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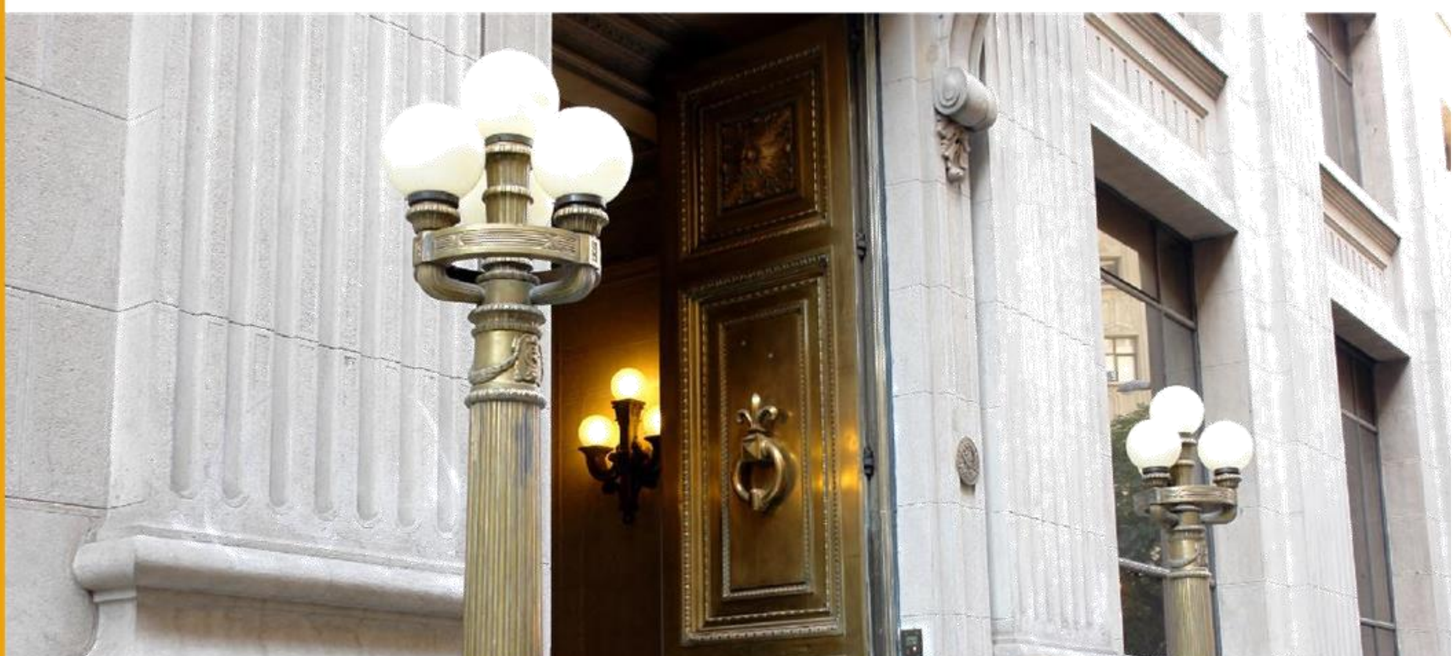

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Transmission Mechanisms in HANK: an Application to Chile*

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Abstract

Households in emerging economies are subject to significant income risk and have low access to financial markets. Leveraging multiple administrative microdata sources, this paper documents significant heterogeneity in asset holdings, income, and income cyclicality across the distribution of Chilean households, as well as considerable income risk. Considering this evidence, we compare the transmission mechanisms between Heterogeneous-Agent New-Keynesian models with search and matching (SAM) and sticky wage frictions (SW), and between one-liquid-asset (OA) and two-asset (TA) specifications. We propose a decomposition of consumption responses into direct, indirect, average, and cross-sectional effects. We show that the transmission mechanisms depend on the labor market setup: in SAM-OA the transmission operates through average and direct effects, while in SW-OA it is through cross-sectional effects. Assets also matter, the transmission in the SW-TA has stronger direct and average effects than SW-OA.

Resumen

Los hogares en economías emergentes están sujetos a un riesgo significativo de ingresos y tienen bajo acceso a los mercados financieros. Aprovechando múltiples fuentes de microdatos administrativos, este artículo documenta una heterogeneidad significativa en la tenencia de activos, ingresos y ciclicidad del ingreso a lo largo de la distribución de los hogares chilenos, así como un considerable riesgo de ingresos. Considerando esta evidencia, comparamos los mecanismos de transmisión entre los modelos neokeynesianos de agentes heterogéneos con búsqueda y emparejamiento (SAM) y fricciones salariales rígidas (SW), y entre especificaciones de un activo líquido (OA) y dos activos (TA). Proponemos una descomposición de las respuestas de consumo en efectos directos, indirectos, promedio y transversales. Mostramos que los mecanismos de transmisión dependen de la configuración del mercado laboral: en SAM-OA, la transmisión opera a través de efectos promedio y directos, mientras que en SW-OA es a través de efectos transversales. Los activos también importan, la transmisión en el SW-TA tiene efectos directos y promedio más fuertes que en el SW-OA.

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1 Introduction

Emerging economies have high inequality, their business cycles are significantly volatile, and they are not fully integrated in worldwide financial markets. As a consequence of that, their households are subject to significant income risk (both through real wage fluctuations and unemployment) and have low access to financial markets. Thus, policymakers in these countries must take these features into account when evaluating the effects of macroeconomic shocks and the consequences of fiscal and monetary policy decisions. In particular, in emerging markets, policy institutions should have models that account for the inequality, the financial frictions and the income risk households in those countries face. A main task in this regard is to evaluate how these features interact.

In this paper, we present a basic framework for Heterogeneous Agents New Keynesian (HANK) models that incorporate the features described above: incomplete markets, idiosyncratic risk, unemployment, and heterogeneity in the responses of labor income to aggregate fluctuations. We study, in models calibrated using administrative microdata for Chile, the role of different assumptions regarding labor and financial markets. The former usually are modeled through wage rigidity or search and matching frictions, and generate different implications for labor market variables, which we will analyze in the light of a HANK model by comparing their transmission mechanisms of fiscal shocks. For the latter, we study the role of assuming a one- or two-asset structure (liquid and illiquid assets as in Kaplan et al., 2018) for the transmission mechanisms of monetary policy shocks.

HANK models, as shown by Auclert et al. (2018), generate dynamic consumption responses to income changes due to the dynamic structure of household asset holdings. These dynamic responses are referred to as *intertemporal marginal propensities to consume* (iMPCs), and imply that households, upon receiving an additional unit of income, distribute their spending smoothly over time, leading to stronger and more front-loaded effects of income and fiscal transfers compared to two-agent models like Galí et al. (2007) and Bilbiie (2008)[1]. HANK models offer additional advantages due to their ability to track the wealth distribution and because they incorporate income heterogeneity meaningfully, which makes them particularly well-suited for analyzing countries like Chile, with high inequality and less developed financial markets. These features becomes especially relevant when studying the impact of fiscal policies, which often have uneven distributional effects. For instance, HANK models can shed light on how policies implemented during the COVID-19 pandemic, while contributing to economic recovery, may also have contributed to the observed rise

[1] These models assume a fixed proportion of consumers with no access to financial markets.

in inflation in various countries.

To analyze the influence of household heterogeneity on the transmission of monetary and fiscal shocks (both progressive and non-progressive transfers), we construct and calibrate three HANK models that differ in terms of their specification for the labor and financial markets. First, we build a sticky wages one-asset (SW-OA) HANK model based on the HANK-illiquid setup by Auclert et al. (2018), where households can hold both liquid and illiquid assets, but can only adjust the holdings of the former and receive income from the latter. Next, we show a version that incorporates search and matching frictions on the one-asset model (SAM-OA), and then present a sticky wages two-asset (SW-TA) version where we extend the SW-OA setup by allowing households to adjust their holdings of illiquid assets at a cost.

Following Patterson (2023)'s decomposition methodology, which builds upon Kaplan et al. (2018) and Auclert (2019), we analyze the different model specifications with regard to their transmission mechanisms and the overall macroeconomic responses to shocks. This approach allows us to examine the cross-sectional relationship between income fluctuations and marginal propensities to consume (MPCs) across different household types.

To understand the mechanisms driving the overall impact of policies, we decompose the model responses into direct effects (a partial equilibrium analysis with no further price variations) and indirect effects (capturing the full general equilibrium effects). Furthermore, we distinguish between average effects, the outcome if all consumers had identical marginal propensities to consume (MPCs) and income responses, and cross-sectional effects, which capture the influence of the relationship between MPCs and income responses across different household types.

The main contribution of this paper is to present a comprehensive analysis of the transmission mechanisms in HANK models, and how different common specifications for labor and financial markets affect these mechanisms, in the context of an emerging economy with high inequality, high income risk, and low asset holdings. With respect to the specification of the labor market, we show it matters[2]. In a model with SAM frictions, unemployment risk generates additional precautionary motives for households, leading to higher MPCs and stronger direct responses of consumption to fiscal transfers than in a sticky wages specification without search frictions.

Regarding financial markets, we show that for our calibration, the transmission mechanisms of monetary policy are not very different between a one-asset and a two-assets specification. We do

[2] Ravn and Sterk (2020) also study the role of SAM frictions in HANK models, although they do not compare the transmission mechanisms with respect to a specification with wage rigidities like those introduced in Erceg et al. (2000)

find, however, than in the two-assets specification, because the capital stock is more rigid due to the additional liquidity costs, monetary policy endogenously generates more persistent effects. Here, we confirm the findings of Bayer et al. (2019) and Kaplan et al. (2018).

The remainder of the paper is as follows. Section 2 shows empirical facts about heterogeneity that matter in HANK models, and relate them to the components of the consumption decomposition. Section 3 describes the models. In section 4 we describe how we analyze the responses of consumption to different shocks in the light of the model, by presenting the consumption decompositions we will use throughout the paper. In section 5 we compare the results of the SAM-OA and SW-OA. In section 6 we compare the results of the SW-OA with the SW-TA. Finally, we conclude in section 7.

2 Facts on Household Heterogeneity in Chile

In this section, we show empirical facts on household heterogeneity in Chile and discuss how these facts affect consumption dynamics according to the abovementioned decompositions. We discuss assets' holdings heterogeneity, labor income inequality, and labor income risk, and we finish with the equity distribution and the cyclicality of markups.

2.1 Assets' Holdings Heterogeneity

We follow Kaplan et al. (2018) to develop our aggregated two-asset (liquid-illiquid) structure. For this purpose, we use financial statements of the banking system, Financial Intermediaries, and Non-Banking companies financial statements, all available on the Comisión para el Mercado Financiero (CMF) website. In addition, we use data from December 2017 to match the information with the data used to calculate the shares of Hand-to-Mouth, which we obtain from household surveys, as describe below.

We define Revolving consumer debt as the Banking Credit Card Debt and the Banking Consumption Credits. The deposits correspond to what the banking system declared to have in their respective financial statements. Fixed Income include the Bond Holding and the amount of the Saving Accounts. Finally, equity is define as the shares and Mutual Funds Holding. Regarding the illiquid Assets we consider the Real Estate net of the present value debt and the motorized vehicles net of their respective debt.[3]

Revolving debt corresponds to bank credit cards, lines of credit, bank or financial consumer loans,

[3]Online Appendix A contains a disagregated information of the aggregates.

Table 1: Values are expressed as a fraction of 2017 GDP.

Liquid		Illiquid	
Revolving consumer debt	-0.12	Net housing	1.93
Deposits	0.05	Net durables	0.13
Fixed income	0.12		
Equity	0.12		
Total	0.17		2.06

credit cards from non-banking institutions, consumer loans in commercial houses (cash advances), credits in savings banks compensation, cooperatives or other similar, educational loans, and other non-mortgage debts. Deposits are the total amount households keep in their checking or sight accounts. Fixed income is the total amount households have invested in different instruments such as time deposits, bonds, savings accounts, and insurance with savings. Equity is the sum of investments in shares, investments in mutual funds, participation in companies or investment funds, and investments in other equity instruments (options, futures, swaps, among others).

There are only two illiquid assets, net housing, defined as the value that households assign to their primary home or other real estate they own, discounting the present value of the mortgage loan debt. And net durables, which corresponds to the value of automotive assets such as cars or trucks, motorcycles, vans or utility vehicles, and other motorized vehicles (boats, planes, helicopters, etc.), as well as other assets such as agricultural or industrial machinery, animals, works of art, etc. discounted from the debt in auto loans.

Table 1 summarizes the aggregate composition of households' portfolios. On the one hand, we find that for Chile, total net liquid assets are about 17 percent of the annual GDP. On the other hand, the illiquid assets holdings we find are about twice the annual GDP. These numbers are in orders of magnitude similar to those found by Kaplan et al. (2018), who find 26 percent for liquid assets and 2.92 times GDP for illiquid assets.

2.2 Share of hand-to-mouth

According to Kaplan and Violante (2014) (see also Kaplan et al., 2014), hand-to-mouth households are the ones that hold little or no liquid wealth relative to their income, whether in cash or in checking or savings accounts. Following their methodology, we estimate the share of hand-to-mouth households using data from the 2017 *Encuesta Financiera de Hogares* (EFH, henceforth). We restricted our sample to households in which the head is between 22 and 79 years, where income is positive, and drop households if all their income originates from self-employment. From an initial sample size of 4,549, we keep 2,777 households for our estimations, which represent approximately 45% of Chilean households [4].

