

Accounting for Consumption Persistence in Response to Fiscal Transfers in Small Open Economy DSGE Models*

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Abstract

Building on [Bilbiie \(2024\)](#), we introduce household income risk into a small open-economy DSGE model in which households can self-insure using both liquid and illiquid assets. This lets us calibrate our model, with an otherwise standard TANK structure, to match the empirically consistent intertemporal marginal propensities to consume (iMPCs) implied by a fully fledged HANK model. We then include this mechanism into a medium-scale DSGE model estimated for the Chilean economy to study consumption dynamics during the COVID-19 period, when fiscal support to households was historically large. We show that the model is able to endogenously account for the persistent consumption dynamics observed in the Chilean data following the transfers, without resorting to exogenous, ad hoc demand shocks.

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1 Introduction

The fiscal response to the COVID-19 pandemic in most countries, motivated by the lockdowns, was unusually large. In particular, in countries like Chile, the fiscal help was delivered mostly through transfers to households. The Chilean government provided direct transfers and three rounds of private pension fund withdrawals, putting resources equivalent to 30% of annual GDP into households within a few quarters; private consumption rose 20% in 2021 and then fell back. Understanding that episode, i.e., how much of the consumption boom and of the subsequent inflation can be attributed to fiscal transfers, requires a quantitative model disciplined by the data. However, the models that central banks use for projections and policy analysis are of the two-agent New Keynesian (TANK) type. In those models, the response of consumption to transfers is mechanical: non-Ricardian households (who are hand-to-mouth) spend the whole transfer on impact, and Ricardian households spend only its annuity value. The implied intertemporal marginal propensities to consume (iMPCs) are therefore front-loaded, which, as ([Auclert et al., 2024](#)) show, is inconsistent with the empirical evidence of a high initial response that decays smoothly over the following periods (see [Fagereng et al., 2021](#)). Given that mismatch, when using a TANK model to explain consumption fluctuations over 2020–2021, it attributes a large share of fluctuations to residual autonomous consumption shocks, which limits the model’s insights about fiscal transfers.

In this paper, we follow [Bilbiie \(2024\)](#) and introduce empirically consistent iMPCs into a small open economy dynamic stochastic general equilibrium (DSGE) model. We show that including these alternative iMPCs changes the reading of the Chilean COVID-19 episode. We extend a [Galí and Monacelli \(2005\)](#) model by including physical capital, a share of financially constrained households, and wage rigidities. Following [Bilbiie \(2024\)](#), we assume households jump stochastically between the Ricardian and the non-Ricardian state, so that Ricardian households face a probability of losing access to financial markets in the next period. This is the tractable heterogeneous-agent New Keynesian (THANK) structure proposed by [Bilbiie \(2024\)](#), which delivers a precautionary savings motive as in heterogeneous-agent New Keynesian (HANK) models like [Kaplan et al. \(2018\)](#) or [Auclert et al. \(2024\)](#). However, this extension keeps the model linear, so we can solve it at the scale of a policy model. We depart from [Bilbiie \(2024\)](#) in that households can self-insure not only with liquid assets –domestic and foreign bonds– but also with illiquid physical capital, of which only a fraction can be liquidated when the household switches state, in the spirit of the two-asset

structure of [Kaplan et al. \(2018\)](#). Thus, the Euler equations for bonds and the first-order condition for capital are both modified by the switching probability. The second extension is to discipline the model with the empirical iMPCs. We use the fact that the MPC is a partial-equilibrium object in the sense that it is the response of consumption to a raise in income, all else equal. So we extend the model with a partial-equilibrium version of the household so we can estimate (and target) the iMPCs along with the rest of the model by feeding the model a one-time, unexpected transfer shock to that block. These iMPCs are a function of the share of non-Ricardian households, the probability of remaining Ricardian, the wage gap between households, and the liquidity cost of capital. We pin down these parameters by system priors following [Andrle and Benes \(2013a\)](#). That exercise delivers an accounting of where each additional unit of income goes: to consumption, investment, or savings, as in the two-asset HANK of [Luetticke \(2021\)](#).

Our main results can be summarized as follows. First, the calibrated THANK block reproduces an iMPCs path that is large on impact and decays smoothly over the subsequent periods. This contrasts with the TANK iMPCs, which is large on impact and close to zero afterward. The intuition is as follows. When households receive a transfer, non-Ricardian households consume it at once, which explains the high impact response in both models. However, in the THANK model, Ricardian households anticipate that they may lose access to financial markets, so they save part of the windfall. In every subsequent period, a fraction of them switches state, bringing their assets to the non-Ricardian state and consuming those resources due to their hand-to-mouth behavior. Hence, constrained households' consumption continues to respond for several quarters after the shock, and the aggregate iMPC inherits a smooth decay that a TANK model cannot generate. Second, the precautionary motive has implications for the steady state. The liquid interest rate is lower due to the wedge between the marginal utilities of the two states, and the illiquid return depends in addition on the liquidity cost, i.e., the smaller the cost of liquidating capital, the more attractive capital becomes as an insurance device and the lower the return households demand to hold it. Finally, we embed the THANK block into the Central Bank of Chile's medium-scale DSGE model for projections and policy analysis (see [García et al., 2019](#) XMAS model). When we analyze consumption over the COVID-19 period in our model, we find that the historical decomposition of private consumption assigns a substantially larger role to transfers and pension withdrawals, and a correspondingly smaller role to autonomous consumption shocks than the original XMAS. The model with empirically consistent iMPCs tracks the paths of consumption, output, and core inflation well, so the improved identification of demand shocks does not come at the cost of fit.

This exercise shows that this THANK mechanism can be added to any medium-scale DSGE at very low cost, while retaining all the features these models need for macroeconomic forecasting and policy analysis.

