpha)$.

A.1 Derivation of eq. (20)

Starting from goods market clearing condition (18) and linearizing around the zero inflation steady state gives:

$$dY_t = dC_{H,t} + dC^*_{H,t}$$

Substituting in for $dC^*_{H,t}$ from (17):

$$dY_t = dC_{H,t} - \eta\alpha^* \left(dP^*_{H,t} - dP^*_{F,t}\right)$$

Using the law of one price $dP^*_{H,t} + d\mathcal{E}_t = dP_{H,t}, dP_{F,t} = d\mathcal{E}_t + dP^*_{F,t}$ and the definition of the CPI $dP_t = \alpha\left(dP_{F,t} + d\tau_t\right) + (1-\alpha)\, dP_{H,t}$ one gets:

$$dY_t = dC_{H,t} - \frac{1}{(1-\alpha)}\eta\alpha^* \left(dP_t - d\mathcal{E}_t - dP^*_{F,t} - \alpha d\tau_t\right)$$
$$\Leftrightarrow dY_t = dC_{H,t} + \frac{1}{(1-\alpha)}\eta\alpha^* dQ_t + \frac{\alpha}{(1-\alpha)}\eta\alpha^* d\tau_t$$

where the second line uses the definition of the real exchange rate $Q_t = \frac{\mathcal{E}_t P^*_{F,t}}{P_t}$. Since the real UIP condition (16) implies $dQ_t = 0$ under a constant real rate policy we have:

$$dY_t = dC_{H,t} + \frac{\alpha}{(1-\alpha)}\eta\alpha^* d\tau_t$$

Linearizing the demand for imported goods (6) gives:

$$dC_{H,t} = (1-\alpha)\, dC_t - \eta\,(1-\alpha)\left(dP_{H,t} - dP_t\right)$$

Next, using the law of one price and the definition of the real exchange rate $dP_{H,t} - dP_t$ can be written as:

$$
\begin{aligned}
dP_{H,t} - dP_t &= \frac{1}{(1-\alpha)} dP_t - \frac{\alpha}{(1-\alpha)} \left(dP_{F,t} + d\tau_t\right) - dP_t \\
&= -\frac{\alpha}{(1-\alpha)} dP_{F,t} + \frac{\alpha}{(1-\alpha)} dP_t - \frac{\alpha}{(1-\alpha)} d\tau_t \\
&= -\frac{\alpha}{(1-\alpha)} \left(d\mathcal{E}_t + dP^*_{F,t}\right) + \frac{\alpha}{(1-\alpha)} dP_t - \frac{\alpha}{(1-\alpha)} d\tau_t \\
&= -\frac{\alpha}{(1-\alpha)} dQ_t - \frac{\alpha}{(1-\alpha)} d\tau_t
\end{aligned}
$$

With a constant real exchange rate we thus have:

$$
dY_t = (1-\alpha)\, dC_t + \alpha\eta \left(1 + \frac{\alpha^*}{1-\alpha}\right) d\tau_t
$$

Further assuming constant tariffs gives equation (20).

A.2 Proof of Proposition 1

First note that under a constant-r rule the consumption function $\mathcal{C}_t$ depends only on the aggregate sequence of labor income, profits and transfers, i.e.:

$$
C_t = \mathcal{C}_t \left(\{Z_s, \Pi_s, T_s\}_{s=0}^{\infty}\right)
$$

or, written in sequence space: $d\boldsymbol{C} = \mathcal{C}\left(\{\boldsymbol{Z}, \boldsymbol{\Pi}, \boldsymbol{T}\}\right)$. Linearizing and subbing this into (20) gives:

$$
d\boldsymbol{Y} = (1-\alpha) \left[\boldsymbol{M}^Z d\boldsymbol{Z} + \boldsymbol{M}^\Pi d\boldsymbol{\Pi} + \boldsymbol{M} d\boldsymbol{T}\right] + \alpha\eta \left(1 + \frac{\alpha^*}{1-\alpha}\right) d\boldsymbol{\tau} \tag{A.1}
$$

To derive Proposition 1 we need to derive an expression for labor income $d\boldsymbol{Z}$. To do this we start from the definition of profits (14). Using $\nu \to 0$ we have that:

$$
\begin{aligned}
\Pi_t &= \frac{P_{H,t}}{P_t} Y_t - Z_t - \frac{(1 + \tau_t - \omega)\, \mathcal{E}_t P^*_{X,t}}{P_t} Y_t \left(1 - \alpha_L\right) - \frac{\theta^P}{2} \pi^2_{H,t} Y_t \\
&= \left[\frac{P_{H,t}}{P_t} - (1 + \tau_t - \omega)\, P^*_{X,t} \left(1 - \alpha_L\right) - \frac{\theta^P}{2} \pi^2_{H,t}\right] Y_t - Z_t
\end{aligned}
$$

Linearizing gives:

$$
\begin{aligned}
d\Pi_t &= \left[1-(1-\omega)(1-\alpha_L)\right] dY_t + Yd\left(\frac{P_{H,t}}{P_t}\right) - Y(1-\omega)(1-\alpha_L)\,dP^*_{X,t} - Y(1-\alpha_L)\,d\tau_t - dZ_t \\
\Leftrightarrow d\Pi_t &= \left[1-(1-\omega)(1-\alpha_L)\right] dY_t - Y\frac{\alpha}{(1-\alpha)}d\tau_t - Y(1-\omega)(1-\alpha_L)\,dP^*_{X,t} - Y(1-\alpha_L)\,d\tau_t - dZ_t \\
\Leftrightarrow dZ_t &= \left[1-(1-\omega)(1-\alpha_L)\right] dY_t - \frac{1}{\alpha_L}\frac{\alpha}{(1-\alpha)}d\tau_t - (1-\omega)\frac{(1-\alpha_L)}{\alpha_L}dP^*_{X,t} - \frac{(1-\alpha_L)}{\alpha_L}d\tau_t - d\Pi_t
\end{aligned}
\tag{A.2}
$$

Assume that we are only interested in a markup shock so $\omega = 1, d\tau_t = 0$. Writing (A.2) in sequence-space and substituting into (A.1) gives:

$$
\begin{aligned}
d\boldsymbol{Y} &= (1-\alpha)\left[\boldsymbol{M}^Z\left[d\boldsymbol{Y} - d\boldsymbol{\Pi}\right] + \boldsymbol{M}^{\Pi}d\boldsymbol{\Pi} + \boldsymbol{M}d\boldsymbol{T}\right] \\
\Leftrightarrow \frac{\boldsymbol{I}}{1-\alpha}d\boldsymbol{Y} &= \boldsymbol{M}^Z d\boldsymbol{Y} - \left[\boldsymbol{M}^Z - \boldsymbol{M}^{\Pi}\right]d\boldsymbol{\Pi} + (1-\alpha)\boldsymbol{M}d\boldsymbol{T}
\end{aligned}
$$

Using the assumption $d\boldsymbol{B} = 0$ implies $d\boldsymbol{T} = 0$, which is eq. (21) in the main text.

A.3 Derivation of eq. (22)

Start by writing out eq. (21) at time t:

$$
\frac{1}{1-\alpha}dY_t = \sum_{s=0}^{\infty} M^Z_{t,s}dY_s - \sum_{s=0}^{\infty}\left[M^Z_{t,s} - M^{\Pi}_{t,s}\right]d\Pi_s
$$

Define $MPC_{t,s}$ as the time t MPC out of a lump-sum transfer at time s and $MPC_{i,t,s}$ the corresponding MPC for some households i in the population. Then, using the budget constraint (2) we have:

$$
\frac{1}{1-\alpha}dY_t = \sum_{s=0}^{\infty} M^Z_{t,s}dY_s - \sum_{s=0}^{\infty}\left[\int MPC_{i,t,s}e_i d\mathcal{G} - \int MPC_{i,t,s}g'\left(a_i, \Pi_{ss}\right)d\mathcal{G}\right]d\Pi_s
$$

Let us first rewrite the term $\int MPC_{i,t,s}e_i d\mathcal{G}$ using that:

$$
\begin{aligned}
\text{Cov}\left(MPC_{i,t,s}, e_i\right) &= \int \left(MPC_{i,t,s} - MPC_{t,s}\right)\left(e_i - \bar{e}\right)d\mathcal{G} \\
&= \int MPC_{i,t,s}e_i d\mathcal{G} - \int e_i MPC_{t,s}d\mathcal{G} - \int \bar{e}MPC_{i,t,s}d\mathcal{G} + \int \bar{e}MPC_{t,s}d\mathcal{G} \\
&= \int MPC_{i,t,s}e_i d\mathcal{G} - \bar{e}MPC_{t,s}
\end{aligned}
$$