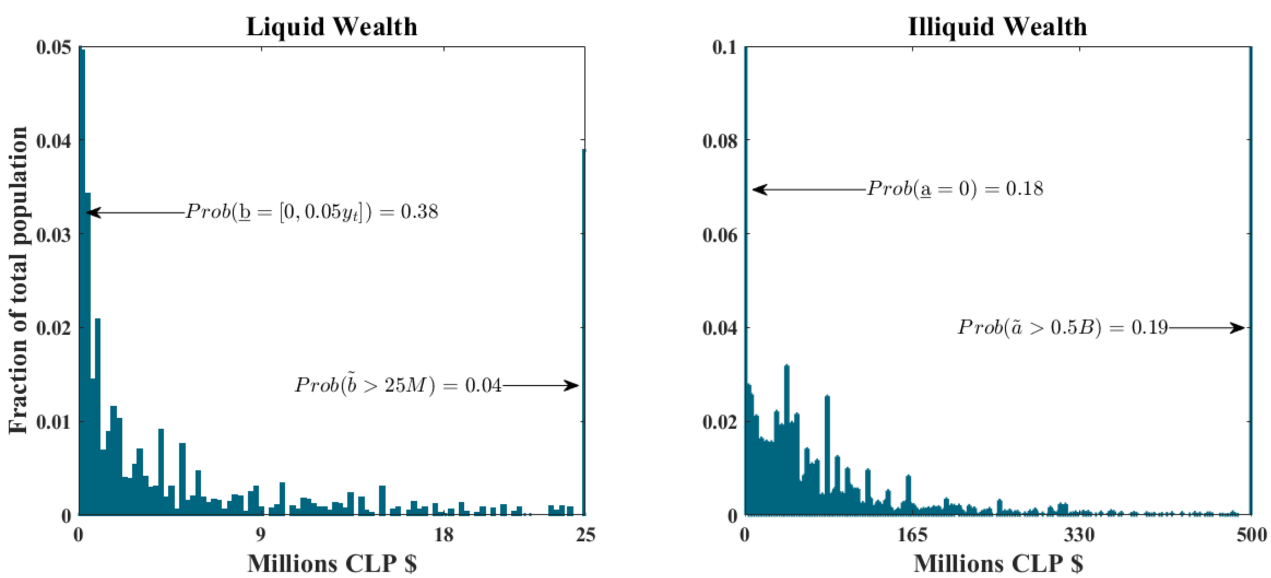
A household is hand-to-mouth if its liquid wealth holdings are equal to or less than five percent of their quarterly income.[5] The difference between rich and poor hand-to-mouth is that the former owns more than zero illiquid wealth. Table 2 shows the results and Figure 1 the distribution of liquid and illiquid wealth.[6]

TABLE 2: Share of Hand to Mouth Households (Fraction of total Population).

	Data
Frac. with b $\approx$ 0 and a = 0	0.08
Frac. with b $\approx$ 0 and a > 0	0.31

Note: b represents liquid asset holdings and a is the illiquid asset holdings.

FIGURE 1: Distributions of Liquid and Illiquid Wealth



Note: $\underline{b}$ is the effective non liquid assets holding range, defined as having less than 5% of the quarterly income in liquid asset holding. $\tilde{b}$ is a variable defined to accumulate the mass of Households with excessive liquidity, defined as the mass s of possessing over $25M$ in illiquid assets. A similar definition was done for the illiquid assets possession. $\tilde{a}$ is accumulates all illiquid asset holding over $500M$, $\underline{a}$ is the lower limit of illiquid assets, nontheless it remains as $a = 0$.

[4] Online Appendix B describes the survey in more detail.

[5] We define income as household labor income, income from pensions, income from subsidies, and other sources of income except the income imputed to the head.

[6] In online Appendix C we discuss more extensively more definitions of the Hand-to-Mouth state considering different criteria. In general, our share of Hand-to-Mouth is consistent with the values found for other measures like the access to checking account of credit cards. We also find that the banking and non-banking rotative credit limits are low. We think these shares of HtM are an upper bound of the financial access. More analysis of these definitions and their implications are left for further research.

2.3 Labor Income Inequality and Risk

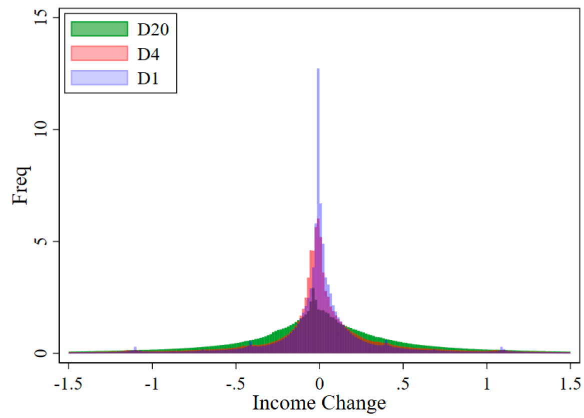
Labor income is a key ingredient of HANK models because it corresponds to most low-earners' income. Thus, labor income risk plays a role in determining consumption. In this section, we study the labor income distribution and labor income risk in Chile, using administrative microdata. The database we use, which is called *Administradora de Fondos de Cesantía (AFC)*, covers all workers with an employment contract since October 2002. Each month, we observe the income received by the worker and, hence, his employment status. To focus on workers with a reasonably strong labor market and following Aldunate et al. (2023), we restrict our sample to males between 25 and 55, who are employed for at least seven months in the sample and earn at least more than half the minimum wage. For each worker included, we define the primary job as their monthly highest-paying job. After these cleaning procedures, our sample contains about 358 million observations (about 44% of the initial database). Focusing on this subset of workers implies that we cover about 83% of the population with this database since the informality rate for males 25-55 years old is 17% (according to Gasparini and Tornarolli, 2009). Finally, we deflate income with headline CPI to obtain real measures.

As Guvenen et al. (2019), we distinguish between earnings growth over short and long horizons to account for workers' short- and long-run shocks to their earnings. We examine log income growth over one, four, and twenty quarters. Then we calculate the different moments for the quarterly income distribution, using a sample between 2003 and 2021 and a sub-sample between 2014 and 2019 (before the pandemics). Table 3 shows the moments of log earnings and the growth of one, four, and twenty-quarters. In Chile there is a high degree of labor income inequality, the variance of log earnings quarterly is about the one we observe in the U.S. with yearly data. The variance of income growth is large in comparison with what we observe for the U.S. amounting at a quarterly frequency to what the U.S. has at a yearly frequency (see Table 14 in online Appendix D). In Chile, the third moment is close to zero on average, with the value being more negative in the 2014-2019 period. This is, it is almost equally likely to receive positive and negative shocks.

Table 3: Empirical moments for earnings in Chile at quarterly frequency. Male workers.

Moments	Full sample	2014-2019
Var: log earns	0.70	0.72
Var: 1-qtr chg.	0.23	0.20
Var: 4-qtr chg.	0.33	0.30
Var: 20-qtr chg.	0.51	0.46
Skew: 1-qtr chg.	-0.02	-0.10
Skew: 4-qtr chg.	-0.01	-0.13
Skew: 20-qtr chg.	-0.02	-0.07
Kurt: 1-qtr chg.	9.91	11.18
Kurt: 4-qtr chg.	8.04	9.01
Kurt: 20-qtr chg.	5.55	6.21

Figure 2: Distributions of Income Growth



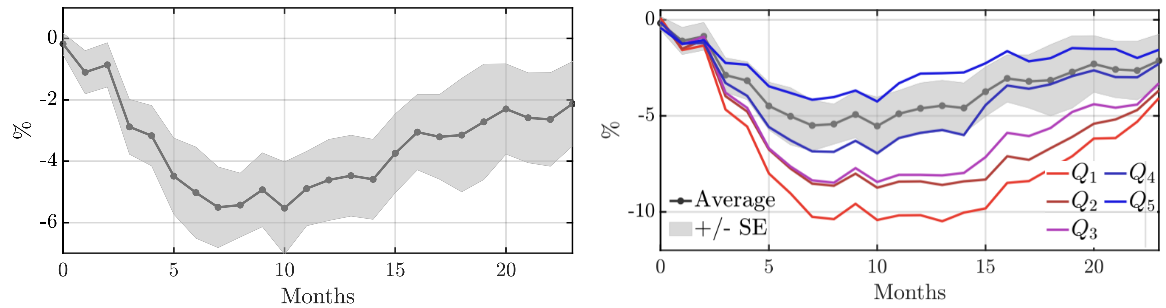
The fourth moment is the one in the data for Chile departs the estimates from normality assumptions. As Table 3 and Figure 2 show, labor income risk has a high kurtosis in Chile, similar to what the literature finds for the U.S. In Chile, we observe that the fourth moment is significantly larger than the three in all the horizons analyzed, meaning that households do not necessarily receive shocks every quarter.[7]

2.4 Heterogeneous Cyclicality of Labor Income

Another relevant heterogeneity in Chile is that workers at the bottom quintiles see their labor fall by more than workers at the top of the distribution in response to recessionary demand shocks. Figure 3, borrowed from Aldunate et al. (2023) shows the response of labor income by quintile of the permanent income distribution of workers in response to a recessionary interest rate shock. They identify a demand shock as a shock to the Chilean interest rate due to an increase in the *Excess Bond Premium* in the US (by Gilchrist and Zakrajšek, 2012), and show that these shocks operate as if they were a demand shock: when there is a contraction, inflation goes down, and unemployment goes up. We use that idea to abstract from the open economy considerations of that paper. Figure 3 shows the responses by quintiles and the average response of labor income to a contractionary demand shock. In Chile, the response of labor income of the first permanent income quintile is 2.5 times larger than that of the fifth quintile labor income in about the whole path of the response. This means poorer workers (with higher MPCs) suffer significantly the most in a recession.

[7]We compare these figures with the ones of the US in the online Appendix D.1.

Figure 3: Responses of labor income in Chile to a credit spread shock along the permanent income distribution. Source: Aldunate et al. (2023)



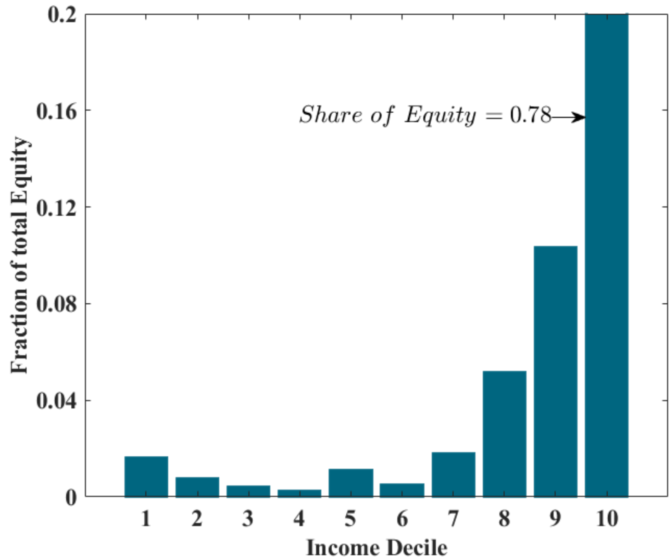
Notes: Responses of labor income to a demand shock. Left: average labor income response. Right: Responses by quintile of the permanent income distribution. Shaded areas represent +/- one standard error. Standard errors computed with Newey-West correction. Data is monthly from 2005m1 to 2018m12.

2.5 Firms' Ownership and the Cyclicality of Markups

One of the main features of New Keynesian models is the cyclicality of markups. Due to price rigidities, the New Keynesian model predicts that markups are countercyclical if the main drivers of aggregate fluctuations are demand shocks. Bauducco et al. (2022) show that this is the case for Chile: markups are unconditionally countercyclical. This means that, at least theoretically, income from profits (dividends) is less cyclical than labor income. This fact implies that in models with inequality and market incompleteness, there is a distribution of income from firms' owners and workers, which (as Bilbiie, 2008 and Debortoli and Galí, 2017 show) may lead to amplification due to higher MPCs of workers. This fact is central in the HANK literature since most of the amplification effects from monetary shocks (and demand shocks in general) rely on countercyclical markups in the absence of other sources of heterogeneity.

In Chile, the ownership of firms is highly concentrated towards the top of the income distribution, meaning that markup countercyclicality not only reflects price rigidities but a redistribution of income between rich and poor households or between low- and high-MPC individuals. According to the EFH 88% of the equity is held by households in the ninth and tenth deciles as Figure 4 shows.

Figure 4: Equity holdings by decile of the income distribution as a share of total equity.



3 Models

To study to what extent heterogeneity impacts the aggregate response to shocks and the role of the empirical facts we presented above, we build a heterogeneous agent New Keynesian model calibrated for Chile. We follow closely the approach–and methods– presented by Auclert et al. (2021). We present three different versions of this model, depending on the labor market setup and the assets available to households. We study models with unemployment risk (as in Ravn and Sterk, 2020) with liquid and illiquid assets (as in Kaplan et al., 2018) and with a fully illiquid asset with sticky wages (as in Auclert et al., 2018). We study the effects of fiscal and monetary policy and their transmission mechanisms. Motivated by recent events we study the effects of fiscal transfers (both progressive and non-progressive as in García et al., 2022) and monetary policy shocks.

Since we use the methods developed by Auclert et al. (2021) to solve the model, that relies on economies with aggregate shocks but without uncertainty, we omit the expectation time-operator in the description of the model. In particular, the method applies a linearization of the sequence-space which relies on shocks that are unexpected but with a known future path.

3.1 Households

The economy is populated by a continuum of households of measure one. Households are heterogeneous in their assets, productivity, and employment state. Households receive utility from consumption and disutility from labor. They maximizes the expected presented discounted value of utility flows $\mathbb{E}\left[\sum_{k=0}^{\infty} \beta^k u(c_{t+k}, h_{t+k})\right]$, where $u(c,h)$ is of the usual CRRA form $\frac{c^{1-1/\gamma}}{1-1/\gamma} - \psi \frac{h^{1+\varphi}}{1+\varphi}$. These households are subject to idiosyncratic productivity uncertainty. There are n_z possible idiosyncratic states where the probability of transitioning between states z and z' is given by $\Pi(z, z')$.

In the model with unemployment, agents have an additional source of uncertainty and, at each period of time, can be employed or unemployed. We denote by e the employment status. If employed, they supply an exogenous number of hours and earn $(1-\tau_t(z_t))w_t z_t h_t \mathcal{F}(z_t, Y_t)$, where w_t is the wage per efficient hour and $\tau_t(z_t)$ is a proportional income tax which can be type-dependent, and $\mathcal{F}(z_t, Y_t)$ an incidence function to account for the cross-sectional response of labor income we show in Section 2. If unemployed, they receive an unemployment benefit denoted by ψ which is distributed in proportion to agents' productivity z_t. Following the Diamond-Mortesen-Pissarides framework, we denote the transition probabilities between unemployment and employment states by $e = [w, u]$. Hence, $\Pi(z, z', e, e')$ is the transition matrix considering both unemployment and income risk. Consequently, income becomes $y_t(z_t, e)$ with $y_t(z_t, .) = [(1-\tau_t(z_t))w_t z_t h_t \mathcal{F}(z_t, Y_t), z_t\omega]$.