This paper relates to three strands of the literature. The first is the literature on the iMPCs and its role in the transmission of fiscal policy. [Auclert et al. \(2024\)](#) show that the iMPCs are sufficient statistics for the response of the aggregate demand to fiscal policy. Additionally, [Kaplan et al. \(2014\)](#) and [Kaplan et al. \(2018\)](#) show that a two-asset structure with a liquid and an illiquid asset generate high MPCs among rich households. [Luetticke \(2021\)](#) uses that structure to study portfolio responses. Relative to these papers, we do not solve a full HANK model, we just extract the iMPCs implied by the HANK model for Chile of [García et al. \(2023\)](#) and match it with a tractable block embedded in a medium-scale policy model. Second, this paper relates the literature which studies the mechanisms of HANK models in tractable settings. [Bilbiie \(2008\)](#) and [Debortoli and Galí \(2017\)](#) show that a two-agent model captures much of the effect of heterogeneity on the transmission of monetary policy. Also, [Werning \(2015\)](#), [Ravn and Sterk \(2018\)](#), [Broer et al. \(2019\)](#), and [Bilbiie \(2024\)](#) show that adding idiosyncratic risk restores the precautionary motive and the amplification that TANK models miss. [Bilbiie \(2024\)](#) estimate this type of THANK model on U.S. data. Our contribution is to extend the THANK structure to a small open economy with physical capital that can be used as an insurance asset. Also, we show that the iMPCs can be an explicit calibration target rather than an outcome. Third, this paper is related to the literature on estimated DSGE models for policy analysis in emerging small open economies like Chile. XMAS ([García et al., 2019](#)) builds on [Medina and Soto \(2007\)](#) and on the New Keynesian core of [Christiano et al. \(2005\)](#) and [Smets and Wouters \(2007\)](#), and features non-Ricardian households as in [Galí et al. \(2007\)](#) and [Coenen et al. \(2013\)](#). We show that the household block of that model can be replaced by a THANK block at low cost. We conclude that doing so changes the sources of consumption fluctuations during an episode dominated by fiscal transfers.

The rest of the paper is organized as follows. Section 2 presents the small open economy THANK model, where we study the implications of income risk and illiquid insurance for the steady-state returns of liquid and illiquid assets, the partial equilibrium block of small households that defines the iMPCs in the model. Section 3 describes the calibration and compares the steady state with a TANK benchmark and the iMPCs, the intertemporal propensities to invest and save, and the general equilibrium response to a transfer shock. Section 4 shows the empirical application to consumption fluctuations around COVID-19 in the XMAS model. Finally, section 5 concludes.

2 A Small Open Economy Tractable HANK Model

The model builds on [Galí and Monacelli \(2005\)](#) extended with physical capital, a share of financially constrained agents, and a union that aggregates labor and supply this labor to firms. We introduce dynamic transitions between Ricardian and non-Ricardian household states, following [Bilbiie \(2024\)](#). This framework allows for a simple and tractable way to integrate household heterogeneity into linearized DSGE models, while retaining key mechanisms and insights from the more computationally intensive heterogeneous-agent New Keynesian (HANK) literature (e.g., [Kaplan et al. \(2018\)](#), [Auclert et al. \(2018\)](#)). In contrast to [Bilbiie \(2024\)](#) we allow for self insurance in liquid and illiquid assets.

In this section, we begin with a brief overview of the key features of the baseline model, and then provide a detailed description of the transition dynamics between Ricardian and non-Ricardian states and their implications for households' optimal decisions regarding consumption, saving, and investment. Finally, we outline our empirical strategy and present the estimation results.

2.1 Model overview

In our model, we assume there are two types of households (following [Galí et al., 2007](#)): Ricardian households, who have full access to financial markets, hold local and foreign bonds, and own firms and capital, and non-Ricardian households, who are out of the financial markets and consume their disposable income each period. Following [Bilbiie et al. \(2023\)](#), we add a probability of transitioning from the Ricardian to the non-Ricardian state, which generates income risk and precautionary motives. In the model, the labor market features a centralized union that chooses the aggregate wage on behalf of the households, subject to labor demand from intermediate firms. The union maximizes the weighted average utility differential between Ricardian and non-Ricardian, subject to the labor demand, as in [García et al. \(2019\)](#) and [Gertler et al. \(2008\)](#). It is important to note that the Union does not choose specific wages based on Ricardian or non-Ricardian status.

Domestic firms are subject to Rotemberg price adjustment costs, set prices in their own currency, and the law of one price holds. The price of exports is denominated in domestic currency, while the price of imports is denominated in foreign currency. Both Ricardian households and the government have access to risk-free assets denominated in domestic and foreign currency. The government budget encompasses expenditures on public consumption, investment, and transfers, which are financed through taxation and debt issuance. Fiscal policy follows a structural balanced

budget rule, whereby desired public spending is anchored to the government's long-term expected income. Monetary policy is conducted according to a standard Taylor rule, responding to output growth and to fluctuations of current and expected inflation.

The model features a limited number of shocks capturing firm productivity, external demand, fiscal and monetary policy shocks, as well as external shocks, such as changes in foreign demand, international interest rates, and to the UIP.

In what follows, we review the model's dynamic transitions between household states and examine their implications for the household optimization problem. Additional details on the model can be found in Appendix ??.

2.2 Household Income Risk and State Transitions

There is a continuum of infinitely lived households of two types: non-Ricardian and Ricardian, with mass ω_t and $1 - \omega_t$ respectively¹. Besides their differences regarding access to financial markets, we assume that non-Ricardian households do not have the possibility of investing in physical capital, and that they face an hourly wage of $w_t^{NR} = \alpha_t^w w_t^R$, with

$$w_t = (\omega_t)w_t^{NR} + (1 - \omega_t)w_t^R \quad (1)$$

$$\alpha_t^w = \alpha^w \left(\frac{y}{y_{ss}} \right)^{\eta^{wNR}} \quad (2)$$

As in [Bilbiie \(2024\)](#), households face a continuous risk of losing and regaining access to financial markets (i.e. switching between Ricardian and Non-Ricardian states). We denote by φ_t the probability of Ricardian agents staying as Ricardians (state R) and φ_t^* the probability of Non-Ricardians staying Non-Ricardians (state NR). Thus, $1 - \varphi_t$ and $1 - \varphi_t^*$ are the transition probabilities from R to NR and NR to R, respectively. The subscript t denotes the time-varying nature of these probabilities, accounting for the fluctuating nature of income risk. These transition probabilities can be represented as a Markov chain process:

$$\begin{pmatrix} \omega & 1 - \omega \end{pmatrix} \begin{pmatrix} \varphi_{t-1}^* & 1 - \varphi_{t-1}^* \\ 1 - \varphi_{t-1} & \varphi_{t-1} \end{pmatrix} = \begin{pmatrix} \omega & 1 - \omega \end{pmatrix}, \quad (3)$$

¹Throughout the paper, variables that are idiosyncratic to Ricardian and non-Ricardian households will be denoted with superscripts R and NR respectively.

Where ω and $(1 - \omega)$ represent the constant share of Ricardian and non-Ricardian households of the economy. As in Bilbiie (2024), the risk income introduced in the model follows a countercyclical behavior described by

$$\varphi_t = \varphi_{ss} \left(\frac{y_t}{y_{ss}} \right)^{\varphi_1} \quad (4)$$

where φ_0, φ_1 represent the steady-state income risk and the inverse of the elasticity of response of the income risk to unemployment deviations of its steady state. Intuitively, higher unemployment leads to more movement across states, reflecting income risk that can arise for various reasons. We deviate from Bilbiie (2024) by using deviations of domestic GDP, rather than an estimate of the output gap.