Implying that:

$$
\int MPC_{i,t,s}e_i d\mathcal{G} = \bar{e}MPC_{t,s} + \text{Cov}\left(MPC_{i,t,s}, e_i\right)
$$

The derivation is the same for $\int MPC_{i,t,s} g(e_i)\, d\mathcal{G}$ term, which gives:

$$\int MPC_{i,t,s} g(e_i)\, d\mathcal{G} = \overline{g(e_i)} MPC_{t,s} + \mathbb{C}\text{ov}\left(MPC_{i,t,s}, g(e_i)\right)$$

Inserting we have:

$$\begin{aligned}
\sum_{s=0}^{\infty}\left[M^{Z}_{t,s} - M^{\Pi}_{t,s}\right] d\Pi_s &= \sum_{s=0}^{\infty}\left[\bar{e} MPC_{t,s} + \mathbb{C}\text{ov}\left(MPC_{i,t,s}, e_i\right)\right] d\Pi_s \\
&\quad - \sum_{s=0}^{\infty}\left[\overline{g(e_i)} MPC_{t,s} + \mathbb{C}\text{ov}\left(MPC_{i,t,s}, g(e_i)\right)\right] d\Pi_s \\
&= \sum_{s=0}^{\infty} MPC_{t,s}\left(\bar{e} - \overline{g(e_i)}\right) d\Pi_s \\
&\quad + \sum_{s=0}^{\infty}\left[\mathbb{C}\text{ov}\left(MPC_{i,t,s}, e_i\right) - \mathbb{C}\text{ov}\left(MPC_{i,t,s}, g(e_i)\right)\right] d\Pi_s
\end{aligned}$$

Since the Markov chain of e_i has mean 1 we have $\bar{e} = 1$. Similarly, since $g(e_i)$ distributes all aggregate profits we have $\overline{g(e_i)} = 1$. We are then left with:

$$\sum_{s=0}^{\infty}\left[M^{Z}_{t,s} - M^{\Pi}_{t,s}\right] d\Pi_s = \sum_{s=0}^{\infty}\left[\mathbb{C}\text{ov}\left(MPC_{i,t,s}, e_i\right) - \mathbb{C}\text{ov}\left(MPC_{i,t,s}, g(e_i)\right)\right] d\Pi_s$$

Writing this in sequence space and subbing into eq. (21) yields eq. (22) in the main text:

$$\frac{\boldsymbol{I}}{1-\alpha} d\boldsymbol{Y} = \alpha_L \boldsymbol{M}^{Z} d\boldsymbol{Y} - \left[\mathbb{C}\text{ov}\left(\boldsymbol{M}^{i}, e_i\right) - \mathbb{C}\text{ov}\left(\boldsymbol{M}^{i}, g(e_i)\right)\right] d\boldsymbol{\Pi}$$

A.4 Phillips curve pass-through matrices

This section derives the expression for the pass-through matrices $\boldsymbol{\kappa}^P, \boldsymbol{\kappa}^W$ appearing in eq. (13) and (15). The baseline analysis assumes a price Phillips-curve of the form:

$$\pi_{H,t}\left(1+\pi_{H,t}\right) = \kappa^P\left(mc_t - \frac{1}{\mu}\right) + \beta \pi_{H,t+1}\left(1+\pi_{H,t+1}\right)$$

or, in linearized form around the zero inflation steady state:

$$d\pi_{H,t} = \kappa^P dmc_t + \beta d\pi_{H,t+1} + \kappa^P d\mu_t \tag{A.3}$$

Imposing $d\pi_\infty = 0$ we have that $d\pi_t = \kappa^P \sum_{s=0}^{\infty} \beta^s dmc_s$. This equation can be written in sequence space as:

$$d\boldsymbol{\pi} = \kappa^P \boldsymbol{\Psi}\left(d\boldsymbol{mc} + d\boldsymbol{\mu}\right) \tag{A.4}$$

where:

$$\mathbf{\Psi} = \begin{bmatrix} 1 & \beta & \beta^2 & \beta^3 & \cdots \\ 0 & 1 & \beta & \beta^2 & \cdots \\ 0 & 0 & 1 & \beta & \cdots \\ 0 & 0 & 0 & 1 & \cdots \\ \vdots & \vdots & \vdots & \vdots & \ddots \end{bmatrix}$$

The final step is to rewrite the equation in terms of price levels instead of inflation. This yields:

$$d\boldsymbol{P} = \boldsymbol{\kappa}^P d\boldsymbol{mc}$$

where $\boldsymbol{\kappa}^P = \kappa^P \boldsymbol{U}\mathbf{\Psi}$ and:

$$\boldsymbol{U} = \begin{bmatrix} 1 & 0 & 0 & 0 & \cdots \\ 1 & 1 & 0 & 0 & \cdots \\ 1 & 1 & 1 & 0 & \cdots \\ 1 & 1 & 1 & 1 & \cdots \\ \vdots & \vdots & \vdots & \vdots & \ddots \end{bmatrix}$$

is a lower triangular matrix. $\boldsymbol{\kappa}^P$ has the following form:

$$\boldsymbol{\kappa}^P = \kappa^P \begin{bmatrix} 1 & \beta & \beta^2 & \beta^3 & \cdots \\ 1 & 1+\beta & \beta+\beta^2 & \beta^2+\beta^3 & \cdots \\ 1 & 1+\beta & 1+\beta+\beta^2 & \beta+\beta^2+\beta^3 & \cdots \\ 1 & 1+\beta & 1+\beta+\beta^2 & 1+\beta+\beta^2+\beta^3 & \cdots \\ \vdots & \vdots & \vdots & \vdots & \ddots \end{bmatrix}$$

Note that with a non-forward looking Phillips curve, $\beta = 0$, then $\boldsymbol{\kappa}^P = \kappa^P \boldsymbol{U}$.
Regarding the New Keynesian wage Phillips curve we have that the linearized NK-WPC is:

$$d\pi_t^W = \kappa^W \left(\frac{1}{\phi} \frac{\varphi}{w} \mu^w L^{\frac{1}{\phi}-1} dL_t - \frac{\varphi}{w^2} \mu^w dw_t \right) + \beta d\pi_{t+1}^W$$

Using that in steady state $\varphi = \frac{w}{\mu^w}$ we get:

$$d\pi_t^W = \kappa^W \left(\frac{1}{\phi} dL_t - \frac{1}{W} dw_t \right) + \beta d\pi_{t+1}^W$$

Then, using the definition of $\mathbf{\Psi}$ above:

$$d\boldsymbol{\pi}^W = \kappa^W \mathbf{\Psi} \left(\frac{1}{\phi} d\boldsymbol{L} - \frac{1}{W} d\boldsymbol{w} \right)$$

To write in terms of wages in levels I use the defined $\boldsymbol{U}$ matrix above, noting that we have to pre-multiply with steady state wages (which was done implicitly for the NKPC as $P_H = 1$ in steady state):

$$\begin{aligned} d\boldsymbol{W} &= \kappa^W \boldsymbol{U} \mathbf{\Psi} \left(\frac{1}{\phi} W d\boldsymbol{L} - d\boldsymbol{w} \right) \\ &= \boldsymbol{\kappa}^W \left(\frac{1}{\phi} W d\boldsymbol{L} - d\boldsymbol{w} \right) \end{aligned}$$

with $\boldsymbol{\kappa}^W \equiv \kappa^W \boldsymbol{U} \mathbf{\Psi}$.