Agents can trade in two assets, a liquid and an illiquid asset, which we denote by b and a respectively. These assets pay an interest rate r_t^b and r_t^a. Asset holdings are subject to a borrowing constraint. The value function of an agent in the state (z, b, a, e) at time t is, therefore

$$V_t(z, b, a, e) = \max_{c,b,a} \; u(c) + \beta \sum_{z,s} \Pi(z, z', e, e') V_{t+1}(z', b', a', e'), \tag{1}$$

$$\text{s.t. } c + b' + a' = (1 + r_t^a)a + (1 + r_t^b)b + y(z, e) + d(z) + f_t(z) + \Phi_t(a', a), \tag{2}$$

$$b \geq 0 \text{ and } a \geq 0. \tag{3}$$

Households receive a fiscal transfer given by $f_t(z)$ and distributed firms' dividends $d_t(z)$, a non linear function to match the evidence presented in Figure 4. These two quantities can also be distributed unevenly among the different households. Finally, the illiquid asset is subject to convex adjustment costs we describe in the calibration.

Given optimal policies $c_t^\star(z, b, a, e)$, $a_t'^\star(z, b, a, e)$, $b_t'^\star(z, b, a, e)$, and denoting $\Psi(z, b, a, e) = Pr(z_t = z, b_{t-1} \in B, a_{t-1} \in A, e_t = e)$ the probability of that combination of states at the start of date t, the distribution Ψ_t has a law of motion

$$\Psi_{t+1}(z', b', a', e') = \sum_{z,e} \Psi_{t+1}(z', b'^{\star-1}, a'^{\star-1}, e') \Pi(z, z', e, e'), \tag{4}$$

where $b'^{\star-1}$ is the inverse of the optimal policy b (and the same applies to $a'^{\star-1}$). For simplicity, we summarize the state in a vector $\boldsymbol{s}$, the combination of possible states, i.e. $\boldsymbol{s} = (z, b, a, e)$. Therefore, in what follows, $\Psi(z, b, a, e) = \Psi(\boldsymbol{s})$, and the aggregate of a variable $x_t(\boldsymbol{s})$ is given by $\int x_t(\boldsymbol{s})\Psi(\boldsymbol{s})d\boldsymbol{s} = X_t$. However, we use the long notation when needed.

Nested Models. The model described above nests the three models we are going to use in the subsequent sections. First, we consider a model with a liquid and a fully illiquid asset without search and matching frictions. This means that $a' = a \;\forall\; t$, $\Pi(z, z', e, e')$ is reduced to $\Pi(z, z')$ and $y_t = (1 - \tau_t(z_t))w_t z_t h_t$. This model, on top of that, has wage rigidities in the definition of the labor market. We call this model *Sticky Wages One-Asset HANK* (SW-OA, henceforth). The second model is the one described above with a fully illiquid asset (with $a' = a \;\forall\; t$). We call this model *Search and Marching One-Asset HANK* (SAM-OA, henceforth). Finally, we consider a model with a partially illiquid asset and with sticky wages and name it *Sticky Wages Two Asset HANK* (SW-TA, henceforth). In the analysis of the models, we compare the effects of the labor market structure (SW-OA with SAM-OA) and the effects of the assets' structure (SW-OA with SW-TA). In the next subsections, we describe all the elements that are common to all of these models, clarifying the ones that are specific to one of these models.

3.2 Firms

There is a continuum of identical firms (indexed by $j \in [0, 1]$) which produce differentiated goods using capital and labor. They rent capital and hire labor, combining them with a Cobb-Douglas function $y_{jt} = Z_t k_{jt-1}^{\alpha} n_{jt}^{1-\alpha}$, with Z_t an aggregate productivity level. Although identical, these intermediate firms are in monopolistic competition and set prices taking into account the demand for their variety. Varieties are aggregated with a Dixit-Stiglitz aggregator with a price elasticity equal to $\frac{\mu_p}{\mu_p - 1}$, with μ_p the steady state markup charged by these firms. Price setting is subject to quadratic Rotemberg adjustment costs, with the cost given by $\frac{\mu_p}{\mu_p-1}\frac{1}{2\kappa_p}\left[\log(1+\pi_{jt})\right]^2 Y_t$. Firms maximize the present discount of profits net of adjustment costs. By standard arguments, the optimality conditions read

$$\log(1 + \pi_t) = \kappa_p \left(mc_t - \frac{1}{\mu_p} \right) + \frac{1}{1 + r_{t+1}^a} \frac{Y_{t+1}}{Y_t} \log(1 + \pi_{t+1})$$
$$h_t = (1 - \alpha) mc_t \frac{Y_t}{N_t}, \quad r_t^k = \alpha\, mc_t \frac{Y_t}{K_{t-1}}$$

where mc_t is the marginal cost. See online Appendix E.1 for details. The aggregate amount of profits generated each period by intermediate firms is given by

$$D_t = (1 - mc_t)\, Y_t - \frac{\theta}{2}\pi_t^2 Y_t.$$

3.3 Mutual Fund

Illiquid assets are equity claims on an investment fund. Thus, the fund's value equals the household's aggregate stock of illiquid assets $\mathcal{A}_t$. The investment fund owns the economy's capital stock K_t and shares in the intermediate producers X_t. The fund makes the economy's investment decision subject to an adjustment cost $\Gamma_t(K_{t+1}, K_t)$. The shares X_t represent a claim on a fraction ϖ of the entire future stream of monopoly profits net of price adjustment costs, Π_t. Let q_t^x denote the share price. The remaining fraction $1 - \varpi$ of profits flows directly into households' liquid assets account. The fund chooses capital, investment, and stocks to maximize the present discounted value of profits, see online Appendix E.2 for details. The fund chooses capital, investment, and stocks such that the returns from the mutual fund, capital, and equity must all be equal. This implies the following arbitrage conditions:

$$(1 + r_{t+1}^a) = \frac{r_t^k - \left[\frac{K_{t+1}}{K_t} - (1-\delta) + \frac{1}{\delta \epsilon_I}\left(\frac{K_{t+1}-K_t}{K_t}\right)^2\right] + \frac{K_{t+1}}{K_t} q_{t+1}^k}{q_t^k} = \frac{(1-\varpi)\Pi_{t+1} + q_{t+1}^x}{q_t^x}.$$

As in Kaplan et al. (2018), we assume there is a share ϖ of profits owned by the fund, while the remainder is distributed directly to households with a distribution rule we discuss in the calibration.[8]

3.4 Labor Markets

To achieve realistic fluctuations in wages and wage inflation, different labor market setups are considered depending on the model. In all models, labor markets are subject to frictions. In the model without search frictions, wages are assumed to be subject to adjustment costs. However, in the SAM-HANK model, a full Diamond-Mortensen-Pissarides setup is assumed. These settings will be further described in what follows.

Sticky Wages. We assume households cannot decide their labor supply directly. Instead, there is a union that supplies aggregate labor. In each household i there is a continuum of tasks denoted

[8] Kaplan et al. (2018) set $\varpi = \alpha$ to isolate equity from fluctuations in countercyclical markups.

by $g \in (0,1)$. A task-specific union decides nominal wages W_t^g for an amount of hours N_t^g. In this setting, unions have market power as workers' tasks are in monopolistic competition. The union aggregates individual labor such that $N_t^g = \int n_t^g(\boldsymbol{s})d\boldsymbol{s}$. Then, we assume there is a Dixit-Stiglitz aggregator, with elasticity of demand for labor tasks ε_w. We also assume nominal wages are sticky and their changes are subject to Rotemberg adjustment costs, $\Theta_t^w = \frac{\mu_w}{\mu_w - 1}\frac{1}{2\kappa_w}\left[\log(1+\pi_{gt}^w)\right]^2 N_t$. The union sets the nominal wages and the wage inflation to maximize the present discounted utility of an average household, weighted by the distribution $\Psi(\boldsymbol{s})$, see details in online Appendix E.3. This setup leads to a wage Phillips curve of the form

$$\log(1+\pi_t^w) = \kappa_w\left[\psi N_t^{\varphi} - \mu_w(1-\tau_t)w_t\mathcal{U}_t\right] + \beta\frac{N_{t+1}}{N_t}\log(1+\pi_{t+1}^w), \tag{5}$$

with $\mathcal{U} = \int u'(c_t)$ and φ is the inverse of the Frisch elasticity. Equation (5) shows a New Keynesian Wage Phillips Curve (NKWPC) that relates wage inflation with hours worked and workers' preferences. As we show in the equation, due to labor market frictions and symmetry, all workers supply N_t hours at a real wage w_t.

Search and Matching. In this version of the model we consider a labor market with search frictions as in Mortensen and Pissarides. We assume there is a Cobb-Douglas matching function $M(U_t, V_t) = m_t U_t^{\gamma} V_t^{1-\gamma}$, which leads to a job finding probability $f_t(\theta_t) = m_t\theta_t^{1-\gamma}$ and a job filling probability $q(\theta) = m_t\theta^{-\gamma}$, where $\theta_t = \frac{V_t}{U_t}$ is the market tightness. U_t is the measure of unemployed workers with $U_t = \int d\Psi(z_t, b, a, e = u)$, and the level of employment is given by $E_t = 1 - U_t$. The probability of becoming unemployed while working is given by an exogenous separation probability s.

Households can not individually supply–and set– labor. Instead, there is an intermediary for each type who hires and sells labor services. This firm's value of a worker with productivity z_t is

$$J(z_t) = (h_t - w_t)z_t + (1-s)\frac{1}{1+r_{t+1}}\mathbb{E}_z[J(z_{t+1}|z_t)],$$

where h_t is the marginal product of labor. The free-entry condition for these intermediaries is

$$\frac{c_v}{q(\theta_t)} = \frac{1}{1+r_{t+1}}\int_{z_t}\mathbb{E}_z[J(z_{t+1}|z_t)]d\Phi(z_t, b, a, e = u).$$

Additionally, we use a Nash-inspired wage rule

$$w_t = (1-\eta)\omega + \eta(h_t + c\theta_t),$$

where η is workers' wage bargaining power. Finally, the intermediary generates profits from the difference between the marginal productivity of labor and the real wage, given by

$$D_t^w = h_t - w_t.$$

These profits are delivered to households in the same way monopolistic profits are.

3.5 Government, Monetary Authority, and Aggregation

The government, in our setting, allocates its spending between government consumption G_t, fiscal transfers to households $f_t(z)$ that can be progressive or not, and unemployment benefits. The government issues liquid debt B_t^g and raises taxes τ_t. Government debt is held by households in their liquid account and pays the return r_t^b. The government, then satisfies the budget constraint

$$B_{t+1}^g = T_t + G_t - \tau_t w_t N_t + (1 + r_t) B_t^g,$$

where the evolution of the fiscal balance depends on a smoothing parameter ρ_X, which determines to what extent additional spending is financed with debt according to:

$$\Delta B_t^g = \rho_X (\Delta B_{t-1}^g + \Delta X_t), \tag{6}$$

where X_t can be T_t or G_t.

The monetary authority follows a Taylor rule for the nominal interest rate i_t:

$$i_t = i^* + \phi_\pi \pi_t + \phi_u (u_t - u_{ss}) + \varepsilon_t^{mp},$$

where we denote by ϕ_π the preference parameter for inflation and ϕ_u for unemployment with u_t is log of unemployment. ε_t^{mp} is a monetary policy shock that follows an AR(1) process. Monetary authorities seek a nominal interest rate target in steady state given by i^* (where $i^* = r$)[9]. Given the inflation level and the nominal interest rate, the real rate is determined by the Fisher equation $(1 + r_t) = \frac{(1+i_t)}{(1+\pi_{t+1})}$.

Since total consumption expenditures is given by $C_t = \int c(\boldsymbol{s}) d\Psi(\boldsymbol{s})$, goods market clearing implies

$$Y_t = C_t + I_t + G_t + \Theta_t^\pi + \Theta_t^w + \Phi_t,$$

[9]With steady state inflation equal to 0.

with $\Phi_t = \int \Phi_t(i) d\Psi_t(i)$ in SW-TA and zero otherwise. And financial markets close:

$$B_t^g = B = \int b \ d\Psi_t(\boldsymbol{s}) \ \text{ and } \ K_t + q_t = \int a \ d\Psi_t(\boldsymbol{s}).$$

4 Sources of Consumption Fluctuations

Based on Patterson (2023) and Kaplan et al. (2018), below we compare the different model assumptions using decompositions of consumption. As Kaplan et al. (2018) show, the transmission mechanism of monetary policy (and hence, of different shocks) changes when we have high MPCs. They show that for monetary policy shocks indirect effects dominate in the total effect of raising the interest rate. This is, monetary policy transmit to consumption mainly through variables other than the interest rate itself, namely labor income, fiscal policy and others. This gives rise to a simple decomposition of the effects of shocks, between *direct* and *indirect* effects. On the other hand, Patterson (2023) shows that in models with inequality, the cross-sectional relationship between MPCs and income fluctuations may be a source of business cycles amplification. This analysis is based on the fact that households' income fluctuations may be different between types of households, and if there is a cross-sectional relationship between MPCs and income fluctuations, there might be amplification of shocks. Hence, we must consider *average* and *cross-sectional* effects of shocks.

Let i denote an individual, aggregate consumption can be written as $C_t(\boldsymbol{S}) = \int c_t(i; \boldsymbol{S}) di$, with $\boldsymbol{S}$ the path (from 0 to T) of a vector of aggregate variables entering individual consumption, like interest rates or wages. We decompose consumption fluctuations $dC_t(\boldsymbol{S})$ as the total consumption differential. In a one-asset economy (with $\boldsymbol{S}_t = \{r_t, \chi_t\}$), the differential is given by the derivatives of consumption with respect to r_t and income of other sources χ_t. Denote the former derivative with $\mathcal{Q}_{t,k}(i) = \frac{\partial c_t(i;\boldsymbol{S})}{\partial r_k}$ and the latter with $\mathcal{M}_{t,k}(i) = \frac{\partial c_t(i;\boldsymbol{S})}{\partial \chi_k}$. These are the responses of consumption in period t to an increase of r and χ_t in period k, respectively. Therefore, the vectors $\mathcal{Q}_t(i)$ and $\mathcal{M}_t(i)$ summarize responses of consumption in t to increases in every period k with $k = [0, ..., T)$. As explained by Auclert et al. (2018) the vector $\mathcal{M}_t(i)$ containes the intertemporal MPCs of household i and $\mathcal{Q}_t(i)$ are the responses of consumption to interest rate innovations. Given these definitions, we can write aggregate consumption changes as

$$dC_t = \int \mathcal{Q}_t(i) dr di + \int \mathcal{M}_t(i) d\chi(i) di, \tag{7}$$

where dr and $d\chi(i)$ are the vectors of changes in interest rates and household i income. Equation (7) can be written as

$$dC_t = \underbrace{\overline{\mathcal{Q}}_t dr}_{\text{Real Rate Effect}} + \underbrace{\overline{\mathcal{M}}_t d\overline{\chi}}_{\text{Average Effect}} + \underbrace{COV_i(\mathcal{M}_t(i), d\chi(i))}_{\text{Cross-Sectional Effect}}. \tag{8}$$

Equation (8) decomposes consumption fluctuations in three components: the direct effect of *Real Rate* fluctuations (just average effects since r_t is common), the *Average Effect* and the *Distributional Effect*. The first component represents the total response of consumption in t to a path in the real interest rate changes dr; the second component is the average responses of consumption to fluctuations in endogenous variables or policies that represent income of households; and the third is the response of consumption to cross-sectional fluctuations in income, representing the relationship between differential responses in income and the MPCs of consumers. This is, given the same average MPCs and a given path in $\overline{\chi}_t$, there are effects from how fluctuations in income distribute among households. We will use these kinds of decompositions in the model to study the effect of different assumptions on consumption fluctuations.