2.3 Household optimization problem

For households of type $j = \{R, NR\}$, instantaneous utility in period t depends on consumption (c_t^j) and the amount of hours worked (h_t) by the household's employed members (n_t):

$$E_t \sum_{s=0}^{\infty} \beta^s \left[\frac{1}{1-\sigma} \left(c_{t+s}^j - \kappa_L \frac{h_t^{1+\phi}}{1+\phi} \right)^{1-\sigma} \right], \quad j \in \{R, NR\} \quad (5)$$

Where κ_L is calibrated in order to accommodate wages from the demand schedule and the labor supply.

2.3.1 Ricardian Households

Ricardian households can save in risk-free bonds denominated in both domestic and foreign currency (b_t^R and b_t^{R*}), which yield gross interest rates of r_{t+1} and r_{t+1}^* , respectively. They also invest in physical capital, k_t , which is rented to firms at a rental rate r_t^k and depreciates at a rate δ . In addition, Ricardian households own domestic firms, from which they receive dividends Γ_t . Labor income is earned at an hourly wage rate w_t^R . Households pay a quarterly lump-sum tax t_t^R , and receive government transfers amounting to tr_t^R .

A key additional component of the Ricardian household's budget constraint is the transfer of wealth associated with the share $(1 - \varphi_t)$ of Ricardians transitioning to the non-Ricardian state, denoted by $TR_t^{R \rightarrow NR}$. The transfer is computed over the household's total *beginning-of-period* wealth. Specifically, it comprises the liquidation value of both financial and physical assets, as

well as any net lump-sum transfer from the government. It excludes labor income, dividends, and contemporaneous fiscal transfers, as these are realized *by the end of the period*, after production has taken place, and when transitioning members are already part of a non-Ricardian household.

Similar to [Kaplan et al. \(2018\)](#), we differentiate assets by their degree of liquidity. Financial assets are assumed to be fully liquid, allowing departing members to sell them at full value. In contrast, physical capital assets are considered illiquid; hence, departing members are able to recover only a fraction α_k of their value when selling them back to the household members who remain in a Ricardian household.

Taking all into account, the budget constraint can be expressed as

$$c_t^R + i_t^R + b_t^r + s_t b_t^f = w_t^R h_t + r_t^k k_{t-1}^R + \Gamma_t^R - t_t^R + \frac{r_{t-1} b_{t-1}^R}{\pi_t} + \frac{s_t r_{t-1}^* b_{t-1}^{*R}}{\pi_t^*} - \frac{\kappa_D}{2} s_t (b_t^{*R} - \bar{b})^2 - TR_t^{R \rightarrow NR}. \quad (6)$$

where

$$TR_t^{R \rightarrow NR} = (1 - \varphi_t) \left[\frac{r_{t-1} b_{t-1}^r}{\pi_t} + \frac{s_t r_{t-1}^* b_{t-1}^f}{\pi_t^*} + \alpha_k q_t k_{t-1} \right] \quad (7)$$

The law of motion of capital is as follows:

$$k_t^R = (1 - \delta) k_{t-1}^R + \left[1 - \frac{\kappa_I}{2} \left(\frac{i_t^R}{i_{t-1}^R} - 1 \right)^2 \right] i_t^R. \quad (8)$$

With depreciation rate $\delta \in (0, 1)$ and convex adjustment costs.

2.3.2 Non Ricardian Households

The non-Ricardian consumption budget is modified relative to the benchmark TANK specification, as the introduced risk creates an additional income source, $TR_t^{R, NR}$, that can finance extra consumption. In other words, the amount of saving before changing status determines the consumption in case that the household switches to non-Ricardian. This share will be pooled and shared by all the non-Ricardian households. As a result, the budget constraint of the non-Ricardian will be

$$c_t^{NR} = w_t^{NR} h_t - t_t^{NR} + \frac{1 - \omega}{\omega} TR_t^{R \rightarrow NR} \quad (9)$$

2.3.3 The Family Head's Problem

For arithmetic convenience, and following Bilbiie (2024), we assume the existence of a single utilitarian family head that makes the consumption and savings decisions for all household members, regardless of their type. The family head faces limits to risk sharing: can freely transfer resources across members of the same household group but not across groups. With this, the family head problem will maximize utility of both household groups, subject to both budget restrictions and the law of motion of capital. Thus, the household head problem is

$$\begin{aligned} \max E_t \sum_{t=0}^{\infty} \beta^s & \left\{ (1-\omega)u_t(C_t^{NR}) + \omega u_t(C_t^R) \right\} \\ \text{s.t.} & \quad (6), (8), (9) \end{aligned}$$

The family head will choose $c_t^R, c_t^{NR}, i_t^R, b_t^R, b_t^{R*}, k_t^R$ taking all the rest of the variables as given (complete).

The intertemporal family head's problem yields the following Lagrangean:

$$\begin{aligned} \mathcal{L}^H = & (1-\omega) \times \left\{ \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \frac{1}{1-\sigma} \left\{ c_t^R - \kappa_L \frac{h_t^{1+\varphi}}{1+\varphi} \right\}^{1-\sigma} \right. \\ & - \lambda_t^R \left[\begin{aligned} & c_t^R + i_t^R + b_t^R + s_t b_t^{*R} - w_t^R h_t - r_t^k k_{t-1} - \Gamma_t^R + t_t^R \\ & - \frac{r_{t-1} b_{t-1}^R}{\pi_t} - \frac{s_t r_{t-1}^* b_{t-1}^{*R}}{\pi_t^*} + \frac{\kappa_D}{2} s_t (b_t^{*R} - \bar{b})^2 + T R_t^{R \rightarrow NR} \end{aligned} \right] \\ & - \lambda_t^R q_t \left[k_t - (1-\delta)k_{t-1} - \left[1 - \frac{\kappa_I}{2} \left(\frac{i_t}{i_{t-1}} - 1 \right)^2 \right] i_t \right] \left. \right\} \\ & + \omega \times \left\{ \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \frac{1}{1-\sigma} \left\{ c_t^{NR} - \kappa_L \frac{h_t^{1+\varphi}}{1+\varphi} \right\}^{1-\sigma} \right. \\ & - \lambda_t^{NR} \left[c_t^{NR} - w_t^{NR} h_t - \Gamma_t^{NR} + t_t^{NR} - \frac{1-\omega}{\omega} T R_t^{R \rightarrow NR} \right] \left. \right\} \end{aligned}$$

Where $\lambda_{t+s}^R, \lambda_{t+s}^{NR}, q_{t+s}$ represent the discount factor of the Ricardian household, the non-Ricardian household, and the capital discount factor of the Ricardian household, respectively.