A.5 Proof of Proposition 2

The proof for Proposition 2 involves solving for $d\mathbf{\Pi}$ as a function of the price shock and output. Starting from the equation:

$$d\Pi_t = \left[1 - (1-\omega)(1-\alpha_L)\right] dY_t - (1-\omega) \frac{(1-\alpha_L)}{\alpha_L} dP^*_{X,t} - \left[(1-\alpha_L) + \frac{\alpha}{(1-\alpha)} \right] \frac{1}{\alpha_L} d\tau_t - dZ_t$$

found in A.2 and using the assumption Leontief production:

$$\begin{aligned} d\Pi_t &= \left[1 - (1-\omega)(1-\alpha_L) - w\alpha_L\right] dY_t - (1-\omega) \frac{(1-\alpha_L)}{\alpha_L} dP^*_{X,t} - \left[(1-\alpha_L) + \frac{\alpha}{(1-\alpha)} \right] \frac{1}{\alpha_L} d\tau_t - dw_t \\ d\Pi_t &= \left[\frac{\mu-1}{\mu} + \omega(1-\alpha_L) \right] dY_t - (1-\omega) \frac{(1-\alpha_L)}{\alpha_L} dP^*_{X,t} - \left[(1-\alpha_L) + \frac{\alpha}{(1-\alpha)} \right] \frac{1}{\alpha_L} d\tau_t - dw_t \end{aligned}$$

Then using the definition of real marginal costs $mc_t = \alpha_L w_t + (1-\alpha_L) P^*_{X,t} (1+\tau_t)$ (which in steady state equals $\frac{1}{\mu}$):

$$d\Pi_t = \left[\frac{\mu-1}{\mu} + \omega(1-\alpha_L) \right] dY_t - \frac{1}{\alpha_L} \frac{\alpha}{(1-\alpha)} d\tau_t + \omega \frac{(1-\alpha_L)}{\alpha_L} dP^*_{X,t} - \frac{1}{\alpha_L} dmc_t$$

To proceed we go to the sequence-space notation and subtract the NKPC from the NKWPC using that $d\boldsymbol{P}_H + \frac{\alpha}{(1-\alpha)} d\boldsymbol{\tau} = d\boldsymbol{P}$

$$
\begin{aligned}
d\boldsymbol{w} &= d\boldsymbol{W} - W\, d\boldsymbol{P} \\
&= \boldsymbol{\kappa}^W \left(\frac{1}{\phi} d\boldsymbol{L} - \frac{1}{W} d\boldsymbol{w} \right) - W\boldsymbol{\kappa}^P d\boldsymbol{mc} - W\boldsymbol{\kappa}^P d\boldsymbol{\mu} - \frac{W\alpha}{(1-\alpha)} d\boldsymbol{\tau} \\
\Leftrightarrow \left(\boldsymbol{I} + \frac{1}{W}\boldsymbol{\kappa}^W \right) d\boldsymbol{w} &= \frac{\alpha_L}{\phi}\boldsymbol{\kappa}^W d\boldsymbol{Y} - W\boldsymbol{\kappa}^P d\boldsymbol{mc} - W\boldsymbol{\kappa}^P d\boldsymbol{\mu} - \frac{W\alpha}{(1-\alpha)} d\boldsymbol{\tau} \\
\Leftrightarrow \left(\boldsymbol{I} + \frac{1}{W}\boldsymbol{\kappa}^W \right) d\boldsymbol{w} &= \frac{\alpha_L}{\phi}\boldsymbol{\kappa}^W d\boldsymbol{Y} - W\boldsymbol{\kappa}^P \left[\alpha_L d\boldsymbol{w} + (1-\alpha_L)\, d\boldsymbol{P}_{\mathbf{X}}^* + (1-\alpha_L)\, d\boldsymbol{\tau} \right] - W\boldsymbol{\kappa}^P d\boldsymbol{\mu} - \\
\Leftrightarrow \left(\boldsymbol{I} + \frac{1}{W}\boldsymbol{\kappa}^W + W\boldsymbol{\kappa}^P \alpha_L \right) d\boldsymbol{w} &= \frac{\alpha_L}{\phi}\boldsymbol{\kappa}^W d\boldsymbol{Y} - W\boldsymbol{\kappa}^P (1-\alpha_L)\, d\boldsymbol{P}_{\mathbf{X}}^* - W\boldsymbol{\kappa}^P d\boldsymbol{\mu} \\
&\quad - \left[\frac{W\alpha}{(1-\alpha)} + W\boldsymbol{\kappa}^P (1-\alpha_L) \right] d\boldsymbol{\tau}
\end{aligned}
$$

To ease notation use the definitions explain the main text:

$$
\begin{aligned}
\Theta^\mu &\equiv \left[\mathbf{I} + \frac{1}{W}\boldsymbol{\kappa}^W + \alpha_L W\boldsymbol{\kappa}^P \right]^{-1} W\boldsymbol{\kappa}^P. \\
\Theta^L &\equiv \left[\mathbf{I} + \frac{1}{W}\boldsymbol{\kappa}^W + \alpha_L W\boldsymbol{\kappa}^P \right]^{-1} \frac{\alpha_L}{\phi}\boldsymbol{\kappa}^W,
\end{aligned}
$$

to get:

$$
d\boldsymbol{w} = \Theta^L d\boldsymbol{Y} - \Theta^\mu (1-\alpha_L)\, d\boldsymbol{P}_{\mathbf{X}}^* - \Theta^\mu d\boldsymbol{\mu} - \Theta^\mu \left[\left(\boldsymbol{\kappa}^P \right)^{-1} \frac{\alpha}{(1-\alpha)} + (1-\alpha_L) \right] d\boldsymbol{\tau}
$$

Sub into profits:

$$
\begin{aligned}
d\boldsymbol{\Pi} = &\left[\frac{\mu - 1}{\mu} + \omega (1-\alpha_L) - \Theta^L \right] d\boldsymbol{Y} \\
&- \left\{ \left(\frac{\boldsymbol{I}}{\alpha_L} - \Theta^\mu \left(\boldsymbol{\kappa}^P \right)^{-1} \right) \frac{\alpha}{(1-\alpha)} + \left(\frac{\boldsymbol{I}}{\alpha_L} - \Theta^\mu \right) (1-\alpha_L) \right\} d\boldsymbol{\tau} \\
&- (1-\alpha_L) \left\{ \frac{1-\omega}{\alpha_L} - \Theta^\mu \right\} d\boldsymbol{P}_{\mathbf{X}}^* + \Theta^\mu d\boldsymbol{\mu}
\end{aligned}
\tag{A.5}
$$

Focusing on the markup shock ($d\boldsymbol{\tau} = 0, d\boldsymbol{P}_{\mathbf{X}}^* = 0$), and substituting into eq. (21):

$$
\frac{\boldsymbol{I}}{1-\alpha} d\boldsymbol{Y} = \boldsymbol{M}^Z d\boldsymbol{Y} - \left[\boldsymbol{M}^Z - \boldsymbol{M}^\Pi \right] \left\{ \left[\frac{\mu-1}{\mu} + \omega(1-\alpha_L) - \Theta^L \right] d\boldsymbol{Y} + \Theta^\mu d\boldsymbol{\mu} \right\}
$$

Defining:

$$
\mathcal{M} \equiv \left\{ \frac{\boldsymbol{I}}{1-\alpha} - \left[\boldsymbol{M}^Z - \boldsymbol{M}^\Pi \right] \left[\Theta^L - \frac{\mu-1}{\mu} - \omega(1-\alpha_L) \right] \right\}^{-1}
$$

We get Proposition 2:

$$d\boldsymbol{Y} = -\mathcal{M}\left[\boldsymbol{M}^Z - \boldsymbol{M}^\Pi\right] \times \boldsymbol{\Theta}^\mu \times d\boldsymbol{\mu}$$

A.6 Proof of Proposition 3

I first derive the derivative of $d\mathbf{Y}$ w.r.t κ^P. For expositional ease, define the objects:

$$\boldsymbol{K} = W\boldsymbol{\kappa}^P, \quad \boldsymbol{R} = \mathbf{I} + \frac{1}{W}\boldsymbol{\kappa}^W + \alpha_L W\boldsymbol{\kappa}^P$$

so that $\boldsymbol{\Theta}^\mu = \boldsymbol{R}^{-1}\boldsymbol{K}$ and $\boldsymbol{\Theta}^L = \boldsymbol{R}^{-1}\frac{\alpha_L}{\phi}\boldsymbol{\kappa}^W$, and define:

$$\boldsymbol{B} = \frac{\boldsymbol{I}}{1-\alpha} - \boldsymbol{M}^Z(1-(1-\omega)(1-\alpha_L)) - \left[\boldsymbol{M}^Z - \boldsymbol{M}^\Pi\right]\left[\boldsymbol{\Theta}^L - \frac{\mu-1}{\mu}\boldsymbol{I} - \omega(1-\alpha_L)\boldsymbol{I}\right]$$

so that $\mathcal{M} = \boldsymbol{B}^{-1}$. The derivative of $d\mathbf{Y}$ w.r.t. κ^P is:

$$\frac{\partial d\mathbf{Y}}{\partial \kappa^P} = -\left[\frac{\partial \mathcal{M}}{\partial \kappa^P}\left[\mathbf{M}^Z - \mathbf{M}^\Pi\right]\boldsymbol{\Theta}^\mu + \mathcal{M}\left[\mathbf{M}^Z - \mathbf{M}^\Pi\right]\frac{\partial \boldsymbol{\Theta}^\mu}{\partial \kappa^P}\right] d\boldsymbol{\mu}$$