Useful Further Consumption Decompositions. The previous decomposition can be made further depending on the model and the variables to analyze. Two useful decompositions appear when we analyze the effects of fiscal transfers and in models with more than one asset. In the case of a fiscal transfer, we can decompose consumption further by separating "direct" effects and "indirect" effects (as in Kaplan et al., 2018 or Auclert, 2019), to understand why the covariance fluctuates, if it is more from direct effects or from general equilibrium effects. This decomposition reads

$$dC_t = \overline{\mathcal{Q}}_t dr + \underbrace{\overline{M}_t d\overline{T} + COV_i(M_t(i), dT(i))}_{\text{Direct}} + \underbrace{\overline{M}_t d\overline{y} + COV_i(M_t(i), dy(i))}_{\text{Indirect}}, \tag{9}$$

whereas the decomposition with two assets is given by

$$dC_t = \overline{\mathcal{Q}}_t dr^b + \overline{\mathcal{G}}_t dr^a + \underbrace{\overline{M}_t d\overline{T} + COV_i(M_t(i), dT(i))}_{\text{Direct}} + \underbrace{\overline{M}_t d\overline{y} + COV_i(M_t(i), dy(i))}_{\text{Indirect}}. \tag{10}$$

5 Comparing SW-OA & SAM-OA HANK

Since there are several ways of modeling labor markets, and in particular, wage rigidities and search and matching are the two most popular, it is necessary to address the differences that arise from assuming one or the other. In this section, we explore that. We compare the differential responses of the two labor market setups embedded in a HANK environment. We first present the calibration and then compare SW-OA with SAM-OA using the above decompositions to analyze the effects of fiscal transfers.

5.1 Calibration

Income distribution and income risk. We embed the distribution of labor income inequality and risk in our model by estimating a stochastic process that is composed by two terms, a permanent and a transitory component. We estimate the parameters of the process and then discretize it to obtain a grid and a Markov chain.

We assume idiosyncratic income (in logs) is given by the sum of two processes z_{1t} and z_{2t}:

$$y_t = z_{1t} + z_{2t} \tag{11}$$

where z_{it} follows

$$\begin{aligned} z_{it} &= \rho_i z_{it-1} + \sigma_i \varepsilon_{it} \\ \varepsilon_{it} &= \begin{cases} \mu_{it} \geq p_i & \sim \mathcal{N}(0,1) \\ \mu_{it} < p_i & 0 \end{cases} \\ \mu_{it} &\sim U[0,1]. \end{aligned}$$

Therefore, we estimate parameters $\{\rho_1, \rho_2, \sigma_1, \sigma_2, p_1, p_2\}$. As noted by the previous literature, the combination of these two processes returns high kurtosis (given by a $p_i \neq 0$) and can match the moments of the growth in income at lower frequencies.

To match the moments of the empirical distribution with the income process in Equation (11), we approximate z_1 and z_2 using a discretization method first proposed by Farmer and Toda (2017) and Tanaka and Toda (2013, 2015). This method is based on matching conditional moments of the discrete approximation with the moments of the true continuous-state process. This is similar to the Rouwenhorst method proposed by Kopecky and Suen (2010), extended for non-linear, non-Gaussian Markovian processes. Therefore, our job is to pin down the parameters that describe the processes z_i, namely ρ_i, σ_i, p_i to match the moments observed in the data and then apply the method by Farmer and Toda (2017) to obtain the discretized version that we feed into the model. We find the parameters by minimizing a loss function that takes a proposed set of parameters and computes how far we are from the desired moments.

Table 4: Empirical and estimated moments of labor earnings in Chile at a quarterly frequency.

Moment	Data	Model
Var $\log(y_t)$	0.719	0.714
Var $\Delta \log(y_t)$	0.195	0.226
Var $\Delta_{20} \log(y_t)$	0.463	0.448
Kur $\Delta \log(y_t)$	11.18	11.617
Kur $\Delta_{20} \log(y_t)$	6.21	6.076

Notes: Source: Unemployment Fund Administration, Chile.

Table 4 shows the moments of quarterly labor income for one-quarter and twenty-quarters log-change in labor income and the variance of the log of income ($\log(y_t)$). We observe that the variance increases with the lag of the difference, and these distributions have a high kurtosis, which decreases with the lag of the change. However decreasing, it is still higher than a normal distribution for the twenty-period change. Table 4 shows that our model matches the empirical moments well.

We show the estimated parameters of the process in Table 5. We estimate a permanent process with high persistence with a half-life of around 43 years (a career shock) and a low probability of occurrence: workers receive these shocks every 3.5 years. The other shock is less persistent but more likely. Households receive it almost every quarter, while its half-life is about 0.4 quarters. With these parameters, we build the transition matrix to discretize them, and we consider three points for the persistent component and eleven for the transitory component.[10]

Table 5: Parameter estimates for idiosyncratic income process.

ρ_1	ρ_2	σ_1	σ_2	p_1	p_2
0.996	0.145	0.511	0.382	0.071	0.958

The incidence function we assume is exponential and given by

$$\mathcal{F}(z, Y_t) = \frac{1}{f_0} \exp\left\{\xi \;\; z \;\; (Y_t - Y_{ss})\right\},$$

with $f_0 = \int \exp\{\xi \;\; z \;\; (Y_t - Y_{ss})\}\, dz$, which guarantees that $\int \mathcal{F}(Y_t) di = 1$ and we set ξ such that we obtain the response pattern we show in Figure 3 in the baseline calibration.

Labor Markets. For the SAM-OA we use the same targets as in the main quantitative DSGE model of the Central Bank of Chile (García et al., 2019): steady-state unemployment rate at 8%,

[10] This process suggests that in Chile, income risk is higher than what we observe in the United States (see online Appendix D for a comparison between Chile and the US). A reason for this high risk is the high worker turnover in Chile. Albagli et al. (2017) conclude that turnover in Chile is higher than all of the OECD countries.

the vacancy filling probability $q(\theta) = 0.8$, and the separation rate to $\delta = 0.04$. In the steady state, the job-finding probability is given by

$$u = \frac{s}{s + p(\theta)} \Rightarrow p(\theta) = s \cdot \frac{1-u}{u} = 0.46.$$

The Nash Bargaining parameter is set to $\eta = 0.5$ (as in García et al., 2019 and Mortensen and Pissarides, 1994). We set $\alpha = 0.5$ (Hosios condition). We calibrate the productivity of the matching function to satisfy the previous conditions, with $m = \frac{p(\theta)}{\theta^{1-\alpha}}$. Finally, we set the Frisch elasticity of labor supply $1/\varphi$ equal to one and we calibrate the disutility of labor to match $H_t = 1$.

For the SW-OA model, we set the labor market markup, μ_w, at 1.085 and the slope of the New Keynesian Wage Phillips curve, κ_w, at 0.1.

Firms. We set the steady state level of capital, as a share of annual GDP, at 2.01 (8.04 quarterly) to match the value of illiquid assets, as a fraction of GDP, from Table 1. The capital share α_k is equal to 1/3. Steady-state productivity level Z is calibrated to obtain a steady-state GDP equal to one ($Y = 1$). The depreciation rate equals 0.01 (from García et al., 2019) and, in the baseline calibration, the capital adjustment cost parameter, ϵ_I, is set to 0.5. Finally, we assume 10% markups ($\mu_p = 1.1$) and a slope of the Price Phillips curve of 0.1.

Government. We set the Taylor rule parameters to $\phi_\pi = 1.25$ and $\phi_U = -1$ in the baseline calibration. We set the level of government spending and fiscal transfers to ten percent of GDP each. Fiscal transfers have two components, a progressive and a non-progressive transfer. We set both to 5% of GDP. Individual transfers are defined by a non-linear function $f(z) = T_t z^{-\aleph_f} f_0$, where f_0 is a scalar which ensures $\int f(z)\Psi(i)di = T_t$ and $\aleph_f$ is the level of progressivity. We solve the model with two transfers which only differ in the progressivity level $\aleph_f$. In the next sections, we introduce two types of policies simultaneously, progressive and non-progressive, to match the distribution of two selected policies delivered in 2020. These parameters are $\aleph_{\boldsymbol{p}} = -1.1$ $\aleph_{\boldsymbol{np}} = 0.4$ in the progressive and the non-progressive policies respectively. We explain how we set these parameters in the next section. In this paper, we assume the government partially finance transfers with debt setting $\rho_T = 0.5$ and we include a tax on dividends equal to 25%. (see García et al., 2022 for further analysis of these assumptions).

Solution Method To solve this heterogeneous-agent model with borrowing constraints, we follow Auclert et al. (2021). To solve the value function, we use Carroll (2006) endogenous grid method, which is a fast and accurate algorithm to solve these kinds of problems. Then, we use a Newton method to solve the steady state of this economy. And finally, to solve the model with aggregate shocks we follow Auclert et al. (2021) as well, who propose to write the model in its Sequence-Space and linearize around that system of equations. We refer the reader to Auclert et al. (2021) for more details on the method.

Table 6: Calibration of SW-OA and SAM-OA models.

	Description	SW-OA	SAM-OA	Source/Target
Preferences				
β	Discount factor	0.95	0.95	Share of HtM (0.39)
γ	EIS	1	1	Garcia et al. (2019)
ψ	Disutility of labor	0.60	0.50	Hours worked (1)
φ	Frisch elasticity	1	1	Standard Calibration
r	Eq. interest rate	2%	2%	
B^g	Agg. bonds	0.33	0.21	Bonds' mkt eq.
Labor Market and Wages				
η	Union's bargaining power		0.5	Mortensen & Pissarides (1994)
α	Elasticity matching fn.		0.5	Mortensen & Pissarides (1994)
s	Separation rate		0.04	Unemployment rate (0.08)
c_v	Vacancy cost		0.18	*Internally calibrated*
m	Matching efficiency		0.537	Job finding rate
μ_w	labor mkt mkup	1.085		
κ_w	Slope NKWPC	0.1		
Fiscal and Monetary Policy				
τ_w	Labor income tax	0.1	0.09	*Internally calibrated*
ϕ_π	Taylor rule (inflation)	1.25	1.25	
ϕ_U	Taylor rule (unemployment)		-1	
Production				
Z	TPF	0.53	0.52	Normalized aggr. output (1)
α_K	Capital share	0.33	0.33	Garcia et al. (2019)
δ	Depreciation rate	0.01	0.01	Garcia et al. (2019)
ε_I	Capital adjustment costs	0.5	0.5	Auclert et al. (2020)
μ_p	goods mkup	1.1	1.1	Garcia et al. (2019)
κ_p	Slope of P.C.	0.1	0.1	
K	Capital in SS.	2.06	2.06	Data (Table 1)

Steady State Calibration. To solve the steady state we leave free the disutility of labor (ψ), the discount factor (β), the level of labor income taxes (τ_w), aggregate bonds holdings (B^g), and the vacancy cost (c_v) in the SAM-OA case. The targets we set are an interest rate of 5% yearly, the share of hand-to-mouth 0.39, hours normalized to one, and the unemployment rate implicitly by satisfying the free-entry condition in the labor market in the SAM-OA case. Additionally, τ^w is determined to satisfy the government budget constraint. Table 6 shows that after this calibration procedure, we obtain in the SAM-OA model: $\beta = 0.95$, $\psi = 0.57$, $c_v = 0.18$ which leads to 0.8 percent of GDP in vacancy costs, a tax rate equal to $\tau^w = 0.09$, and aggregate bond holdings equal to 0.18 as a share of annual GDP (very close to the values in Table 1 of 0.19). On the other hand, in the SW-OA model, we obtain: $\beta = 0.94$, $\psi = 0.73$, $\tau_w = 0.1$, and bond holdings equal to 0.32.

Additionally, Table 7 shows the MPCs implied by the two models we compare in steady state. We argue that this is the main source of differences between the SAM-OA and the SW-OA. Because the SAM-OA has an additional layer of risk due to unemployment, and unemployment would affect workers of all income levels, SAM frictions generate higher MPCs along the distribution of income. In Table 7 we observe two additional facts: first, that MPCs are decreasing in income (because wealth correlates with income); second that the difference between models, i.e., the effect of unemployment on MPCs, is also decreasing in income. That is because labor income is more important at the bottom of the distribution than at the top of the distribution. As we will see below, these facts have important effects on consumption dynamics, driving the differences between SW-OA and SAM-OA models both on the size and the transmission mechanisms of the effects.

Table 7: MPCs by quintile of the income distribution in SW-OA and SAM-OA.

	Q1	Q2	Q3	Q4	Q5	Avg. MPC
SW-OA HANK	0.637	0.544	0.271	0.265	0.114	0.255
SAM-OA HANK	0.894	0.592	0.293	0.268	0.144	0.451

Note: The MPCs are expressed at a quarterly frequency.

5.2 Response to a Fiscal shock

In this section, we study the role of labor markets' frictions in the transmission of fiscal transfers. We follow García et al. (2022) by comparing the role of progressive and non-progressive transfers when monetary policy is loose (the monetary authority does not respond to inflation, $\phi_\pi = 0$) or tight (the monetary authority responds strongly to increases in inflation, $\phi_\pi = 1.25$).[11]. Next, we show the impulse responses and the decomposition of each case comparing SW-OA with SAM-OA.

[11] García et al. (2022) define progressivity of transfers which match fiscal transfer schemes in times of COVID in Chile.