Ricardian and non Ricardian consumption FOC's Consumption itself is not affected the cyclical risk

$$\lambda_t^R = \left(c_t^R - \kappa_L \frac{h_t^{R^{1+\varphi}}}{1+\varphi} \right)^{-\sigma} \quad (10)$$

$$\lambda_t^{NR} = \left(c_t^{NR} - \kappa_L \frac{h_t^{NR^{1+\varphi}}}{1+\varphi} \right)^{-\sigma} \quad (11)$$

Local and foreign Bonds FOC . From the local and foreign bonds, we derived the following Euler equations.

$$\mathbb{E}_0 \beta \left\{ \frac{r_t}{\pi_{t+1}} (\varphi_{t+1} \lambda_{t+1}^R + (1 - \varphi_{t+1}) \lambda_{t+1}^{NR}) \right\} = \lambda_t^R \quad (12)$$

$$\mathbb{E}_0 \beta \left\{ \frac{s_{t+1} r_t^*}{\pi_{t+1} s_t} (\varphi_{t+1} \lambda_{t+1}^R + (1 - \varphi_{t+1}) \lambda_{t+1}^{NR}) \right\} = \lambda_t^R \left[1 + \kappa_D (b_t^f - \bar{b}) \right] \quad (13)$$

Similar to [Bilbiie \(2024\)](#) we found euler equations that relates the contemporaneous discount factor with expected value of the discount factor. From these equations, we can see the implications for the steady state of the interest rate and, moreover, as we allowed the Ricardian to include foreign bonds in its transfers, we see the same relationship affecting the real exchange rate through UIP.

Capital FOC. As contrary on what is in [Bilbiie \(2024\)](#) capital FOC it is also modified. This is implied by the fact that we include capital as part of the Ricardian assets, which can be liquidated to bring it to its non-Ricardian period. With this, the capital FOC is as follows:

$$q_t = \beta(r_t^k + q_{t+1}(1 - \delta)) \frac{\lambda_{t+1}^R}{\lambda_t^R} + \beta(1 - \varphi_{t+1}) \alpha_k q_{t+1} \frac{(\lambda_{t+1}^{NR} - \lambda_{t+1}^R)}{\lambda_t^R} \quad (14)$$

We can see here that the contemporaneous discount factor of capital q_t depends on the expected value of the rate of capital, the price of the investment, the capital utilization rate, and the depreciation rate. However, an additional term appears (second line) that reflects the risk becoming non-Ricardian in the expected value of q_{t+1} .

Investment

$$1 = q_t \left[1 - \frac{\kappa_I}{2} \left(\frac{i_t^R}{i_{t-1}^R} - 1 \right)^2 - \kappa_I \left(\frac{i_t^R}{i_{t-1}^R} \right) \left(\frac{i_t^R}{i_{t-1}^R} - 1 \right) \right] + \kappa_I \beta \mathbb{E}_t \left[\frac{\lambda_{t+1}^R}{\lambda_t^R} q_{t+1} \left[\left(\frac{i_{t+1}^R}{i_t^R} \right)^2 \left(\frac{i_t^R}{i_{t-1}^R} - 1 \right) \right] \right]. \quad (15)$$

2.4 Wage setting

There is a centralized union that sets the aggregate wage on behalf of the households, subject to the labor demand of the intermediate firms. The union maximizes the weighted average utility differential between Ricardian and non-Ricardian, subject to the labor demand, as in [García et al. \(2019\)](#) and [Gertler et al. \(2008\)](#). It is important to note that the Union does not choose specific wages over the Ricardian and non-Ricardian status, and this is a structural source of inequality.

$$\begin{aligned} \max_{w_t} \mathcal{W}_t &= (1 - \omega) \frac{U_t^R}{\lambda_t^R} + \omega \frac{U_t^{NR}}{\lambda_t^{NR}} = w_t h_t - \left(\frac{(1 - \omega)}{\lambda_t^R} + \frac{\omega}{\lambda_t^{NR}} \right) \kappa_L \frac{h_t^{1+\varphi}}{1 + \varphi} \\ \text{s.t. } w_t &= (1 - \alpha) m c \frac{y_{Ht}}{h_t} \end{aligned}$$

Where the optimal labor supply is given by

$$w_t = \frac{\kappa_L h_t^\varphi}{(1 - \alpha)} \quad (16)$$

This result is quite similar to the decentralized problem, except that the Union applies a markup of $1/(1 - \alpha)$ over the marginal disutility of work.

2.5 Fiscal Policy

The difference between current spending and current income is covered by the issuance of government bonds denominated in foreign currency, so the asset position for the government is as follows

$$s_t b_t^g = s_t r_t^* b_{t-1}^g - p_{Ht} g_{Ht} - tr_t + t_t \quad (17)$$

The lump-sum taxes are defined to finance a share of the deviation of the deficit. Both transfers and taxes are subject to idiosyncratic shocks.

$$t_t = \gamma^g s_t (b_t^g - \bar{b}) + \rho_{t-1}^t t_{t-1} + \nu_t^t \quad (18)$$

$$tr_t = \alpha_t^{TR} + \rho^{TR} * tr_{t-1} + \nu_t^{TR} \quad (19)$$

2.6 Precautionary savings in a THANK with liquid and illiquid insurance

Before jumping into the results section, it is useful to consider the implications of introducing income risk and the possibility of insuring by holding illiquid assets. We can do so by looking at the steady-state expressions of the liquid (bonds) and illiquid (capital) rates.

From the domestic bonds Euler eq (12)) the r_{ss} can be expressed as

$$r_{ss} = \frac{1}{\beta} \underbrace{\left(\varphi_{ss} + (1 - \varphi_{ss}) \frac{\lambda_{ss}^{NR}}{\lambda_{ss}^R} \right)}_{A^{-1}}^{-1} \quad (20)$$

Here we see that the multiplicative factor $A^{-1} < 1$ shifts the rate downwards as the condition $\frac{\lambda_{ss}^{NR}}{\lambda_{ss}^R} > 1$ holds. This condition is going to be met as the $c_{ss}^R > c_{ss}^{NR}$ after the transfer. In simple terms, the probability of switching states must decrease absolute utility. In this way, we have that RRicardians want to save more, anticipating a possible state switch. Holding other factors fixed, the liquid rate decreases

From the FOC of capital (14)) the r_{ss}^k can be expressed as

$$r_{ss}^k = \frac{1}{\beta} - (1 - \delta) - \alpha_k \left[\underbrace{\varphi + (1 - \varphi_{ss}) \frac{\lambda_{ss}^{NR}}{\lambda_{ss}^R}}_A - 1 \right] \quad (21)$$

Here we see that A now enters additively, shifting the illiquid rate downward when the condition $\frac{\lambda_{ss}^{NR}}{\lambda_{ss}^R} > 1$ holds. In this case, as $A > 1$, the liquidity costs (α_k) govern the degree of distortion that will affect the illiquid rate: The lower the liquidity costs (easier to self-insure with capital), the bigger the desire to hold more capital and therefore less the return demanded to hold that capital.