To evaluate the sign it suffices to derive the signs of $\frac{\partial \mathcal{M}}{\partial \kappa^P}$ and $\frac{\partial \boldsymbol{\Theta}^\mu}{\partial \kappa^P}$. Since $\boldsymbol{\kappa}^P = \kappa^P \boldsymbol{U}\boldsymbol{\Upsilon}$, we have $\boldsymbol{K} = \kappa^P W\boldsymbol{U}\boldsymbol{\Upsilon}$ and $\frac{\partial \boldsymbol{R}}{\partial \kappa^P} = \alpha_L W\boldsymbol{U}\boldsymbol{\Upsilon}$. Using the matrix inverse derivative identity $\frac{\partial \boldsymbol{A}^{-1}}{\partial x} = -\boldsymbol{A}^{-1}\frac{\partial \boldsymbol{A}}{\partial x}\boldsymbol{A}^{-1}$:

$$\frac{\partial \boldsymbol{\Theta}^\mu}{\partial \kappa^P} = -\boldsymbol{R}^{-1}\frac{\partial \boldsymbol{R}}{\partial \kappa^P}\boldsymbol{R}^{-1}\boldsymbol{K} + \boldsymbol{R}^{-1}\frac{\partial \boldsymbol{K}}{\partial \kappa^P} = \boldsymbol{R}^{-1}\left[\boldsymbol{I} - \alpha_L W\boldsymbol{U}\boldsymbol{\Upsilon}\boldsymbol{R}^{-1}\right]W\boldsymbol{U}\boldsymbol{\Upsilon} \geq 0$$

where the inequality follows since $\boldsymbol{R}^{-1}\boldsymbol{K} = \boldsymbol{\Theta}^\mu \leq \boldsymbol{I}$ implies $\alpha_L W\boldsymbol{U}\boldsymbol{\Upsilon}\boldsymbol{R}^{-1} \leq \boldsymbol{I}$. Since $\boldsymbol{\kappa}^W$ does not depend on κ^P:

$$\frac{\partial \boldsymbol{\Theta}^L}{\partial \kappa^P} = -\boldsymbol{R}^{-1}\frac{\partial \boldsymbol{R}}{\partial \kappa^P}\boldsymbol{R}^{-1}\frac{\alpha_L}{\phi}\boldsymbol{\kappa}^W = -\alpha_L W\boldsymbol{R}^{-1}\boldsymbol{U}\boldsymbol{\Upsilon}\boldsymbol{R}^{-1}\frac{\alpha_L}{\phi}\boldsymbol{\kappa}^W \leq 0$$

The derivative of $\boldsymbol{B}$ with respect to κ^P is therefore:

$$\frac{\partial \boldsymbol{B}}{\partial \kappa^P} = -\left[\boldsymbol{M}^Z - \boldsymbol{M}^\Pi\right]\frac{\partial \boldsymbol{\Theta}^L}{\partial \kappa^P} = \alpha_L W\left[\boldsymbol{M}^Z - \boldsymbol{M}^\Pi\right]\boldsymbol{R}^{-1}\boldsymbol{U}\boldsymbol{\Upsilon}\boldsymbol{R}^{-1}\frac{\alpha_L}{\phi}\boldsymbol{\kappa}^W \geq 0$$

and therefore:

$$\frac{\partial \mathcal{M}}{\partial \kappa^P} = -\boldsymbol{B}^{-1}\frac{\partial \boldsymbol{B}}{\partial \kappa^P}\boldsymbol{B}^{-1} = -\alpha_L W\boldsymbol{B}^{-1}\left[\boldsymbol{M}^Z - \boldsymbol{M}^\Pi\right]\boldsymbol{R}^{-1}\boldsymbol{U}\boldsymbol{\Upsilon}\boldsymbol{R}^{-1}\frac{\alpha_L}{\phi}\boldsymbol{\kappa}^W\boldsymbol{B}^{-1} \leq 0$$

Since both $\frac{\partial \mathcal{M}}{\partial \kappa^P} \leq 0$ and $\frac{\partial \boldsymbol{\Theta}^\mu}{\partial \kappa^P} \geq 0$, both terms in $\frac{\partial d\mathbf{Y}}{\partial \kappa^P}$ are non-positive, proving that:

$$\frac{\partial d\mathbf{Y}}{\partial \kappa^P} \leq 0$$

whenever $\boldsymbol{M}^Z \geq \boldsymbol{M}^\Pi$.

For the derivative w.r.t. κ^W, $\frac{\partial d\mathbf{Y}}{\partial \kappa^W}$, we have:

$$\frac{\partial d\mathbf{Y}}{\partial \kappa^W} = -\left[\frac{\partial \mathcal{M}}{\partial \kappa^W}\left[\mathbf{M}^Z - \mathbf{M}^\Pi\right]\boldsymbol{\Theta}^\mu + \mathcal{M}\left[\mathbf{M}^Z - \mathbf{M}^\Pi\right]\frac{\partial \boldsymbol{\Theta}^\mu}{\partial \kappa^W}\right] d\boldsymbol{\mu}$$

Since $\boldsymbol{\kappa}^W = \kappa^W \boldsymbol{U\Psi}$, we have $\frac{\partial \boldsymbol{R}}{\partial \kappa^W} = \frac{1}{W}\boldsymbol{U\Psi}$, and $\boldsymbol{K} = W\boldsymbol{\kappa}^P$ does not depend on κ^W, so:

$$\frac{\partial \boldsymbol{\Theta}^\mu}{\partial \kappa^W} = -\boldsymbol{R}^{-1}\frac{\partial \boldsymbol{R}}{\partial \kappa^W}\boldsymbol{R}^{-1}\boldsymbol{K} = -\frac{1}{W}\boldsymbol{R}^{-1}\boldsymbol{U\Psi}\boldsymbol{R}^{-1}W\boldsymbol{\kappa}^P = -\boldsymbol{R}^{-1}\boldsymbol{U\Psi}\boldsymbol{R}^{-1}\boldsymbol{\kappa}^P \leq 0$$

For $\boldsymbol{\Theta}^L = \boldsymbol{R}^{-1}\frac{\alpha_L \kappa^W}{\phi}\boldsymbol{U\Psi}$, both $\boldsymbol{R}$ and $\boldsymbol{\kappa}^W$ depend on κ^W, giving:

$$\frac{\partial \boldsymbol{\Theta}^L}{\partial \kappa^W} = -\boldsymbol{R}^{-1}\frac{1}{W}\boldsymbol{U\Psi}\boldsymbol{R}^{-1}\frac{\alpha_L \kappa^W}{\phi}\boldsymbol{U\Psi} + \boldsymbol{R}^{-1}\frac{\alpha_L}{\phi}\boldsymbol{U\Psi} = \boldsymbol{R}^{-1}\frac{\alpha_L}{\phi}\left[\boldsymbol{I} - \frac{\kappa^W}{W}\boldsymbol{U\Psi}\boldsymbol{R}^{-1}\right]\boldsymbol{U\Psi} \geq 0$$

where the inequality follows by an analogous argument to before. Therefore:

$$\frac{\partial \boldsymbol{B}}{\partial \kappa^W} = -\left[\boldsymbol{M}^Z - \boldsymbol{M}^\Pi\right]\frac{\partial \boldsymbol{\Theta}^L}{\partial \kappa^W} \leq 0$$

and:

$$\frac{\partial \mathcal{M}}{\partial \kappa^W} = -\boldsymbol{B}^{-1}\frac{\partial \boldsymbol{B}}{\partial \kappa^W}\boldsymbol{B}^{-1} = \boldsymbol{B}^{-1}\left[\boldsymbol{M}^Z - \boldsymbol{M}^\Pi\right]\frac{\partial \boldsymbol{\Theta}^L}{\partial \kappa^W}\boldsymbol{B}^{-1} \geq 0$$

The two terms in $\frac{\partial d\mathbf{Y}}{\partial \kappa^W}$ therefore have opposite signs. Since $\frac{\partial \boldsymbol{\Theta}^\mu}{\partial \kappa^W} \leq 0$ and $\mathcal{M} \geq 0$, the second term $\mathcal{M}\left[\boldsymbol{M}^Z - \boldsymbol{M}^\Pi\right]\frac{\partial \boldsymbol{\Theta}^\mu}{\partial \kappa^W} \leq 0$ dominates, proving that:

$$\frac{\partial d\mathbf{Y}}{\partial \kappa^W} \geq 0$$

whenever $\boldsymbol{M}^Z \geq \boldsymbol{M}^\Pi$.