Loose Monetary Policy. Figures 5 and 6 show the responses of macroeconomic variables to a fiscal transfer shock in the SW-OA and the SAM-OA models, calibrated to generate the same impact response of the ratio $\frac{w_t}{n_t}$. With a loose monetary policy, fiscal transfers have a big expansionary effect on consumption, with impact multipliers larger than one in the case of the progressive policy in both models. The reason is that due to the unresponsive monetary policy, the increase in inflation generates a fall in the real rate in the short run which stimulates the economy further. Quantitatively, and due to the calibration we use, the responses in both SW-OA and SAM-OA are similar (this can be observed in the responses of the macroeconomic aggregates), but the transmission mechanisms change, as can be seen in the responses of labor market variables and prices.

FIGURE 5: IRFs of Macroeconomic Variables to a progressive/non-progressive Fiscal Transfer Shock in SW-OA model, loose Monetary Policy.

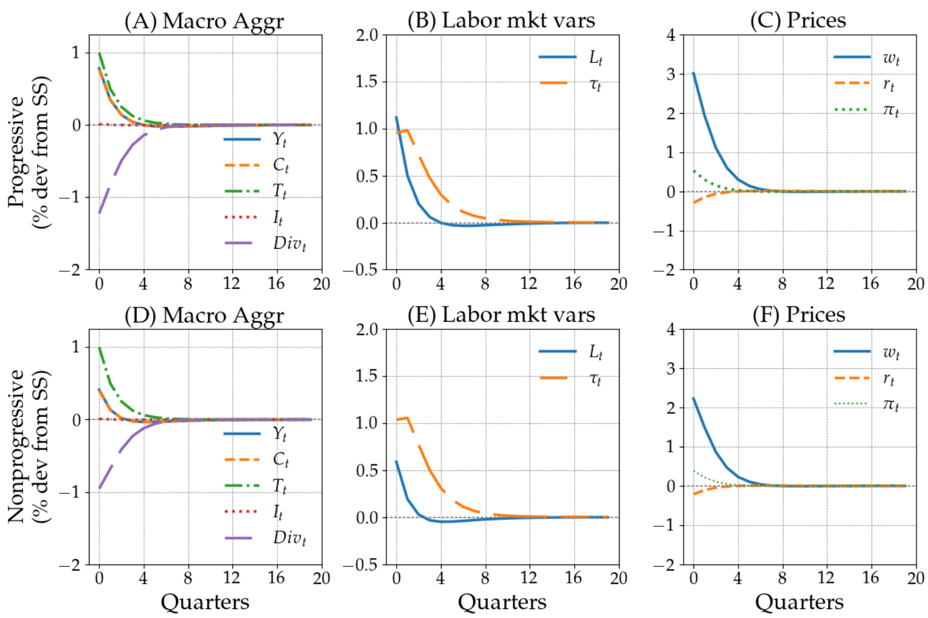
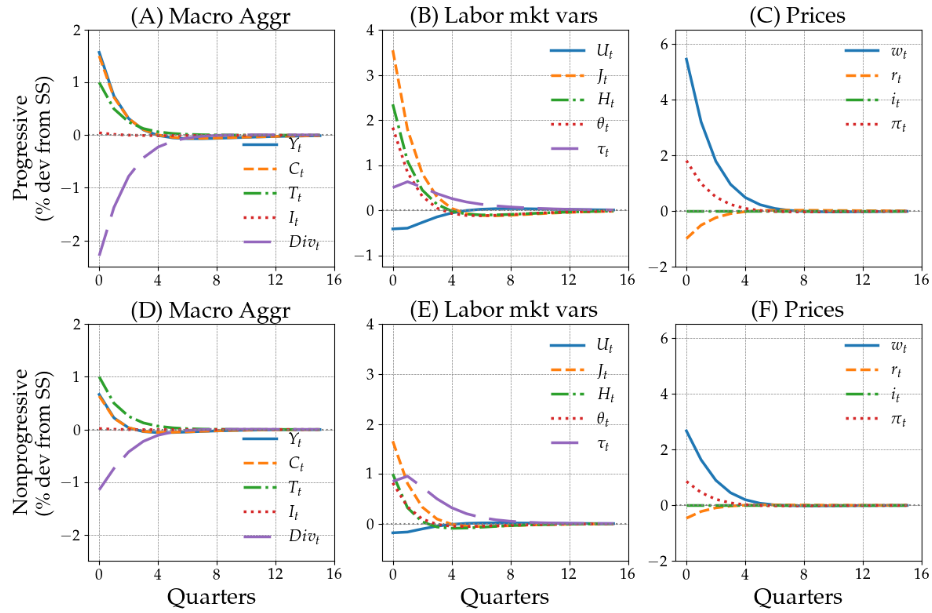


FIGURE 6: IRFs of Macroeconomic Variables to a progressive/non-progressive Fiscal Transfer Shock in SAM-OA model, loose Monetary Policy.

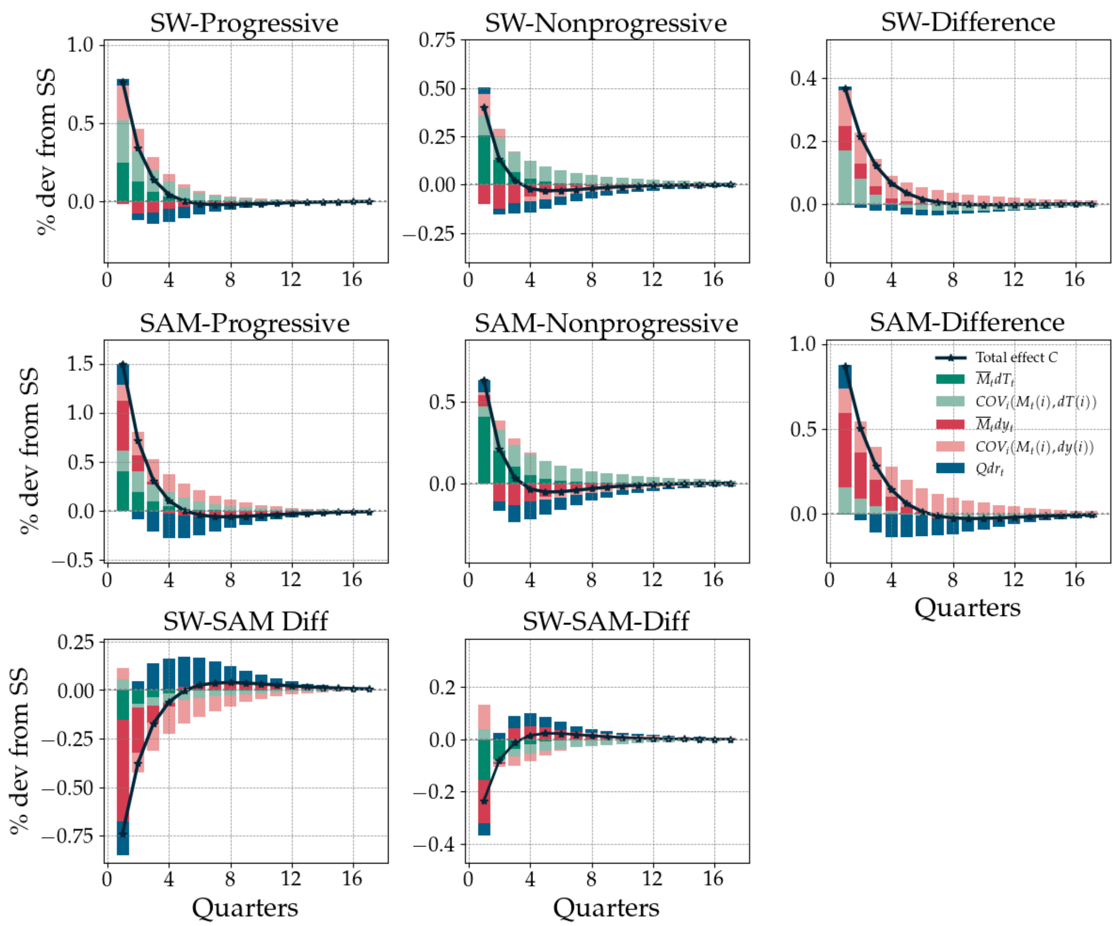


To understand the differences between both models, it is better to use the decomposition we propose in Section 4, which separates the response of consumption into the effect of the real rate and the impact of marginal propensities to consume (and their distribution). Figure 7 shows the decomposition for SW-OA and SAM-OA, as well as progressive and non-progressive policies with their respective differences. Note that in our calibration, the impact of policies not only depends on the progressivity of the policy but depends on the model assumptions. We decompose the consumption response to the transfer, calling it the *direct* effect, and an indirect effect (from changes in $dy_t(i)$) which is the response of consumption to labor income (represented by wages, hours, and labor income taxes) and dividends. For completeness, we include the effect of the interest rate.

Note the effect of the larger MPCs in SAM-OA. This is represented by the dark-green bar in Figure 7. In both cases, the dark green bars are larger in SAM, which means that the direct-average effect of these policies is larger in SAM. While this is true on average, the SW-OA has (on impact) a larger cross-sectional effect from transfers, that becomes lower from the second quarter. All this implies that the initial impulse in SAM-OA is larger than in SW-OA due to higher MPCs (which we describe in Table 7).

Recall that a feature we include in the model is the cross-sectional unequal responses of labor income to the shocks (see section 2) that in addition to the countercyclical markups and unemployment in SAM-OA, generates cross-sectional responses of income ($dy_t(i)$). These facts generate responses in the component $COV(M_t(i), dy_t(i))$. We find that the cross-section term jumps in both policies; however, in the SW-OA that term is more responsive and drives most of the effects of fiscal transfers. This means that to generate amplification, SW-OA needs features that generate redistribution between MPCs to a larger extent than SAM-OA, in which the average effects of shocks mainly drive the action. This could be due to the effects of having higher MPCs, but also to the effect of unemployment, which is about similar for all households.

FIGURE 7: Consumption Decomposition, SW and SAM Model with a loose Monetary Policy.



Tight Monetary Policy. Figure 8 and 9 show the responses of macroeconomic variables to a fiscal transfer shock in the SW-OA and the SAM-OA models respectively. With a tight monetary policy, fiscal transfers have a low expansionary effect on consumption, with impact multipliers slightly positive but with a dynamic response negative from the second quarter. This implies that to have a strong response of aggregates to fiscal policy, monetary policy should not react in the opposite direction.

Figure 8: IRFs of Macroeconomic Variables to a progressive/non-progressive Fiscal Transfer Shock in SW-OA model, tight Monetary Policy.

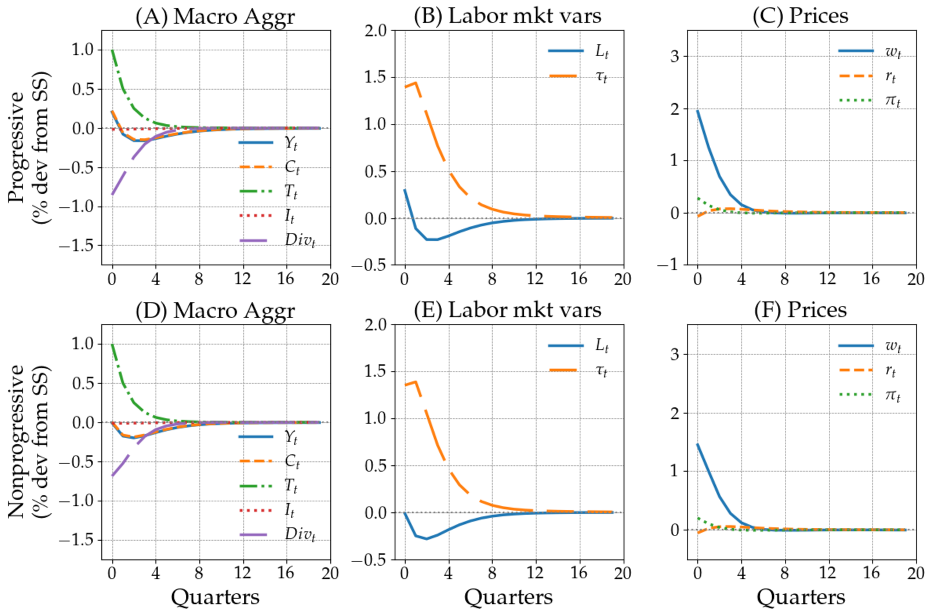


Figure 9: IRFs of Macroeconomic Variables to a progressive/non-progressive Fiscal Transfer Shock in SAM-OA model, tight Monetary Policy.