2.7 IMPC's and other objects

2.8 Small Households and Partial equilibrium responses

Part of the appeal of heterogeneous agent models lies in their ability to match empirically consistent iMPCs. Note that the core concept of the marginal propensity to consume is inherently a partial equilibrium one. It refers to the response of an individual agent to an income shock that affects their behavior but has no impact on aggregate prices or quantities in the economy. Accordingly, the HANK literature typically analyzes iMPCs by solving the model and then feeding an income shock into the household's optimal policy function to study their dynamic responses.

In this paper, where we have a goal to incorporate the matching of iMPCs as an explicit object to be considered within the estimation problem, we choose to model the partial equilibrium responses as the response of a set of agents within the model that can respond to shocks but that are small enough to affect the rest of the economy, and as such, their responses do not feed back to the rest of the model's blocks.

In particular, the equilibrium conditions that govern the behavior of these *small households* replicate the optimality conditions derived in Section A.1, but with all prices and variables not directly chosen by the household fixed at their steady-state values. Denoting the variables corresponding to *small households* with a tilde (i.e., $\tilde{X}$ represents the small household counterpart to the variable X), and defining ε_t as a one-time disposable income shock with no persistence, we obtain:

$$\mathbb{E}_0 \beta \left\{ r_{ss}^* \left(\hat{\varphi}_{ss} \hat{\lambda}_{t+1}^R + (1 - \hat{\varphi}_{ss}) \hat{\lambda}_{t+1}^{NR} \right) \right\} = \hat{\lambda}_t \left[1 + \kappa_D \left(\hat{b}_t^{*R} - \bar{b} \right) \right] \quad (22)$$

$$\hat{q}_t = \beta (r_{ss}^k + \hat{q}_{t+1} (1 - \delta)) \frac{\hat{\lambda}_{t+1}^R}{\hat{\lambda}_t^R} + \beta (1 - \hat{\varphi}_{ss}) \alpha_k q_{ss} \frac{(\hat{\lambda}_{t+1}^{NR} - \hat{\lambda}_{t+1}^R)}{\hat{\lambda}_t^R} \quad (23)$$

$$1 = \hat{q}_t \left[1 - \frac{\hat{\kappa}_I}{2} \left(\frac{\hat{i}_t^R}{\hat{i}_{t-1}^R} - 1 \right)^2 - \kappa_I \left(\frac{\hat{i}_t^R}{\hat{i}_{t-1}^R} \right) \left(\frac{\hat{i}_t^R}{\hat{i}_{t-1}^R} - 1 \right) \right] + \kappa_I \beta \mathbb{E}_t \left[\frac{\hat{\lambda}_{t+1}^R}{\hat{\lambda}_t^R} \hat{q}_{t+1} \left[\left(\frac{\hat{i}_{t+1}^R}{\hat{i}_t^R} \right)^2 \left(\frac{\hat{i}_t^R}{\hat{i}_{t-1}^R} - 1 \right) \right] \right]. \quad (24)$$

$$\begin{aligned} \hat{c}_t^R + \hat{i}_t^R + \hat{b}_t^f &= w_{ss}^R \hat{h}_{ss} + r_{ss}^k \hat{k}_{t-1}^R + \Gamma_{ss}^R - t_{ss}^R + t r_{ss}^R * \nu^{IMPC} + r_{ss}^* \hat{b}^f \\ &\quad - \frac{\kappa_D}{2} \left(\hat{b}_t^f - \bar{b} \right)^2 - \widehat{TR}_t^{R \rightarrow NR}. \end{aligned} \quad (25)$$

$$\widehat{c}_t^{NR} = w_{ss}^{NR} h_{ss} - t_{ss}^{NR} + tr_{ss}^{NR} * \nu^{IMPC} + \frac{1 - \omega}{\omega} \widehat{TR}_t^{R \rightarrow NR} \quad (26)$$

$$\widehat{TR}_t^{R \rightarrow NR} = (1 - \varphi_{ss}) \left(r_{ss}^* \widehat{b}_{t-1}^f + \alpha_k q_{ss} \widehat{k}_{t-1}^R \right) \quad (27)$$

$$\widehat{k}_t^R = (1 - \delta) \widehat{k}_{t-1}^R + \left[1 - \frac{\kappa_I}{2} \left(\frac{\widehat{i}_t^R}{\widehat{i}_{t-1}^R} - 1 \right)^2 \right] \widehat{i}_t^R - (1 - \varphi_{ss}) (\widehat{k}_t^R - k_{ss}^R) \quad (28)$$

Notably, the equation 12 is not present on the partial equilibrium block. This is due as we have perfect arbitrage between local and foreign bonds in steady state the *small household* is indifferent between in which bond will invest. Moreover, the portfolio cost present in the foreign bond holdings keeps the bond model stationary. Regarding capital, we have another important departure from equation 8. This *small household* effectively has a leakage of capital represented by $(1 - \varphi_{ss})(\widehat{k}_t^R - k_{ss}^R)$. The intuition is that when we have only one household, the capital is no longer in possession of this household; it will be in the possession of the rest of the Ricardians. This mechanism is not present in the general equilibrium model, where it is assumed that the capital will remain among Ricardians.

All parameters involved are the same as in the rest of the model. The idea is that when a non-persistent income shock ν_t^{IMPC} is realized, the household will obtain more resources along its budget constraint. The household will allocate consumption and savings through bonds and capital following its optimality condition that relates contemporaneous and future consumption. Part of the new resources will be transferred to the non-Ricardian agent, and he will consume all his available resources. All prices remain unchanged as we are interested in the individual reaction of the agents while the economy itself is not disturbed. The final overall IMPC will be the following.

$$IMPC(t) = \omega * \psi_{\varepsilon}^{\widetilde{C}^R}(t) + (1 - \omega) * \psi_{\varepsilon}^{\widetilde{C}^{NR}}(t)$$

Where $\psi_{\varepsilon}^{\widetilde{C}^R}(t)$ and $\psi_{\varepsilon}^{\widetilde{C}^{NR}}(t)$ correspond to the response at time t to a non-persistent income shock of the partial equilibrium Ricardian and non-Ricardian consumption, respectively.