B Policy response to markup shock

B.1 Monetary policy

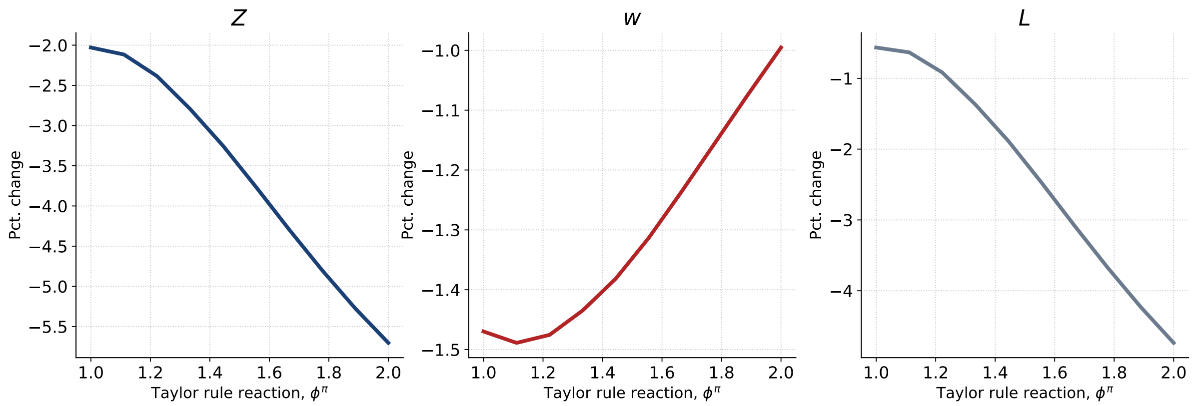


Figure A.1: Response of real labor income, real wages and labor to markup shock with varying inflation coefficient in Taylor rule

B.2 Fiscal policy

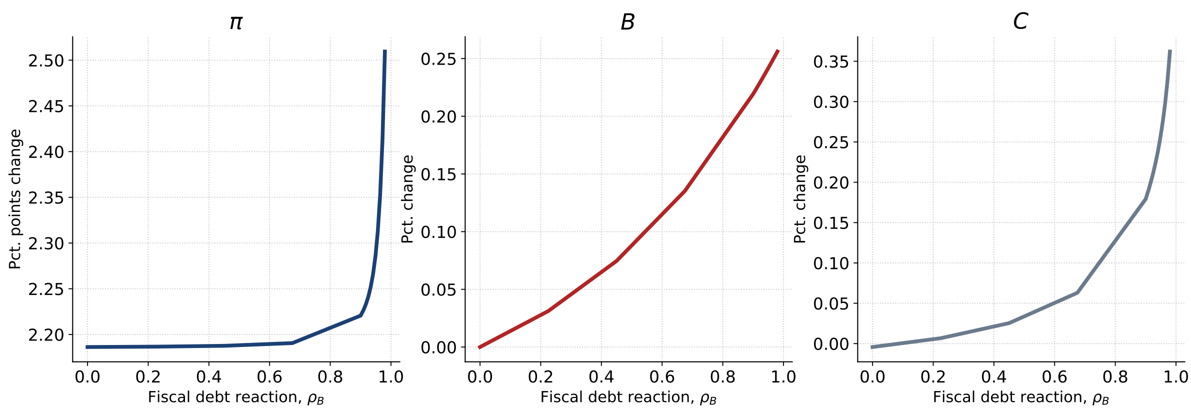


Figure A.2: Response of inflation, government bonds and consumption to markup shock with debt reaction

C Model extensions with markup shock

C.1 Investment

Standard model (Friction free investment) . I consider two versions of the baseline model investment and capital. In the first model, which feature the standard neoclassical investment setup, production is given by a Cobb-Douglas production function:

$$Y_t = A_t K_{t-1}^{\alpha_K} R_t^{1-\alpha_K}$$

where R_t is a CES aggregate of labor and materials. With $\alpha_K = 0$ one recovers the baseline model without capital. Firms optimize subject to a quadratic adjustment cost

$\Phi(I_t, K_t) = \frac{\phi}{2}\left(\frac{I_t}{K_t} - \delta\right)^2 K_t$ where investment follows from the law of motion $K_t = (1-\delta)K_{t-1} + I_t$. Profits are:

$$\Pi_t = \frac{P_{H,t}}{P_t} Y_t - P_{X,t} X_t - Z_t - I_t - \Phi(I_t, K_t)$$

The first-order conditions are:

$$q_t^I = \frac{1}{1+r_t}\left[MPK_{t+1} + (1-\delta)q_{t+1}^I - \frac{\partial \Phi(I_{t+1}, K_{t+1})}{\partial K_{t+1}}\right]$$
$$\frac{I_t}{K_t} = \delta + \frac{1}{\phi}(q_t^I - 1)$$

where q_t^I is the Lagrange multiplier associated with the investment law of motion (Tobin's Q), and $MPK_{t+1} = mc_t \alpha_K K_{t+1}^{\alpha_K - 1} R_{t+1}^{1-\alpha_K}$ is the marginal product of capital.

Investment with financial frictions. The second version of the problem I consider contains a stylized version of a model with internal financing constraints (Lian and Ma 2021; Drechsel 2023). Production is still Cobb-Douglas, and the steady state is frictionless so that the aggregate capital stock satisfies:

$$MPK = r + \delta$$

and investment follows from the law of motion. Away from the steady state the an earnings constraint binds, which implies that a fraction s of operating surplus is used for investment:

$$I_t - \delta K_{t-1} = s \times dOS_t$$

where:

$$OS_t = \frac{P_{H,t}}{P_t} Y_t - P_{X,t} X_t - Z_t$$

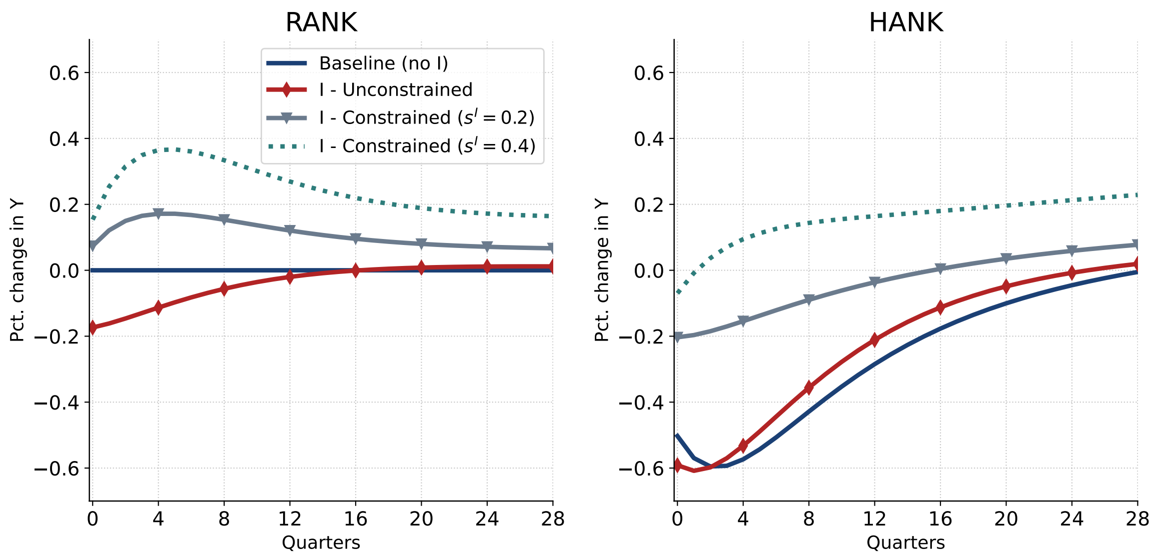


Figure A.3: Response to markup in the RANK and HANK model

Baseline refers to the model without capital and investment. *I - Unconstrained* refer to the models with investment subject only to an adjustment cost. *I - Constrained* refer to models with investment, where investment is constraint by an earnings constraint.