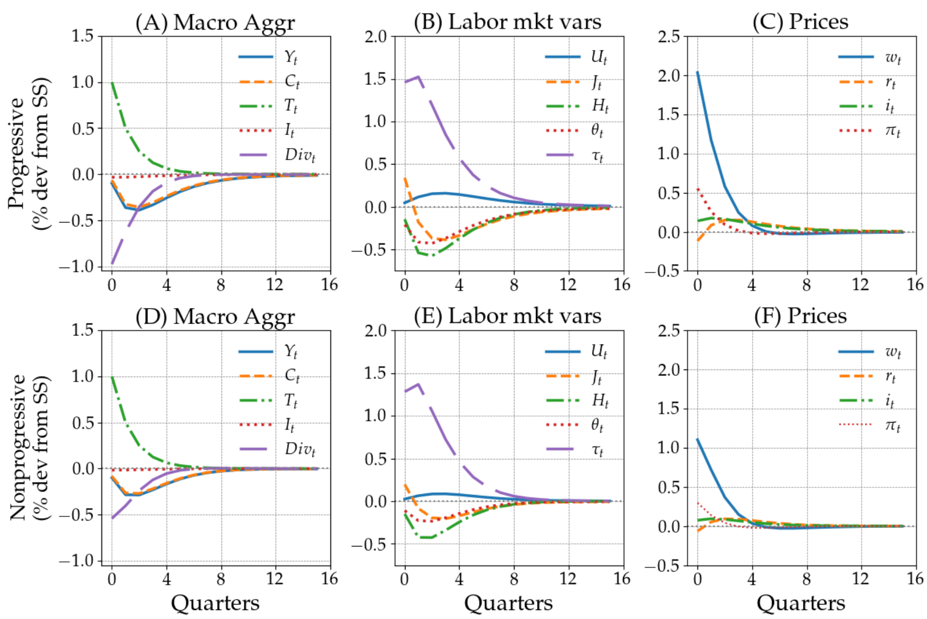
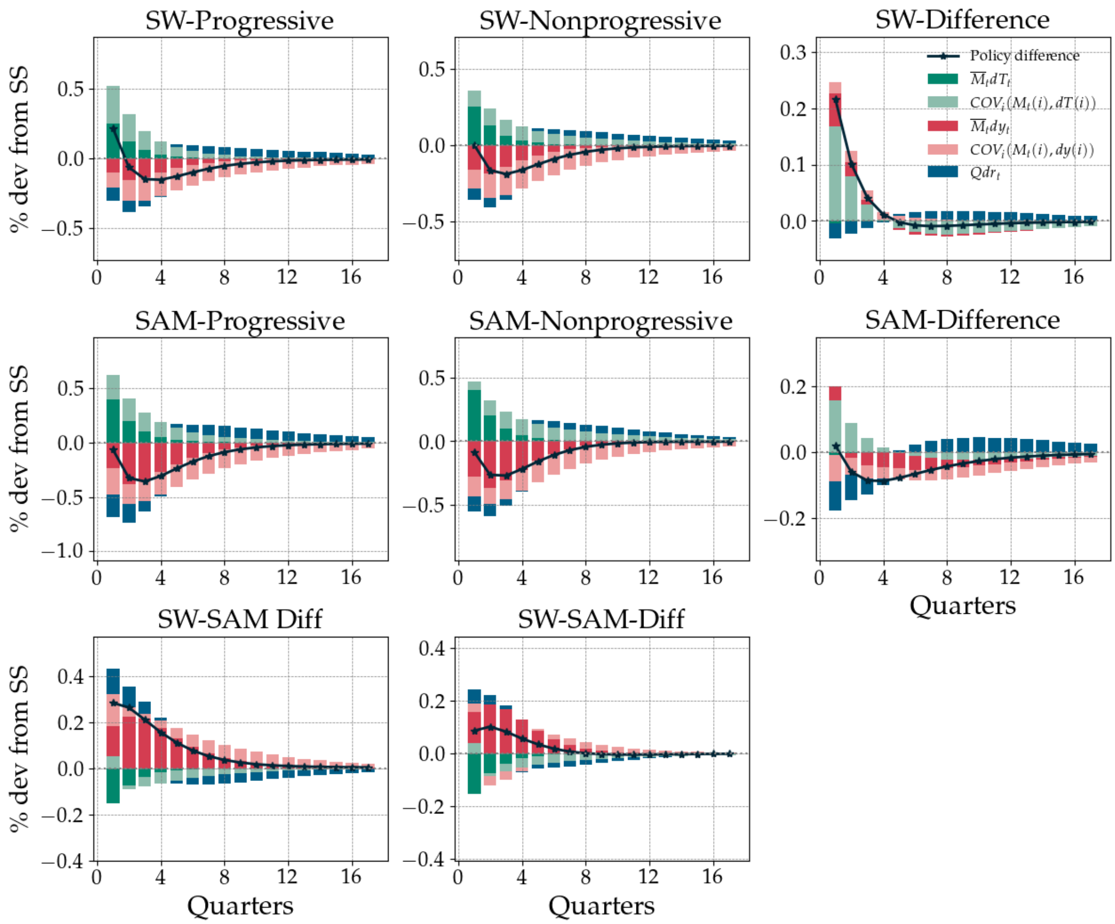


Figure 10 displays the decomposition in this case. It shows a similar result we had before. In this case, we also find that cross-sectional effects are stronger in SW-OA than in SAM-OA, while the average effects are stronger in the SW-OA. Finally, the effect of the interest rate is very similar in both settings, with again, the SAM-OA being stronger than in SW-OA.

Figure 10: Consumption Decomposition, SW and SAM Model



6 Comparing SW-OA with SW-TA HANK

Recent literature emphasizes the importance of the asset structure for monetary policy (see Kaplan et al., 2018 and Luetticke, 2019), in particular on the role of assets liquidity for the transmission of monetary policy shocks and the generation of high marginal propensities to consume. They argue that having only a liquid asset does not generate the MPCs we observe in empirical analyses, and a way to generate them is to split total household wealth into liquid and illiquid assets.

In particular, Kaplan et al. (2018) conclude that when considering two assets, the transmission of monetary policy substantially changes; this is, there is a more prominent role of the indirect effects from monetary policy shocks (those unrelated to the interest rate the monetary authority controls). However, in the previous section, we showed that a one-asset model with a fully illiquid asset works similarly to what is exposed by Kaplan et al. (2018). Therefore, in this section, we compare our OA-SW model described previously and a two-asset sticky wages model. We compare the response of consumption to monetary policy shocks, focusing on the transmission mechanisms. The idea is to establish the need to incorporate more complexity (a second asset) into an already complex model. First, we show the calibration of the SW-TA model and then compare this with the SW-OA model we analyzed above.

6.1 Calibration

Most of the calibration of the Two-Asset model is the same as the one-asset models described above. Nevertheless, in the SW-TA model, as the illiquid asset holdings are a choice, we must calibrate it accordingly. Therefore, two dimensions are left to calibrate in the SW-TA model. First, the parameter of the profits' distribution ϖ; and second the liquidity cost function

$$\Phi_t(a', a) = \frac{\phi_1}{\phi_2} \left| \frac{a' - (1 + r_t^a)a}{(1 + r_t^a)a + \phi_0} \right|^{\phi_2} \left|(1 + r_t^a)a + \phi_0\right|, \tag{12}$$

with ϕ_0 representing the absolute value of changing the portfolio, which generates an inaction zone for the deposits to the illiquid account; ϕ_1 controls the level of the cost of changing the portfolio which affects the marginal decision between investing in the two assets, and hence, determines the spread between the liquid and illiquid assets; and ϕ_2 which is the curvature of the cost. We set $\phi_2 = 2.03$, and calibrate ϕ_0 to match the share of wealthy hand-to-mouth according to Table 2. We obtain $\phi_0 = 0.01$. Then, we calibrate ϕ_1 to match the level of total illiquid assets according to Table 1. We obtain $\phi_1 = 8.05$. Finally, and similar to the previous section, we calibrate β, φ, and B to close the liquid assets market, the labor supply in $H = 1$, and the share of poor hand-to-mouth according to Tables 1 and 2. We obtain $\beta = 0.97$, $\psi = 0.7$, $B = 0.19$. The remaining parameter is ϖ, which we set (similar to Kaplan et al., 2018) equal to α.

Table 8 shows the MPCs implied in the SW-OA and the SW-TA models. On average, the SW-TA model has larger MPCs. Furthermore, note that MPCs decline much slower than in the SW-OA model. Note also that the lower quintile has a slightly lower MPC in the SW-TA than in the SW-OA. As a result, MPCs are flatter in the SW-TA model than in the SW-OA. This is due to the existence of wealthy hand-to-mouth in this model, which are households with relatively high income and illiquid wealth and without liquid assets.

Table 8: MPCs by quintile of the income distribution in SW-OA and SW-TA.

	Q1	Q2	Q3	Q4	Q5	Avg. MPC
SW-OA HANK	0.637	0.544	0.271	0.265	0.114	0.255
SW-TA HANK	0.593	0.524	0.479	0.335	0.2096	0.428

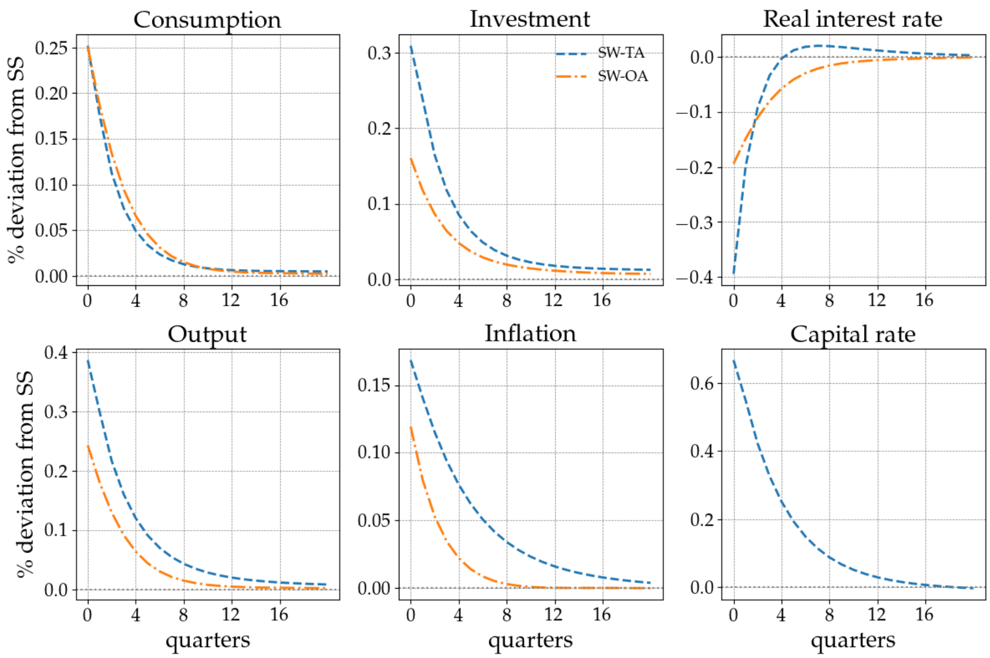
Note: The MPCs are expressed at a quarterly frequency.

6.2 Monetary Policy Shocks

Figures 11 and 12 show the impulse responses of the main macroeconomic variables to a monetary policy shock and the decomposition of the consumption response to a monetary policy shock. In this exercise, we calibrate the shock to have the same consumption response on impact in both models and the same remainder parameters. Figure 11 shows that the output response is stronger in the SW-TA model than in the SW-OA. The reason is the investment behavior because a fall in the nominal interest rate generates a boom in consumption and investment in both models, and the incentives to accumulate capital rise. Here we observe the main difference between the fully illiquid and the partially illiquid models: since in the SW-TA model households are allowed to accumulate capital actively as well, and it is a decision at an individual level, we observe a stronger response of investment than in the SW-OA for a given response of consumption. This is a key result from the SW-TA model, since for a given response of consumption there is also a higher output response, due to demand for investment. Additionally, the persistence of investment is higher in the SW-TA, even though the real interest rate recovers quickly; this result also arises from household decisions to accumulate illiquid assets.

Figure 12 shows the decomposition for both the SW-OA and SW-TA models. We decompose the consumption response into the liquid and illiquid interest rates (when this applies), and we call *direct* effect the response of the liquid interest rate. On the other hand, we define as indirect effects ($dy_t(i)$) the response of consumption to labor income (represented by wages, hours, and labor income taxes) and dividends. As above, we show the effects from the other income sources split into the average and the cross-sectional effects. We find insignificant differences between the response of consumption in both models. Even though investment is more persistent in the SW-TA model, this does not affect consumption dynamics (recall that we designed the exercise to have the same consumption response on impact in both models). However, we find that the transmission mechanisms are very different between SW-TA and SW-OA models.

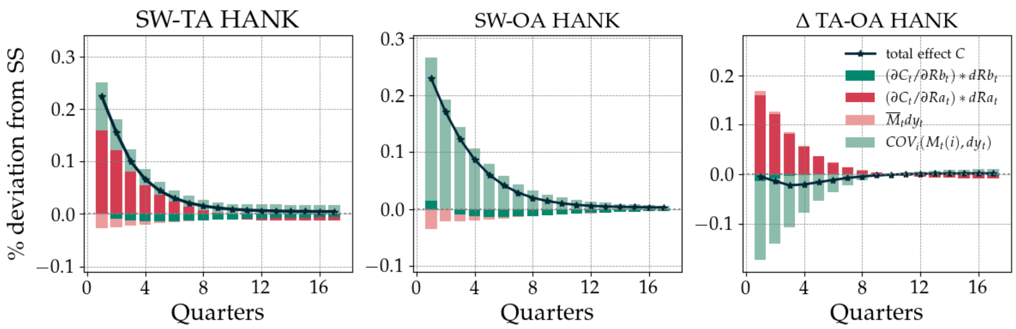
Figure 11: Effects of a Monetary Policy Shock: SW-OA vs SW-TA



As Figure 12 shows, we find that in the SW-TA model, most of the effect is due to the interest rate on the illiquid asset. The reason is that the response of the illiquid interest rate r_t^a increases significantly, mainly due to the rise in the return to capital. That effect gives a stronger rise in investment that expands output further than in the SW-OA. This latter effect makes the indirect effect of the indirect effect significantly lower than the effect on the interest rate. In Online Appendix G we show the same exercise for the case of low capital adjustment costs and that the transmission mechanism changes significantly. Thus, for the calibration for Chile, monetary policy also relies on the response of investment and the responses are mostly indirect through illiquid assets and cross-sectional effects.[12]

[12]The effects of an investment in HANK is also studied by Alves et al. (2020) that extend Kaplan et al. (2018) with capital adjustment costs and by Auclert et al. (2020) show that investment is key to the transmission mechanism of monetary policy in HANK.

FIGURE 12: IRF Monetary Policy Shock Decomposition



7 Conclusions

From a diverse set of administrative microdata for Chile, we document substantial heterogeneity in asset holdings, income sources, levels, and their cyclicality across the household income distribution. In particular, we show higher prevalence of hand-to-mouth households compared to the US, with greater income (and unemployment) risk. Additionally, we show that the income of lower quintile households is more responsive to shocks than for higher quintiles.

Considering those facts, we build–and calibrate to Chilean data– different Heterogeneous Agents New Keynesian models to study the transmission mechanisms of fiscal and monetary policy shocks through consumption.

First, we compare labor market setups. We find that specifications with SAM feature larger MPCs, which leads to more significant direct effect of fiscal policies than in a sticky wages model specification. Additionally, the SAM specification's higher average MPCs lead to higher overall response to transfers, where the average response dominates the cross-sectional effects. Facing monetary shocks, we show that the cumulative response in a SAM specification is larger for a shock calibrated to generate the same consumption response on impact. We attribute this difference to a cross-sectional effect of the monetary policy shock that operates through unemployment, which is persistent in SAM and absent in the sticky wages specification. Second, we study different financial markets setups, in particular, the role of assets liquidity. We find that for our calibration, the differences between the SW-TA and the SW-OA specifications come from the accumulation of illiquid assets. In the two assets specification, we find an additional source of capital stock persistence coming from illiquidity costs that propagates into labor income and to the rate return to capital. This leads to a redistribution between capital and labor where, when capital goes up, shocks are amplified.

This paper is part of an ongoing effort at the Central Bank of Chile to understand consumption dynamics and identify the most critical elements within the HANK toolkit. Further research avenues include incorporating open economy considerations and expanding labor market features, given their key role in driving consumption fluctuations within HANK models. Additionally, analyzing the role of heterogeneity in consumption across different goods during business cycles remains an open question.