3 Model's Quantitative Results

3.1 Calibration

To incorporate information from our external target for the IMPCs, we proceed to identify the THANK's block parameters. We use IRF matching as [Auclert et al. \(2020\)](#) and [Christiano et al. \(2005\)](#). We define the IMPC ($J(\Psi)$) as function of the vector of parameters $\Psi = (\omega, \bar{\varphi})'$. The empirical IMPC is denoted by $\hat{J}$. V is a diagonal scaling matrix that could represent the uncertainty over the precision of the target IMPC; in this implementation, it is a vector of weights that decay at a constant rate. The estimator $\hat{\Psi}$ solves

$$\min_{\Psi} (J(\Psi) - \hat{J})' V^{-1} (J(\Psi) - \hat{J})$$

Looking at the equation for the liquid asset return rate in [20](#), it is easy to see that the size of the transfer from Ricardian to non-Ricardian households affects the ratio of marginal utilities of consumption and, therefore, its steady-state value. To offset this change, we allow β to adjust endogenously so as to keep the return rate unchanged. However, allowing β to vary also affects the illiquid asset return rate, as shown in equation [21](#). Results are shown in the following table.

TABLE 1: Quarterly calibration: baseline THANK and benchmark TANK model

Parameter	Description	TANK	THANK	Source
<i>A. Preferences</i>				
β	Discount factor	0.99	0.9579	iMPC matching
σ	Relative risk aversion (inverse EIS)	2.00	2.00	Bilbiie (2024)
ϕ	Inverse Frisch elasticity	1.00	1.00	Galí (2015)
κ_L	Labor-disutility weight	cal.	cal.	
h_{ss}	Steady-state hours	1/3	1/3	Normalization
<i>B. Technology and nominal rigidities</i>				
α	Capital share in production	0.33	0.33	García et al. (2019)
δ	Capital depreciation rate	0.025	0.025	Christiano et al. (2005)
ε	Elasticity of substitution across varieties	6.00	6.00	Galí and Monacelli (2005)
θ	Calvo price stickiness (implies κ_P)	0.66	0.66	Smets and Wouters (2007)
κ_I	Investment adjustment cost	2.48	2.48	Christiano et al. (2005)
<i>C. Open economy</i>				
γ	Trade openness (import share)	0.30	0.30	García et al. (2019)
η	Armington elasticity (intratemporal substitution)	1.50	1.50	García et al. (2019)
$\bar{D}$	External debt / annual GDP target	0.4	0.4	García et al. (2019)
κ_D	Portfolio (debt) adjustment cost	0.001	0.001	Schmitt-Grohé and Uribe (2003)
g_y	Public-consumption share of GDP	0.20	0.20	García et al. (2019)
<i>D. Monetary policy (Taylor rule)</i>				
ϕ_π	Response to inflation	1.50	1.50	García et al. (2019)
ϕ_y	Response to output	0.125	0.125	
ϕ_e	Response to nominal depreciation	0.00	0.00	García et al. (2019)
ρ_r	Interest-rate smoothing	0.80	0.80	Smets and Wouters (2007)
<i>E. Fiscal policy</i>				
$\bar{b}^g$	Government debt / GDP	0.20	0.20c	Coenen et al. (2013)
γ^g	Tax response to debt gap	0.05	0.05	Galí et al. (2007)
α^T	Lump sum tax steady state	1	1	Normalization
ρ_T	Tax-rule persistence	0.0	0.0	Own assumption
α^{TR}	Lump sum tax steady state	1	1	Normalization
ρ_{TR}	Transfer-rule persistence	0.0	0.0	Own assumption
<i>G. Exogenous processes</i>				
ρ_a	TFP shock	0.90	0.90	Own assumption
ρ_g	Public-spending shock	0.90	0.90	Own assumption
ρ_{r^*}	Foreign monetary shock	0.90	0.90	Own assumption
ρ_{y^*}	Foreign demand shock	0.90	0.90	Own assumption
<i>H. THANK block</i>				
φ_{ss}	Steady state probability to stay Ricardian		0.83	iMPC matching
φ_1	Probability to stay Ricardian elasticity to the cycle		0.10	Own assumption
ω	Share of non-Ricardian households	0.34	0.34	iMPC matching
ω_T	Share of taxes and transfers going to non Ricardian	0.34	0.34	iMPC matching
α_w	Wage ratio between Ricardian and non-Ricardian		0.85	iMPC matching
η_w	Wage ratio cycle elasticity		0.10	Own assumption
α_k	Liquidity cost of capital		0.22	iMPC matching

Notes. Quarterly frequency. “cal.” denotes a parameter pinned residually by a steady-state restriction rather than set directly (κ_L is recovered from the labor-supply condition given h_{ss}).

3.2 Steady state results

The table 2 shows the numerical results of calibration over the steady state of this model in comparison with a benchmark model. This benchmark model is a TANK and features the same

TABLE 2: Steady-state values used in the plotted comparison.

Variable	Benchmark-TANK	THANK
c	0.86	0.88
c_R	1.06	0.90
c_{NR}	0.50	0.85
r	1.03	1.03
i	0.12	0.10
k	4.91	4.39
rk	0.05	0.06
w	1.67	1.67
w_R	1.76	1.76
w_{NR}	1.51	1.51
dR	0.40	0.40
$tr_{R \rightarrow NR}$	–	0.18

Note: Values are reported in the same units as the plotted steady-state comparison and are truncated to two decimals.

structural calibration in the ω and α_w parameters, so we have the same structural inequality. However, it does not incorporate income risk, so there is no possibility of switching states; therefore, there is no need for self-insurance of any type. Notably, the disposable income inequality will be defined by profits (Γ_t^R), wage ratio (α_w) and rental rate of capital (r_t^k).

We include this table to illustrate how the partial-equilibrium matching mechanism generates changes in the general-equilibrium steady state. First, and most importantly, Ricardian consumption declines as households allocate resources to insure against the possibility that the adverse state materializes ($tr_{R \rightarrow NR} > 0$). Conversely, non-Ricardian households receive additional resources, leading their consumption to exceed that of the benchmark case. Notably, under the baseline calibration, the condition $\frac{\lambda_{ss}^{NR}}{\lambda_{ss}^R} > 1$ holds, generating downward pressure on equilibrium interest rates. This effect is fully offset by adjustments in β for the liquid asset return rate, but it still affects rk . Specifically, as shown in 21, the joint effects of β , α_k , and A increase the return to capital, making capital accumulation and investment less attractive.

3.3 Intertemporal propensities in the model

Intertemporal marginal propensities to consume (iMPCs) are typically not emphasized in RANK or TANK models, as the dynamics of consumption over time following a one-period income shock are rather trivial. Ricardian households follow Friedman’s permanent income hypothesis, which, when applied to infinitely lived agents, implies that they save the entire income windfall and consume only the return on the extra income they receive. As a result, their iMPCs can be defined simply as a row filled with values equal to the net interest rate. In contrast, non-Ricardian or hand-to-mouth households consume all their income as soon as they receive it; thus, their iMPCs consist of a

one in the first period followed by zeros. Then, RANK models feature the iMPC profile of the featured representative agent, usually Ricardian, while TANK models produce an average iMPC that combines the profiles of both types of households, resulting in a high iMPC in the first period, followed by very low values thereafter (see [Auclert et al. \(2018\)](#) for an analysis of these concepts).