C.2 Wage indexation

Proposition 3 highlights the importance of real wage dynamics for the transmission of the shock in models with distribution effects. A natural remedy to stabilize real wages in volatile inflation environments is to index nominal wages to CPI inflation (e.g. Fischer (1976)). Specifically, indexing wages to CPI inflation at rate ι modifies the Rotemberg adjustment cost on nominal wages to $\frac{\theta^W}{2}\left(\left(1+\pi_t^W\right)/\left(1+\pi_t\right)^{\iota}-1\right)^2$, see Ascari et al. (2011).[18] The implied wage Phillips curve is then given by:

$$\left(\pi_t^W - \iota\pi_t\right)\left(1+\pi_t^W - \iota\pi_t\right) = \kappa^W\left(\frac{\xi'\left(L_t\right)}{w_t}\mu^W - 1\right) + \beta\left(\pi_{t+1}^W - \iota\pi_{t+1}\right)\left(1+\pi_{t+1}^W - \iota\pi_{t+1}\right)$$

With wage indexation present in the Phillips curve the effects of a markup shock captured in Proposition 2 modifies to:

Proposition 8. *The general equilibrium response of output $d\mathbf{Y}$ to a markup shock is with wage indexation:*

$$d\mathbf{Y} = -\mathcal{M}\left[\mathbf{M}^Z - \mathbf{M}^\Pi\right] \times \boldsymbol{\Theta}^\mu \times d\boldsymbol{\mu}, \tag{A.6}$$

where the pass-through to markups $\boldsymbol{\Theta}^\mu$ is given by:

$$\Theta^\mu \equiv \left[\mathbf{I} + \frac{1}{W}\boldsymbol{\kappa}^W + \alpha_L W \boldsymbol{\kappa}^P\right]^{-1} W\left(1-\iota\right)\boldsymbol{\kappa}^P. \tag{A.7}$$

[18] For tractability I assume that wages are indexed to current inflation, but this is not central to my results.

Proof: appendix C.3.

Inspecting (A.6)-(A.7) one finds that the presence of wage indexation modified the response of output in a manner similar to the degree of price stickiness κ^P. This implies that a sufficient degree of wage indexation is able to dampen the effect on aggregate demand from the markup shock (Proposition 3) by stabilizing the real wage since a higher ι fundamentally ties nominal wage growth to inflation. Figure A.4 illustrates this numerically. With fully indexed wages real wages are fully stabilized, and there is zero redistribution occurring in the economy, thus leading to full demand stabilization.

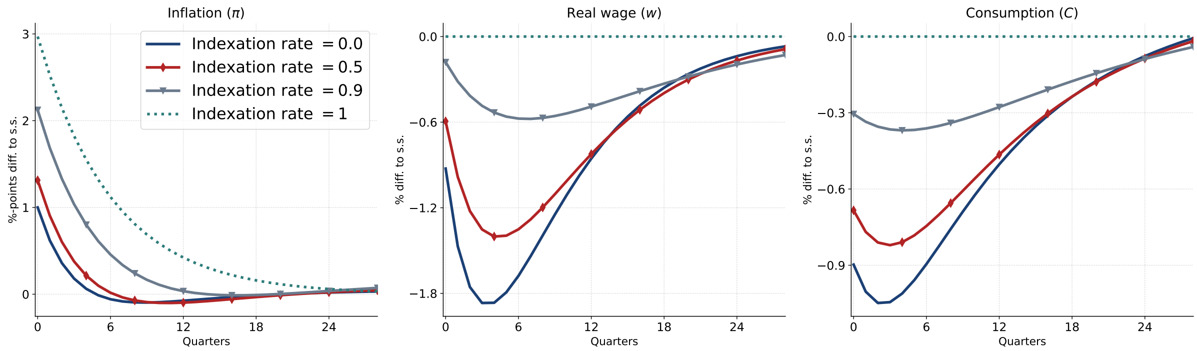


Figure A.4: Transmission of markup shock with varying degree of wage indexation

C.3 Proof of Proposition 8

The derivation of eq. (A.6) is unchanged with wage indexation, as only $\boldsymbol{\Theta}^\mu$ is affected. To derive $\boldsymbol{\Theta}^\mu$ under wage indexation, I start by linearizing the wage Phillips curve with indexation:

$$\pi_t^W = \iota\pi_t + \kappa^W \left(\frac{\varphi L_t^{\frac{1}{\phi}}}{w_t} \mu^W - 1 \right) + \beta \left(\pi_{t+1}^W - \iota\pi_{t+1} \right)$$

$$\Rightarrow d\pi_t^W = \iota d\pi_t + \kappa^W \left(\frac{1}{\phi} dL_t - \frac{1}{W} dw_t \right) + \beta \left(d\pi_{t+1}^W - \iota d\pi_{t+1} \right)$$

Then, using the definition of $\mathbf{\Psi}$ above we get the sequence-space representation:

$$d\boldsymbol{\pi}^W - \iota d\boldsymbol{\pi} = \kappa^W \mathbf{\Psi} \left(\frac{1}{\phi} d\boldsymbol{L} - \frac{1}{W} d\boldsymbol{w} \right)$$

To write in levels instead of rates, I use $\boldsymbol{U}$ to get:

$$d\boldsymbol{W} - \iota W d\boldsymbol{P} = \boldsymbol{\kappa}^W \left(\frac{W}{\phi} d\boldsymbol{L} - d\boldsymbol{w} \right)$$

where $\boldsymbol{\kappa}^W \equiv \kappa^W \boldsymbol{U}\boldsymbol{\Upsilon}$ as before.

To solve for $\boldsymbol{\Theta}^\mu$, I start by subbing the NKPC into the NWPC:

$$
\begin{aligned}
d\boldsymbol{W} - \boldsymbol{\kappa}^W \left(\frac{W}{\phi} d\boldsymbol{L} - d\boldsymbol{w}\right) &= \iota W d\boldsymbol{P} \\
\Leftrightarrow d\boldsymbol{W} - W d\boldsymbol{P} + W d\boldsymbol{P} - \boldsymbol{\kappa}^W \left(\frac{W}{\phi} d\boldsymbol{L} - d\boldsymbol{w}\right) &= W\iota d\boldsymbol{P} \\
\Leftrightarrow d\boldsymbol{w} - \boldsymbol{\kappa}^W \left(\frac{W}{\phi} d\boldsymbol{L} - d\boldsymbol{w}\right) &= W(\iota - 1) d\boldsymbol{P} \\
\Leftrightarrow d\boldsymbol{w} - \boldsymbol{\kappa}^W \left(\frac{W}{\phi} d\boldsymbol{L} - d\boldsymbol{w}\right) &= W(\iota - 1) \boldsymbol{\kappa}^P (d\boldsymbol{mc} + d\boldsymbol{\mu}) \\
\Leftrightarrow d\boldsymbol{w} - \boldsymbol{\kappa}^W \left(\frac{W}{\phi} d\boldsymbol{L} - d\boldsymbol{w}\right) &= W(\iota - 1) \boldsymbol{\kappa}^P (\alpha_L d\boldsymbol{w} + d\boldsymbol{\mu}) \\
\Leftrightarrow d\boldsymbol{w} &= -\left[\boldsymbol{I} + \boldsymbol{\kappa}^W + W(1-\iota)\boldsymbol{\kappa}^P \alpha_L\right]^{-1} W(1-\iota)\boldsymbol{\kappa}^P d\boldsymbol{\mu}
\end{aligned}
$$

giving the expression in eq. (A.7).

C.4 Fisher effects

A mechanism often brought up in the context of large inflation surges is the redistribution that occurs between borrowers and savers when debt contracts are nominal (see e.g. Auclert 2019; Nuño and Thomas 2022; M. K. Brunnermeier et al. 2023). The baseline model assumes that households save in real assets, and thereby sidesteps this channel. To evaluate this effect I introduce a share θ^n of nominal bonds into the economy. The budget constraint of households is unchanged in real terms, but the total real return is then given by $r_t^a = \theta^n r_t^n + (1-\theta^n) r_t$ where r_t^n is the real return on nominal bonds. I assume that these bonds are potentially long term and that they pay exponentially decaying coupons. A bond purchased at time 0 at nominal price q_t gives a stream $\{\delta^s\}_{s=0}^\infty$ of nominal payments. With $\delta = 0$ standard, short-term bonds are recovered. Arbitrage implies that the bond price follows:

$$q_t = \frac{1 + \delta q_{t+1}}{1 + i_t},$$

such that the expected real return on nominal bonds is the same as for real bonds. The return is given by:

$$1 + r_t^n = \frac{\frac{1+\delta q_t}{q_{t-1}}}{1 + \pi_t}.$$

With a constant-r rule as before the only effect on household behaviour comes from an initial revaluation effect on nominal bonds which occurs at time 0 (only surprise inflation affects the return). The consumption function is now a function of real income, profits and the date 0 real return on assets, $C_t = \mathcal{C}\left\{Z_t, \Pi_t, r_0\right\}$. Linearizing in sequence-space and using $dr_0 = \theta^n dr_0^n$ we have that:

$$d\boldsymbol{C} = \boldsymbol{M}^Z d\boldsymbol{Z} + \boldsymbol{M}^\Pi d\Pi + \boldsymbol{M}^{r_0}\theta^n dr_0^n,$$

where $\boldsymbol{M}^{r_0}$ is a column vector whose entries reflect the response of consumption to the initial revaluation effect at time 0. Note that at the individual household level the entries in this vector would be positive for savers and negative for borrowers. To proceed, I linearize time 0 nominal returns to get:

$$dr_0^n = \underbrace{\frac{\delta}{q_{ss}} dq_0}_{\text{Long term bond effect}} - \underbrace{d\pi_0}_{\text{Fisher effect}}.$$