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Transmission Mechanisms in HANK: an Application to Chile

Benjamín García Mario Giarda Carlos Lizama Ignacio Rojas

Online Appendix

A Assets decomposition, different Data Sources

Liquid				Illiquid				Total
		EFH	CMF			EFH	CMF+CBC	
	Banking Credit Cards	-0.011	-0.0322	Net housing	Net Primary House	0.898	1.93 (-0.251)	
	Banking Credit Lines	-0.003			Net Other House	0.384		
	Banking Consumption Credits	-0.027	-0.0795					
Revolving consumer debt	Non-Banking Credit Cards	-0.005						
	Non-Banking Consumption Credits	-0.003						
	Cooperative Credits	-0.005						
	Other Loans	-0.003	-0.008					
		-0.06	-0.12			1.282	1.93	
Deposits		0.01	0.05					
	Bonds	-	0.012					
Fixed income	Saving Accounts	-	0.105					
	Saving Insurance	-		Net durables	Net Cars	0.106		
	Other	-			Other Real Assets	0.022		
		0.056	0.12			0.128	0.128	
	Shares	-	0.003					
Equity	Mutual Funds	-	0.07					
	Other	-						
	Investment Funds	-	0.044	AFP		0.187	0.722	
		0.083	0.114					
APV		-						
Education Loans		-0.014						
Total		0.08	0.164			1.597	2.06	2.23

Table 1: Values are expressed as a fraction of 2017 GDP.

B The Household Finance Survey (EFH)

The Household Finance Survey (*Encuesta Financiera de Hogares*) - EFH - is a national waves survey carried out every 3 years by the Central Bank of Chile. The latest waves are from years 2011, 2014, 2017 and 2021 (due to COVID reasons it had to be delayed one year). The EFH aims to characterize the financial balance of chilean households. Specifically, the survey inquires on the position of the household's savings, debts, income, financial assets, use of means of payment, accessibility to the financial system, among others[1].

The survey identifies the Head of each household, collapsing all information the rest of the members on her/his answers. We identified that household, where the Head of it is less than 22 years old are mostly students, the majority of them with financial assistance from a family member, thus they do not fit into the scope of our analysis (they belong to a household that we do not possess information about). The other group we left out are the ones where the Head of the household is older than 79 years. The reason of exclusion follows the same spirit of the younger ones. The majority of these households receive some form of aid from their sons and/or daughters, making the analysis bias (we do not have information about the earning, debt and assets of the other households).

The survey contemplate questions regarding the labor, pension income, government transfers, subsidies, all treated as income. There are households whose main labor income is reported as self-employment. When analysing the current month income in annual terms and the last year income there are significant differences. As we can not identified the real income of these households we decided to remove them from the analysis[2].

On the side of the household's wealth, the survey identifies well the debt and assets positions. On the one hand, this survey ask about the accessibility to credit cards and the amount percentage of the disposable credit used (currently and in the last year). Additionally, there are questions about each household's member loans position. On the other side, there are several questions about the amount of disposable money in the bank accounts (the survey asks about the current amounts as well as the mean of the last year) and the amount not targeted to be used to pay bill in the current month. Additionally, there are several questions regarding the financial assets holdings.

C Obtaining the Shares of Hand-to-Mouth and robustness analysis

In the current appendix we discuss the construction of the share of Hand-to-Mouth using the *Encuesta Financiera de Hogares 2017 (EFH 2017)*. There is a newer version of this survey (EFH 2021), however, we stick to 2017 wave due to the allowance of the pension funds withdrawals taken during 2020 and 2021 to face the impact of the COVID-19 pandemic. As consequence of the aforementioned

[1]This survey follows the oversampling of wealthier urban households and is representative of the sub-populations at the macro-zone level.

[2]Also as doing this we are been consistent with the labor income definition used in section 2.3.

Table 2: Shares of HtM

Asset def.	Illiquid Assets def.	Share of HtM Poor	Rich	Total	Asset def.	Illiquid Assets def.	Share of HtM Poor	Rich	Total
	Principal Home	0.14	0.29			Principal Home	0.12	0.27	
SR wo. E	All Real Estates	0.12	0.31	0.43	12m Saving wo. E	All Real Estates	0.11	0.28	0.39
	Real Estates & Durables	0.08	0.35			Real Estates & Durables	0.08	0.31	
	Principal Home	0.14	0.30			Principal Home	0.12	0.28	
SR w. E	All Real Estates	0.12	0.32	0.44	12m Saving w. E	All Real Estates	0.11	0.29	0.40
	Real Estates & Durables	0.08	0.36			Real Estates & Durables	0.07	0.33	

measures at that point in time Households kept an unusual amount of liquid Assets compared to any other time analyzed.

The EFH 2021 contains question regarding the Household's Asset stock, income, present valued debt, access to the financial market, among others. All Assets and debt is aggregated in the head of the Household answers. Table 10 is constructed using three common assumptions to construct the share of HtM.

First of all, we kept only the self-identified Head of the Household. The second common assumption is to eliminate all Households, where the Head of it is younger than 22 years old and the ones older than 79 years old. Finally, we drop all IDs where it is reported to have received a negative income.

There is a last assumption on the Entrepreneurs population on the survey (it makes to vary the remaining total Households in tha sample). There are Households who report to been entrepreneurs as their primary source of income. The first option we made is to drop them out of the sample, as their reported income may be not representative of the gross annual income due to the volatile nature of some entrepreneurs. The definition under this assumption is presented in the top panel of table 2 (expressed as wo. E). The bottom panel of the table shows the shares of HtM Households made under a softer measure of the dropped Entrepreneurs, we only drop a Household, that do not report the income (presented as w. E).

Focusing on the Asset holding, we added up all self-reported net values of the Asset, such as, Deposits, Fixed Income Assets[3], the Equity Assets[4], net of the reported debt[5]. This way to sum up the net liquid Asset holding is presented in the left hand panel in table 2 under the label of self-reported (SR). There is an additional check it can be made. The EFH 2017 contains an additional

[3]Correspond to the total amount households have invested in different instruments such as time deposits, bonds, savings accounts, and insurance with savings.

[4]The sum of investments in shares, investments in mutual funds, participation in companies or investment funds, and investments in other equity instruments (options, futures, swaps, among others).

[5]Bank credit cards, lines of credit, bank or financial consumer loans, credit cards from non-banking institutions, consumer loans in commercial houses (cash advances), credits in savings banks compensation, cooperatives or other similar, educational loans, and other non-mortgage debts.

question regarding the saves made by the Household during the 12 months to the survey. Thus, it is possible to correct one last time the possible misreporting of the liquid Asset holding described above. The aforementioned replacement is presented in the right-hand side of table 2 under the *12 m Saving* label.

Finally, there are three different ways in which the illiquid Assets can be grouped. The first definition used in the analysis was to considered only the net valuation of th principal Home as the illiquid Asset holding - presented in the top panel of each subcategory -, then we used the possession of all real estates net valuation (the middle panel of each subcategory). Finally, we considered all real estates plus the reported durables Assets net of their debt as the illiquid Asset holding (the bottom panel in each subcategory explained before).

The preferred subcategory to Measure the HtM Households of the chilean economy is the 12m Saving wo. Entrepreneurs, take as the illiquid Assets all Real Estates plus Durables. It allows to correct the possibility of misreporting and takes into account all material Assets outside of the finacial markets.

C.1 Robustness Analysis

Table 3: Dichotomic Share of HtM

	No Sav. last 12m	No CC possession	No Checking Acc.	No Cred Line Acc.	No CLA, CC nor NBCC
wo. E	0.3646	0.3677	0.0835	0.3502	0.1791
w. E	0.3744	0.3792	0.0854	0.3614	0.1846

As discussed above the measure of HtM Households may vary depending in the assumptions one follows when constructing the ratio. We created some dichotomic based shares of HtM to have a bottom (soft) estimate of the ratio. The EFH 2017 contains questions about the availability of some financial instruments and if the people in it were able to save any amount during the last 12 months. We looked at the ratio of the Households under both Entrepreneurs assumption, whether it possess some financial instruments, such as Banking Credit Card, Checking Account, Credit Line Account and any of the aforementioned instruments. Additionally, we obtained the ratio of Households that reported to have save any amount during the last 12 months prior to the survey. The results are presented in table 3.

Table 3 shows some interesting facts. First of all the ratio of Checking Account availability in the chilean economy is much wider than any other ratio considered in the analysis is due to Government policy of managing via Banco Estado - a Commercial Bank with Government ownership - to have available to any 18 years old citizen a Checking Account with a limit to have in it. Thus, there should be no friction in the accessibility to this specific financial instrument.

Table 4 presents the average of the ratio between the instrument limit given by the financial system and the quarterly income of the entire Household. The three analyzed instruments show that the amount given to the Households does not cover them for a large period of time. The available level of credit covers less than two months of income in case of losing a job on average terms. This ratio is considering the ideal case, where the limit is at full disposal. A better way to get the constrained Household that have a financial instrument to their disposal is presented in table 5.

Table 4: Financial instrument limit as quarterly income (ratio)

	Credit Cards	Credit Lines	No banking CC
wo. E	0.6819	0.4604	0.5808
w. E	0.6795	0.4857	0.5678

Table 5 shows two different measure of a soft HtM ratio. The first measure are those Households that have all their available credit used (in the respective financial instrument). If we take the Total column this share of HtM Households is around 0.25, to obtain the amount of HtM in the aggregate level it is necessary to add the 0.18 of those Households that do not have any financial instrument (presented in the last column of table 3), what give us that this soft HtM measure is around 0.43. Once again near the shares obtained in the principal analysis.

Table 5: Spare amount in Credit Cards as HtM Measures

	Banking CC	Non-Banking CC	Total
No amount available to be used	0.258	0.282	0.25
Less than 15% of quarterly income to spare	0.441	0.598	0.476

D Tables and Figures

D.1 Empirical

Finally, Table 6 in the Appendix compares the income risk moments between Chile and the U.S. at an annual frequency. In Chile, income inequality is 50% larger than in the U.S., measured as the variance of the log of earnings. Income volatility is higher as well as measured by the variance and the kurtosis of the changes of the log labor earnings. The variance of one and five-year growth in Chile are twice as large as the ones in the U.S., a similar phenomenon happens with the kurtosis which is larger for the U.S. than for Chile, meaning that the probability of receiving a shock in the U.S. is significantly lower than in Chile. These facts are consistent with previous evidence that the labor market in Chile is significantly more dynamic than in OECD countries, Albagli et al. (2017).

Moments	United States	Chile (Full sample)	Chile (Sub-sample)
Variance: log earns	0.70	1.14	1.12
Variance: 1-year change	0.23	0.53	0.48
Variance: 5-year change	0.46	0.88	0.82
Skewness: 1-year change		0.00	-0.14
Skewness: 5-year change		-0.02	-0.14
Kurtosis: 1-year change	17.8	6.80	7.47
Kurtosis: 5-year change	11.6	5.15	5.68

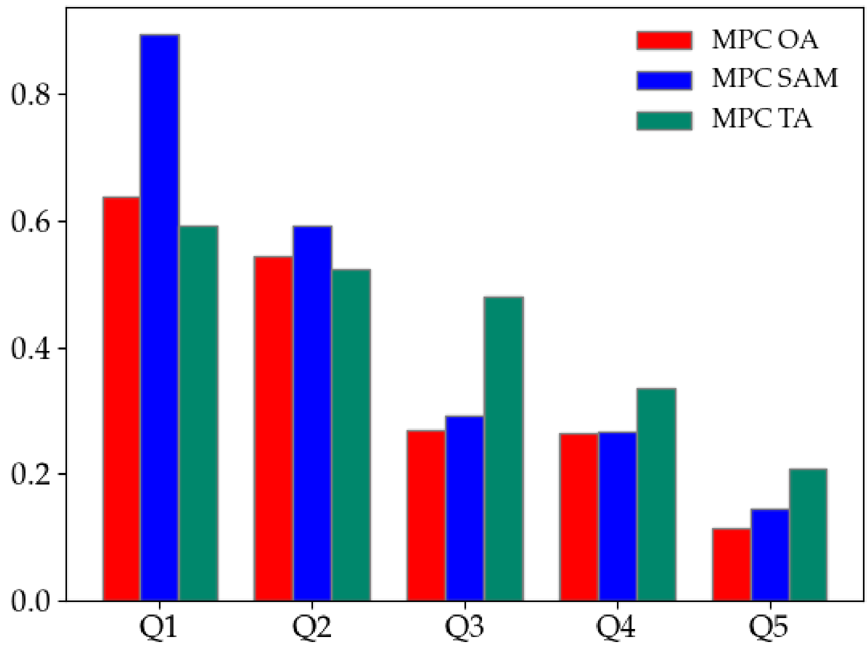
Table 6: Empirical moments for earnings in United States and Chile at annual frequency.

Moments	Full sample	2014-2019
Variance: log earns	0.70	0.69
Variance: 1-qtr chg.	0.21	0.18
Variance: 1-year chg.	0.30	0.26
Variance: 5-year chg.	0.49	0.43
Skewness: 1-qtr chg.	0	-0.07
Skewness: 1-year chg.	0	-0.11
Skewness: 5-year chg.	0	-0.06
Kurtosis: 1-qtr chg.	10.15	11..69
Kurtosis: 1-year chg.	8.47	9.63
Kurtosis: 5-year chg.	5.69	6.45

Table 7: Empirical moments for earnings in Chile at quarterly frequency. All workers.

D.2 Figures of Section 5

FIGURE 1: MPCs Comparison



E Details of the model

E.1 Firms

Intermediate firms solve:

$$
\begin{aligned}
J_t(p_{jt-1}) = & \max_{y_{jt},p_{jt},k_{jt},n_{jt}} \left\{ \frac{p_{jt}}{p_t} y_{jt} - h_t n_{jt} - r_t^k k_{jt-1} - \frac{\mu_p}{\mu_p - 1} \frac{1}{2\kappa_p} \left[\log(1+\pi_{jt})\right]^2 y_{jt} + \frac{J(p_{jt})}{1+r_{t+1}^a} \right\} \\
\text{s.t.} \quad & y_{jt} = Z_t k_{jt-1}^{\alpha} n_{jt}^{1-\alpha}, \\
& y_{jt} = \left(\frac{p_{jt}}{p_t}\right)^{-\frac{\mu_p}{\mu_p-1}} Y_t.
\end{aligned}
$$

The first-order conditions, after symmetry, read

$$\log(1+\pi_t) = \kappa_p \left(mc_t - \frac{1}{\mu_p} \right) + \frac{1}{1+r^a_{t+1}} \frac{Y_{t+1}}{Y_t} \log(1+\pi_{t+1})$$

$$h_t = (1-\alpha) mc_t \frac{Y_t}{N_t}$$

$$r^k_t = \alpha\, mc_t \frac{Y_t}{K_{t-1}}$$

where mc_t is the marginal cost.