In contrast, Heterogenous agents models as [Krusell and Smith \(1998\)](#), [Kaplan et al. \(2018\)](#), [Auclert et al. \(2018\)](#), emphasize how different agents across the income distribution are potentially closer to their budget constraint, and thus, along with income risk, precautionary motives arise. These precautionary motives generate larger savings in some households than in the counterfactual without risk, especially when closer to the borrowing constraint. This generates a consumption function which is increasing and concave in assets. This means there is a decreasing function of marginal propensities to consume along the assets distribution. This is: there are households with large MPCs in those models, which leads to a consumption response to a transitory income shock that reflects the full distribution of propensities to consume. In subsequent periods, some households will allocate the interest rate earnings from the proportion that they saved to consumption, while others, being more constrained, will spend a large proportion of their remaining resources. Over time, the proportion of households that still have leftovers from the temporal income shock will converge to zero, and the overall consumption response of the economy will be aligned with the income generated from initial savings. This leads, in turn, to average iMPC dynamics that start high and then feature a smooth decay, matching the target.

In this section, we show the implications of our modeling and estimation choices for the model's ability to generate realistic iMPCs. As shown in Figure 1, panel (a), the model-implied iMPC closely matches its HANK counterpart, while differing substantially from the flat and short-lived iMPCs generated by the RANK and TANK models. This consumption behavior is further illustrated in panel (b), which decomposes the responses into Ricardian and non-Ricardian contributions. The Ricardian response is relatively small, reflecting households' tendency to save most of the additional resources. By contrast, the non-Ricardian response exhibits a more persistent pattern, driven by the consumption smoothing provided by Ricardian agents who transition into the negative state. Without the THANK mechanism, this behavior would not be possible.

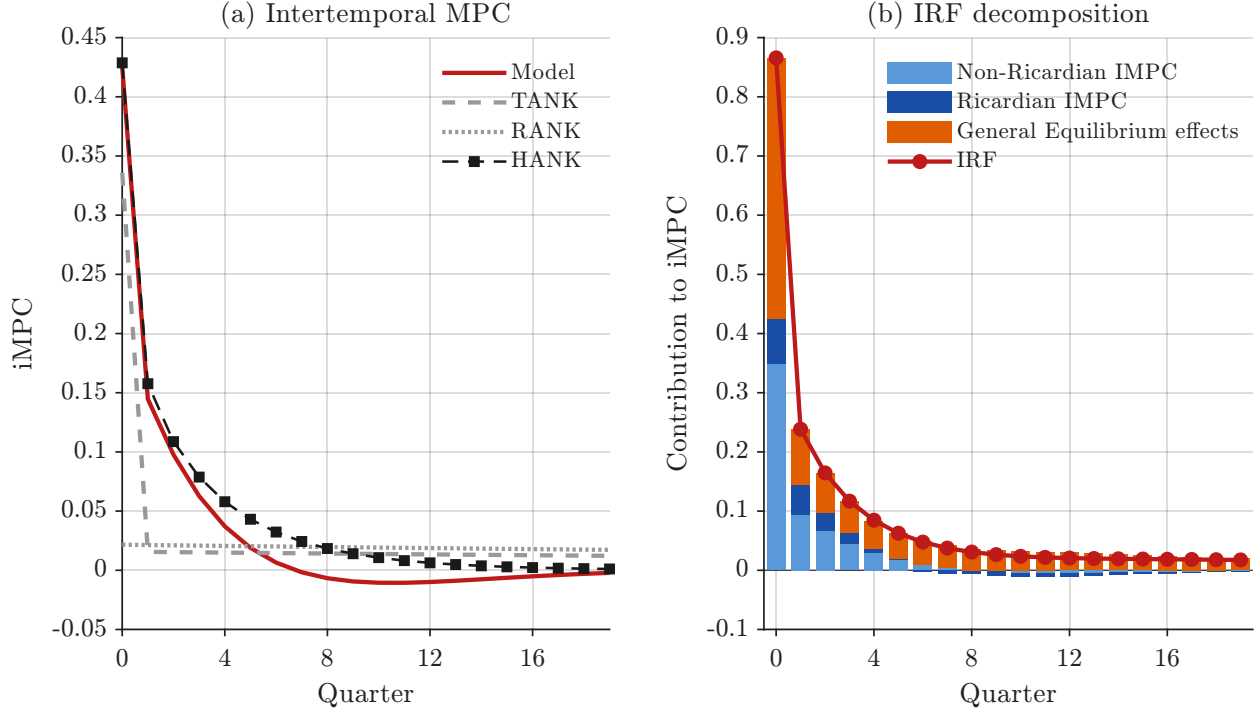


FIGURE 1: Intertemporal marginal propensity to consume and IRF decomposition of a one-time income shock

It is important to note that our methodology for computing iMPCs exploits both the model's linear structure and the modular configuration of its partial-equilibrium blocks. These two features also allow us to perform an impulse response function (IRF) decomposition, shown in Figure 1 panel (b). Specifically, the general-equilibrium response to a transitory income shock, or to any other shock, can be separated into the component explained by the iMPCs and a residual component represented by the orange bars. This residual captures the combined contribution of all other general-equilibrium mechanisms affecting consumption, including changes in production, exchange-rate movements, shifts in expectations, monetary policy responses, and other propagation channels. The decomposition therefore provides a transparent framework for quantifying the extent to which consumption dynamics are driven directly by households' marginal propensities to consume, rather than by general equilibrium adjustments in the economy.

3.4 Intertemporal Marginal Propensities to consume, invest and save: partial equilibrium accountability

This partial equilibrium exercise allows for a complete accountability of resources in the partial equilibrium block. One additional unit of income generates flows with no persistence that can be

easily tracked. Following the literature of two assets HANK's like [Luetticke \(2019\)](#), we are able to compute as well marginal propensities to invest. This allows us to track which portion of the extra resources goes to consumption, savings, or investment.

To begin, the figure 2 (B) panel shows the iMPC and its contributions. Here we have to keep in mind that under the current calibration ω is around 0.3. Here we can see that the non-Ricardian spend the entire extra income, while the Ricardian partially allocate it to bonds and investment. Based on 2 panel (A), we see that most of the extra income that goes to the Ricardian goes to bonds and a minority to investment. Notably, the structural risk (in steady state) and the increased asset holdings generate a positive transfer from the Ricardian to the non-Ricardian, which fuels non-Ricardian consumption in subsequent periods.