Thus the initial revaluation effect depends on two terms. With short bonds ($\delta = 0$) there is the usual Fisher effect of surprise inflation, whereby the value of nominal assets depreciates with the increase in inflation. With long term nominal bonds ($\delta > 0$) there is an additional effect since the bond has a duration of more than one period. For a given nominal interest rate, the increase in inflation also affects the value of the bond going forward, which is captured in the initial valuation dq_0. This effect can be found to be:

$$dq_0 = -\sum_{s=0}^{\infty} \frac{\delta^s}{\left(1+i_{ss}\right)^{2+s}} \left(1+\delta q_{ss}\right)\left(dr_{t+1+s} + d\pi_{t+1+s}\right)$$

High future real rates or inflation reduce the current price of the bond, with the effects being increasing in the longevity of the bonds δ. Using this expression, the overall effect on aggregate consumption is:

$$d\boldsymbol{C} = \underbrace{\boldsymbol{M}^Z d\boldsymbol{Z}}_{\text{Labor income}} + \underbrace{\boldsymbol{M}^\Pi d\Pi}_{\text{Profits}} - \underbrace{\boldsymbol{M}^{r_0}\theta^n \left[\sum_{s=0}^{\infty} \frac{\delta^s}{\left(1+i_{ss}\right)^{2+s}} \left(1+\delta q_{ss}\right) d\pi_{t+1+s} + d\pi_0\right]}_{\text{Fisher effects}}$$

As before a markup shock induces a negative effect on consumption from labor income and a positive effect from profits. If households hold nominal bonds, $\theta^n > 0$ there is an additional effect, which scales with the marginal propensity to spend out of time-0 unexpected returns $\boldsymbol{M}^{r_0}$. For savers this will tend to be a negative effect since the real value of their bonds get reduced by inflation, thus acting as a negative income shock. Borrowers experience the opposite, and will generally increase in consumption in response to this channel, leaving the overall sign of $\boldsymbol{M}^{r_0}$ uncertain. At the individual the MPC out of date-0 returns is the MPC out of a cash-transfer, times the initial net-nominal position of the household, $mpc_i \times a_i^n$. Aggregating we can write this as:

$$\boldsymbol{M}^{r_0} = \boldsymbol{M} \times A^n + \mathbb{C}\text{ov}\left(\boldsymbol{M}_i, a_i^n\right)$$

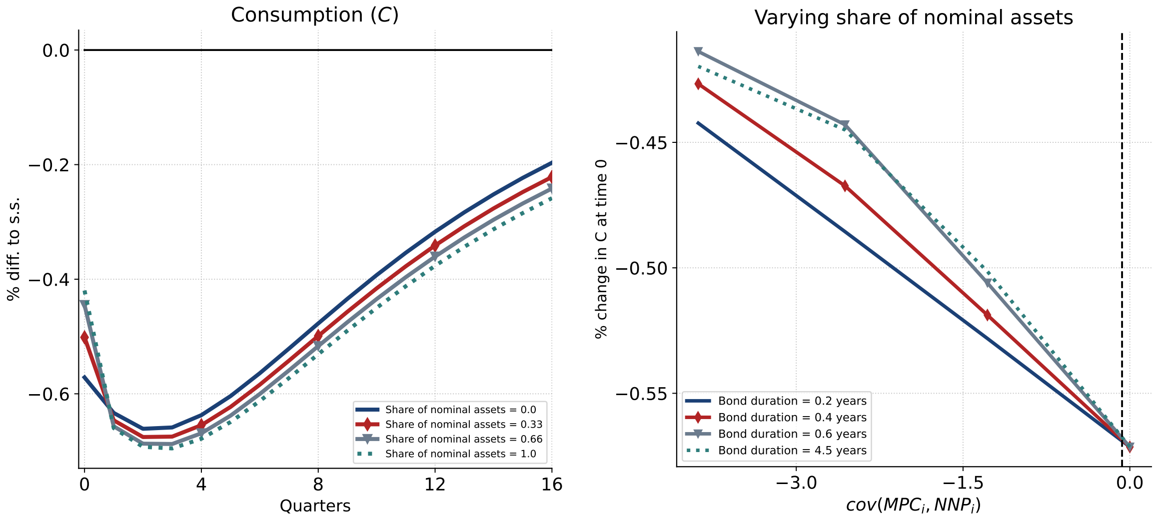
Given that the aggregate net-nominal position is generally positive, the first term is positive. The second term captures redistribution, between borrowers and savers, and is negative when borrowers have larger MPCs than savers. Auclert (2019) uses the Italian Survey of Household Income and Wealth to measure the covariance between MPCs and net nominal positions - i.e. $\mathbb{C}\text{ov}\left(\boldsymbol{M}_i, a_i^n\right)$ - and measure a positive, but quantitatively small effect of redistribution on consumption.

The left panel in Figure A.5 shows the effects of the markup shock on aggregate consumption for varying degree of nominal bonds, all with $\delta = 0.94$ to match an average duration of 4.5 years as in Doepke and Schneider (2006).[19] A larger share of nominal bonds imply redistribution towards borrowers, who in this model tend to have higher MPCs than savers. With enough nominal bonds this can potentially overturn the initial decline in consumption causing the aggregate response to turn positive. The response in the following quarters, however, is amplified relative to the baseline with real bonds because savers reduce their consumption, and though their initial time 0 MPCs are smaller than the corresponding MPCs of borrowers, their intertemporal MPCs are typically larger. Figure A.6 plots the intertemporal MPCs by borrowers and savers which clearly showcases this point.

However, the standard incomplete markets model has a tendency to overstate the aggregate effects of the Fisher redistribution channel. The right panel in Figure A.5 shows the change in consumption at time 0 as a function of the covariance $\mathbb{C}\text{ov}\left(\boldsymbol{M}_i, a_i^n\right)$, obtained by varying the share of nominal assets θ^n. With a larger share of nominal assets the model predicts a large negative covariance, implying strong effects of redistribution. However, the size of this covariance is many times larger than the empirical estimate from Auclert (2019).[20] If I calibrate θ^n to match the empirical covariance from Auclert (2019), the Fisher effect is quantitatively small, and the effect from declining real labor income dominates, and consumption declines following a markup shock, as in the baseline model.

[19] For this model exercise I set the borrowing constraint to minus one times the average quarterly steady-state labor income $\underline{a} = -Z_{ss}$ as in Kaplan et al. (2018).

[20] The model over-predicts the size of this covariance because all constraint households are up against the borrowing limit $\underline{a}$, whereas empirically there is typically bunching around the point $a = 0$, where the Fisher effect is limited. This can be remedied by introducing a borrowing premium, see Faccini et al. (2024).



(a) Response of aggregate consumption to a markup shock

(b) dC_0 with varying share of nominal bonds and duration

Figure A.5: Model with Fisher debt-inflation effects

Note: The left panel shows response of aggregate consumption for different shares of nominal assets θ^n fixing the bond duration to 4.5 years ($\delta = 0.94$). The right panel shows the response of aggregate consumption at time 0 as a function of the covariance between net-nominal positions and MPCs for different levels of bond durations.