E.2 Mutual Fund

The mutual fund solves the following problem:

$$A_0 := \max_{\{K_{s+1}, I_s, X_{s+1}\}} \sum_{s=0}^{\infty} \left(\frac{1}{1+r^a_s} \right) \left[r^k_t K_t - I_t - \Gamma(K_{s+1}, K_s) + \varpi \Pi_s X_s - q^x_s((1+r^a_s) X_{s+1} - X_s) \right]$$

$$\text{s.t.} \quad K_{s+1} = (1-\delta) K_s + I_s$$

where $\Gamma(K_{t+1}, K_t) = \frac{1}{2\delta\epsilon_I} \left(\frac{K_{t+1} - K_t}{K_t} \right)^2 K_t$

The first-order conditions with respect to capital, investment, and stocks are:

$$(1+r^a_{t+1}) q^k_t = r^k_t - \left[\frac{K_{t+1}}{K_t} - (1-\delta) + \frac{1}{2\delta\epsilon_I} \left(\frac{K_{t+1} - K_t}{K_t} \right)^2 \right] + \frac{K_{t+1}}{K_t} q^k_{t+1}$$

$$q^k_t = 1 + \frac{1}{\delta\epsilon_I} \left(\frac{K_{t+1} - K_t}{K_t} \right)$$

$$q^x_t = \frac{(1-\varpi)\Pi_{t+1} + q^x_{t+1}}{1+r^a_{t+1}}$$

E.3 Sticky Wages

We assume households cannot decide their labor supply directly. Instead, there is a union that supplies aggregate labor. In each household i there is a continuum of tasks denoted by $g \in (0,1)$. A task-specific union decides nominal wages W^g_t for an amount of hours N^g_t. In this setting, unions have market power as workers' tasks are in monopolistic competition. The union aggregates individual labor such that $N^g_t = \int n^g_t(\boldsymbol{s}) d\boldsymbol{s}$. Then, we assume there is a Dixit-Stiglitz aggregator that determines aggregate labor, given by:

$$N_t = \left(\int_0^1 (n^g_t)^{\frac{\varepsilon_w - 1}{\varepsilon_w}} dg \right)^{\frac{\varepsilon_w}{\varepsilon_w - 1}},$$

where ε_w is the elasticity of the demand for labor tasks, which is also a measure of the market power of the union. The Dixit-Stiglitz aggregator gives rise to the following demand for each task g:

$$n_t^g = \left(\frac{W_t^g}{W_t}\right)^{-\varepsilon_w} N_t.$$

We assume nominal wages are sticky and their changes are subject to Rotemberg adjustment costs in logs. The problem of the union is to the nominal wage and the wage inflation rate by solving:

$$U(w_{gt-1}) = \max_{n_{gt}, w_{gt}} \int (u(c_{it}) - v(n_{it})) \;\; d\Psi_t(\boldsymbol{s}) - \frac{\mu_w}{\mu_w - 1}\frac{1}{2\kappa_w}\left[\log(1+\pi_{gt}^w)\right]^2 N_t + \beta U_{t+1}(w_{gt})$$

$$s.t.$$

$$n_{gt} = \left(\frac{w_{gt}}{w_t}\right)^{-\frac{\mu_w}{\mu_w - 1}} N_t$$

$$\pi_{gt}^w = (1+\pi_t)\frac{w_{gt}}{w_{gt-1}} - 1.$$

This setup leads to a wage Phillips curve in the main text, (5).

E.4 Government

The government, in our setting, allocates its spending between government consumption G_t, fiscal transfers to households $f_t(z)$, and unemployment benefits. Transfers are heterogeneous across households and can be progressive $f_t'(z) < 0)$, $f_t'(z) > 0$, or flat $f_t'(z) = 0$. The way transfers are distributed across households satisfies $\int f_t(z)\Psi(\boldsymbol{s})d\boldsymbol{s} = T_t$, where T_t denotes the aggregate amount of transfers. The government finances its spending by issuing real-denominated debt B_t^g and by levying taxes on labor income, τ_t. Government debt is held by households in their liquid account and pays the return r_t^b.

Transfers are lump-sum in the sense that households take these as given and do not enter the first-order conditions. However, they affect optimal decisions due to market incompleteness.

The government's budget constraint is then given by

$$B_{t+1}^g = T_t + G_t - \tau_t w_t N_t + (1 + r_t)B_t^g.$$

The evolution of the fiscal balance depends on a smoothing parameter ρ_x, which determines to what extent additional spending is financed with debt according to:

$$\Delta B_t^g = \rho_x(\Delta B_{t-1}^g + \Delta X_t) \tag{1}$$

where X_t can be T_t or G_t, where the steady-state level of debt is determined in the market for bonds where households participate with their savings. The fiscal balance rule in equation 1 captures the fact that governments do not necessarily raise taxes to finance additional spending, as they can also issue more debt. Naturally, the government financing strategy is key for characterizing consumption dynamics as the Ricardian equivalence does not hold in these models.

F Response to a Monetary shock in SW-OA v/s SAM-OA

It is also useful for us to compare the different settings analyzing monetary policy shocks. Figure 2 shows the response of aggregate variables to a monetary policy shock in the calibration we used before. However, we calibrate the size of the monetary policy shock to generate the same response of consumption on impact we observe in both models. We do that to study the transmission mechanism of the shock more closely. The first we find is that due to the nature of the frictions we have in both models, inflation is more responsive in SW-OA than in SAM-OA. This is because of the stronger price rigidity wage rigidities generate. Also, we have that investment responds more strongly in the SAM-OA than in the SW-OA. That is due most likely to the stronger response of marginal costs that is positively related in this model to the return to capital.

Figure 3 shows the decomposition of consumption to the monetary policy shock in two terms, the direct response to the interest rate given by the dark-green bar, the average-indirect in dark-red and the cross-sectional indirect in light-red. We can mention several results from this plot. First, that the direct effects are very similar, accounting for a small portion of the total effect on impact. Second, from all of the indirect effects, the cross-sectional term is what drives the expansion in consumption. We observe that the average responses of income (labor income and income from dividends) go down, whereas the cross-sectional effect counteracts that. This is, monetary policy operates in this case in both models through the cross-sectional effect. The third result relates to the difference between SW-OA and SAM-OA, where the former has a more persistent response, which is mainly due to the persistence of employment this model has.

Overall, we find that, unlike the case of a fiscal transfer, a monetary policy shock has a similar transmission mechanism in both models. This means that properly calibrated, we can use both of them for the analysis of the transmission of monetary policy shocks.

Figure 2: IRF Monetary Policy Shock

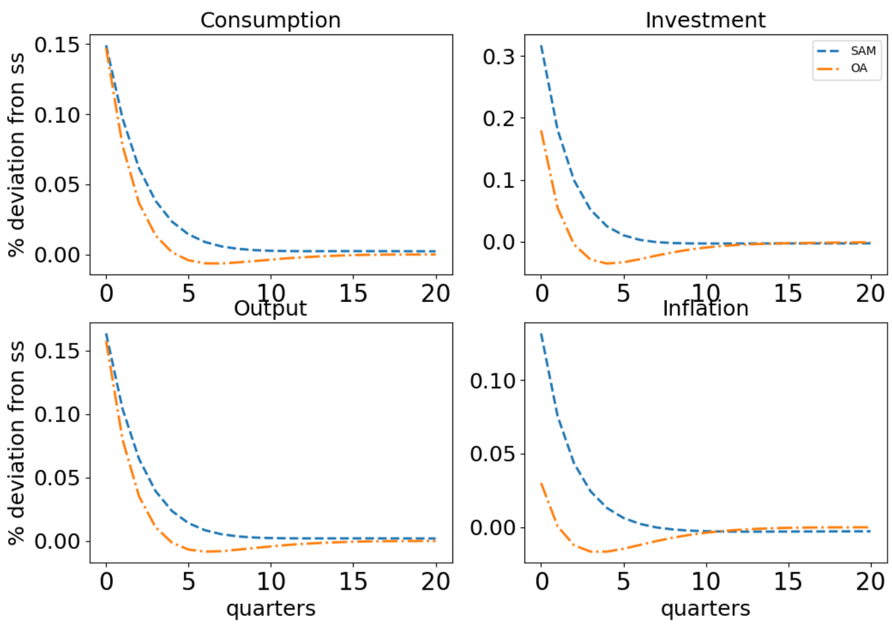
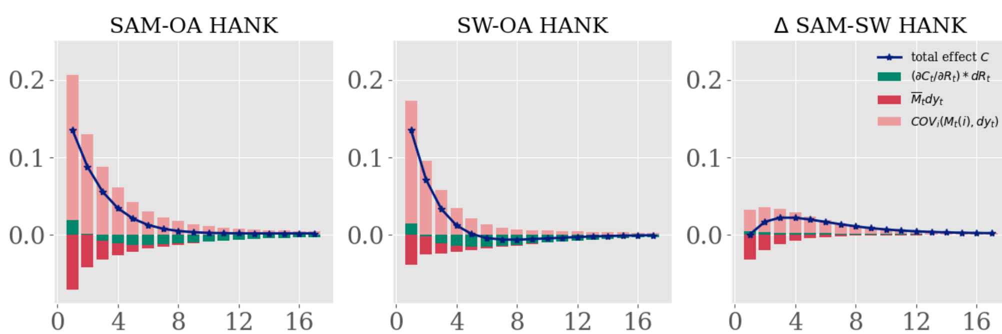


Figure 3: IRF Monetary Policy Shock Decomposition



G The Role of Investment in the Monetary Transmission in SW-OA and SW-TA

Figure 4 shows the comparison between SW-OA and SW-TA varying the parameter of capital adjustment costs function from high cost ($\epsilon^I = 0.5$) to low cost ($\epsilon^I = 6$). Notice that in this case, we observe a very different investment response, while again it is stronger in the SW-TA than in the SW-OA due to the endogenous illiquid investment. Additionally, the response of consumption changes significantly, which is due to the higher income generated by a higher–and more persistent–capital. Capital takes a few quarters to increase and generate higher wages and dividends, which is the reason for the more persistent consumption response.

FIGURE 4: IRF Monetary Policy Shock SW-TA v SW-OA, $\epsilon^I = 6$

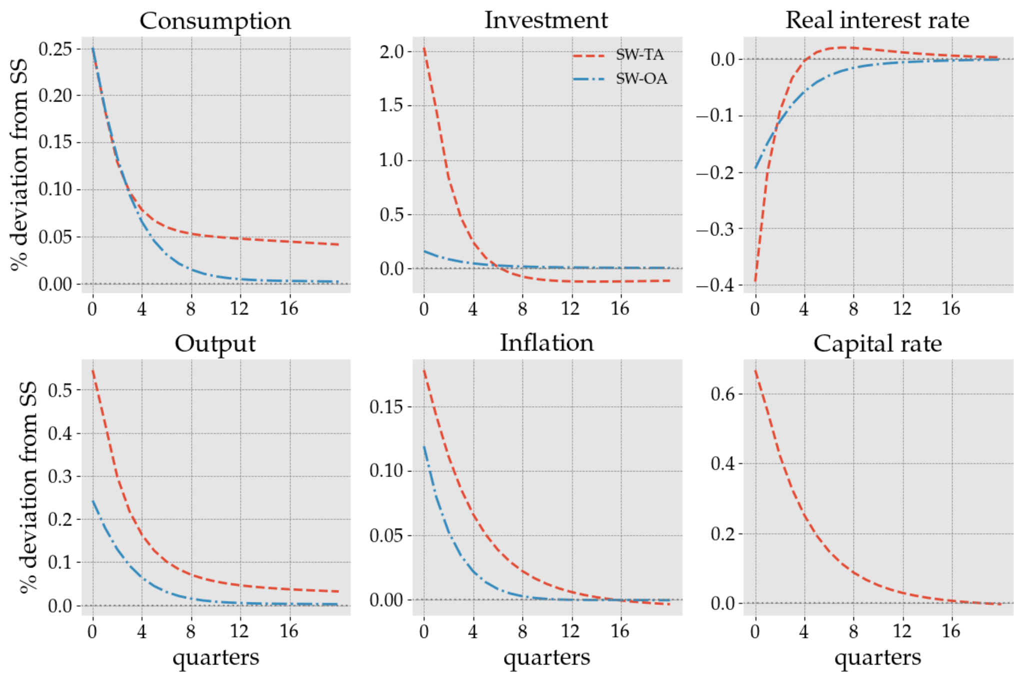
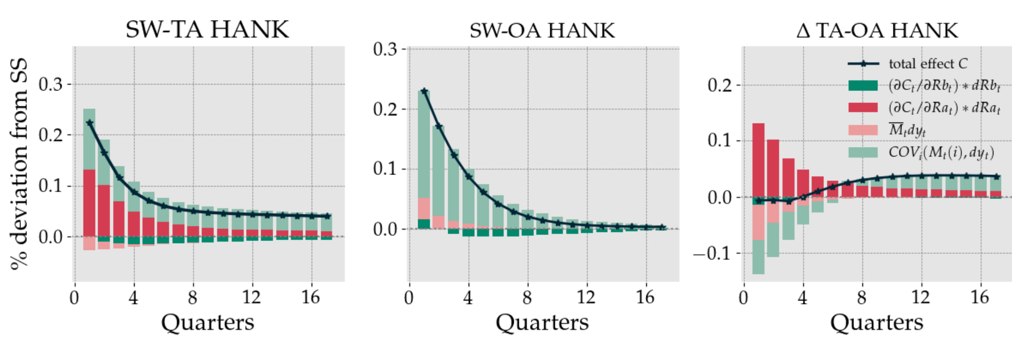


Figure 5 shows the decomposition for the case of low capital adjustment costs. The figure shows that the consumption response is now due more to the response of income, particularly the cross-sectional effect. We also observe that the effect of the illiquid interest rate is still strong but milder than with higher capital adjustment costs.[6]

FIGURE 5: IRF Monetary Policy Shock Decomposition, $\epsilon^I = 6$



[6]The effects of investment in HANK is also studied by Alves et al. (2020) that extend Kaplan et al. (2018) with capital adjustment costs and by Auclert et al. (2020) show that investment is key to the transmission mechanism of monetary policy in HANK.

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