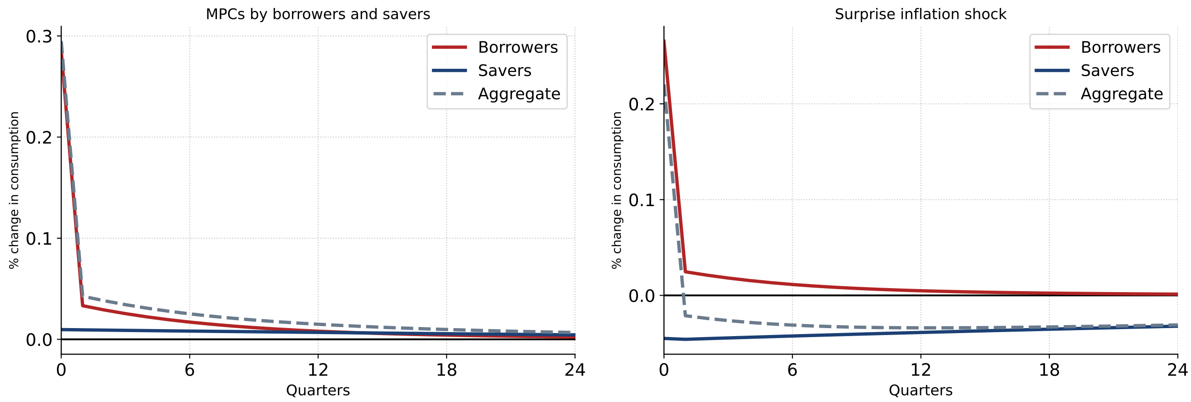


Figure A.6: Partial equilibrium responses by borrowers and savers

D Cost-push shocks

D.1 Neutrality of Cost-push shocks when $dP^*_{F,t} = dP^*_{X,t}$

Define $p_{X,t} = \frac{P_{X,t}}{P_t}$ as the price of imported materials in domestic CPI units. If $p_{X,t} = 0$ then the shock has no real effects on the domestic economy. To see when this case arises, consider the linearized versions of $p_{X,t}$ and Q_t under the law of one price:

$$dp_{X,t} = d\mathcal{E}_t + dP^*_{X,t} - dP_t$$
$$dQ_t = d\mathcal{E}_t + dP^*_{F,t} - dP_t$$

With a constant real rate and a UIP condition we have $dQ_t = 0$. Clearly if $dP^*_{X,t} = dP^*_{F,t}$ then $dp_{X,t} = 0$ and the shock to import prices have no effect on the domestic economy. Note that a constant real rate does not neutralize the relative price effects of a tariff, only the exchange rate movements.[21]

D.2 Proof of Proposition 4

Subbing (A.2) in to (A.1) with $d\boldsymbol{T} = d\boldsymbol{\tau} = 0$ gives:

$$\frac{\boldsymbol{I}}{1-\alpha}d\boldsymbol{Y} = \boldsymbol{M}^Z\left[1-(1-\omega)(1-\alpha_L)\right]d\boldsymbol{Y} - \left[\boldsymbol{M}^Z - \boldsymbol{M}^\Pi\right]d\boldsymbol{\Pi} - \boldsymbol{M}^Z(1-\omega)\frac{(1-\alpha_L)}{\alpha_L}d\boldsymbol{P}^*_{\boldsymbol{X}}$$

To derive (29), use (A.5):

$$\begin{aligned}\frac{\boldsymbol{I}}{1-\alpha}d\boldsymbol{Y} = &\left\{\boldsymbol{M}^Z\left(1-(1-\omega)(1-\alpha_L)\right) - \left[\boldsymbol{M}^Z - \boldsymbol{M}^\Pi\right]\left[\frac{\mu-1}{\mu} + \omega(1-\alpha_L) - \Theta^L\right]\right\}d\boldsymbol{Y}\\ &- \left[\boldsymbol{M}^Z - \boldsymbol{M}^\Pi\right](1-\alpha_L)\Theta^\mu d\boldsymbol{P}^*_{\boldsymbol{X}} - \boldsymbol{M}^\Pi(1-\omega)\frac{(1-\alpha_L)}{\alpha_L}d\boldsymbol{P}^*_{\boldsymbol{X}}\end{aligned}$$

Solving for output one obtains:

$$d\boldsymbol{Y} = -\mathcal{M}\left[\boldsymbol{M}^Z - \boldsymbol{M}^\Pi\right](1-\alpha_L)\Theta^\mu d\boldsymbol{P}^*_{\boldsymbol{X}} - \mathcal{M}\boldsymbol{M}^\Pi(1-\omega)\frac{(1-\alpha_L)}{\alpha_L}d\boldsymbol{P}^*_{\boldsymbol{X}}$$

where:

$$\mathcal{M} \equiv \left\{\frac{\boldsymbol{I}}{1-\alpha} - \boldsymbol{M}^Z\left(1-(1-\omega)(1-\alpha_L)\right) - \left[\boldsymbol{M}^Z - \boldsymbol{M}^\Pi\right]\left[\Theta^L - \frac{\mu-1}{\mu} - \omega(1-\alpha_L)\right]\right\}^{-1}$$

E Tariff shock

Combining (A.2) and (A.1) in the case where $dP^*_{X,t} = 0$ and $d\tau_t \neq 0$ gives:

$$\begin{aligned}\frac{\boldsymbol{I}}{(1-\alpha)}d\boldsymbol{Y} = &\boldsymbol{M^Z}\left[1-(1-\omega)(1-\alpha_L)\right]d\boldsymbol{Y} - \boldsymbol{M^Z}\left[\frac{1}{\alpha_L}\frac{\alpha}{(1-\alpha)} + \frac{(1-\alpha_L)}{\alpha_L}\right]d\boldsymbol{\tau}\\ &- \left[\boldsymbol{M^Z} - \boldsymbol{M^\Pi}\right]d\boldsymbol{\Pi} + \boldsymbol{M}^\tau dT + \frac{\alpha}{(1-\alpha)}\eta\left(1+\frac{\alpha^*}{1-\alpha}\right)d\boldsymbol{\tau}\end{aligned}$$

[21] Of course monetary policy could be chosen to neutralize any relative price movements even in the presence of tariffs, but this would induce an additional effect on household consumption through intertemporal substitution.

Then, using that $\frac{1}{\alpha_L} - (1-\alpha)\, d\tau_t = dT_t$ in the case where government debt is not adjusted, and using (A.5):

$$\left[\frac{\boldsymbol{I}}{(1-\alpha)} - \boldsymbol{M}^{\boldsymbol{Z}}\left[1-(1-\omega)(1-\alpha_L)\right] - \left[\boldsymbol{M}^{\boldsymbol{Z}} - \boldsymbol{M}^{\boldsymbol{\Pi}}\right]\left[\Theta^L - \frac{\mu-1}{\mu} - \omega(1-\alpha_L)\right]\right] d\boldsymbol{Y}$$
$$= -\boldsymbol{M}^{\boldsymbol{Z}}\left[\frac{1}{\alpha_L}\frac{\alpha}{(1-\alpha)} + \frac{(1-\alpha_L)}{\alpha_L}\right] d\boldsymbol{\tau}$$
$$+ \left[\boldsymbol{M}^{\boldsymbol{Z}} - \boldsymbol{M}^{\boldsymbol{\Pi}}\right]\left\{\left(\frac{\boldsymbol{I}}{\alpha_L} - \Theta^{\mu}\left(\boldsymbol{\kappa}^P\right)^{-1}\right)\frac{\alpha}{(1-\alpha)} + \left(\frac{\boldsymbol{I}}{\alpha_L} - \Theta^{\mu}\right)(1-\alpha_L)\right\} d\boldsymbol{\tau}$$
$$+ \boldsymbol{M}^{\boldsymbol{\tau}} dT + \frac{\alpha}{(1-\alpha)}\eta\left(1 + \frac{\alpha^*}{1-\alpha}\right) d\boldsymbol{\tau}$$

Defining the multiplier as:

$$\mathcal{M} = \left[\frac{\boldsymbol{I}}{(1-\alpha)} - \boldsymbol{M}^{\boldsymbol{Z}}\left[1-(1-\omega)(1-\alpha_L)\right] - \left[\boldsymbol{M}^{\boldsymbol{Z}} - \boldsymbol{M}^{\boldsymbol{\Pi}}\right]\left[\Theta^L - \frac{\mu-1}{\mu} - \omega(1-\alpha_L)\right]\right]^{-1}$$

I obtain the final expression:

$$d\boldsymbol{Y} = -\mathcal{M}\Theta^{\mu}\left[\boldsymbol{M}^{\boldsymbol{Z}} - \boldsymbol{M}^{\boldsymbol{\Pi}}\right]\left\{\left(\boldsymbol{\kappa}^P\right)^{-1}\frac{\alpha}{(1-\alpha)} + (1-\alpha_L)\right\} d\boldsymbol{\tau}$$
$$+ \mathcal{M}\left(\frac{1}{\alpha_L} - (1-\alpha)\right)\left[\boldsymbol{M}^{\boldsymbol{\tau}} - \frac{\boldsymbol{I}}{1-\alpha}\boldsymbol{M}^{\boldsymbol{\Pi}}\right] d\boldsymbol{\tau}$$
$$+ \mathcal{M}\frac{\alpha}{(1-\alpha)}\eta\left(1 + \frac{\alpha^*}{1-\alpha}\right) d\boldsymbol{\tau}$$