Regarding investment, the Ricardian household will allocate resources trying to move closer to its desired level of capital at a speed governed by the adjustment costs. At the same time, this small household will have a leakage of capital each period as detailed in section 2.8 given by $(1 - \varphi_{ss})(\hat{k}_t^R - k_{ss}^R)$. The optimal investment will be given by equation 24, where the self insurance gain will be governend by α_k and $(1 - \varphi_{ss})$

On the other hand, the whole trajectory of the iMPC Savings can be explained by the consumption-smoothing desire of Ricardian households and by the Euler equation: extra income will increase the consumption of both agents, will decrease marginal utilities according to σ , and will return optimal demand for bonds in the next period. Intuitively, the Ricardian household will save because he anticipates the possibility of a negative state, and at a determined point will borrow to maintain the size of the transfer.

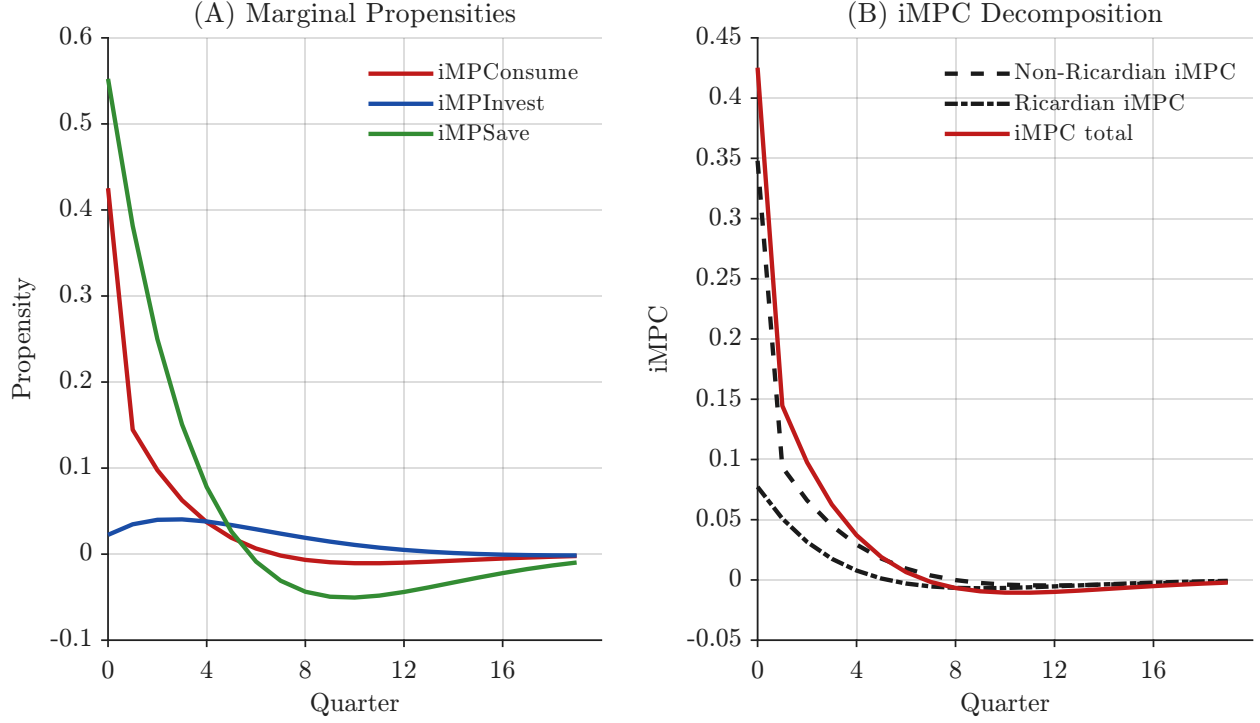


FIGURE 2: Intertemporal propensities - Partial equilibrium block IRF's after a non-persistent 1-unit income shock.

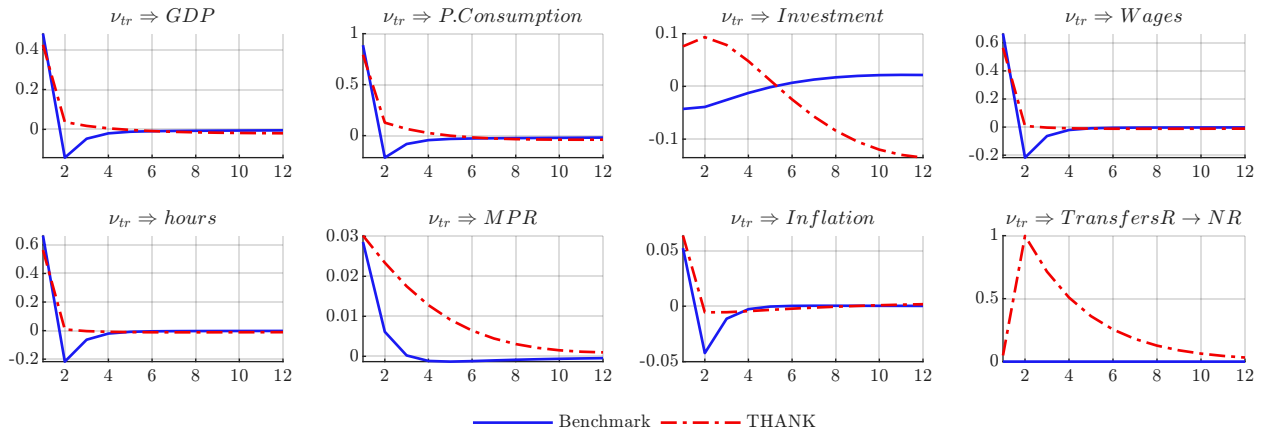
In contrast to TANK models' iMPCs, the non-Ricardian agents now derive an indirect benefit from the Ricardian holdings, as we incorporated the switching regime. The transfers are the device that ensures the non-Ricardian agents have a non-flat iMPC. The transfer itself is defined by the risk probability $(1 - \varphi_{ss})$ and liquidity costs (α_k) but crucially by the consumption levels. In this sense, the calibration of steady-state bond holdings and capital can crucially define whether the condition $\frac{\lambda^{NR}}{\lambda^R} > 1$ holds. Different from [Auclert et al. \(2018\)](#), where the authors analytically described that the discounted sum of iMPC has to be equal to 1, here we have that the possibility of insurance with illiquid assets and the liquidity costs generate the possibility that this condition does not necessarily hold. In the next section, we describe the issue, and we propose an exercise to understand the degree of distortion that we incorporate.

3.5 Income shocks in general equilibrium

To further examine the implications of introducing income risk into the economy, we analyze the general-equilibrium effects of a transfer shock rather than focusing solely on the dynamics of the *small household* response. Figure 3 presents the impulse response functions following a one-time, non-persistent government transfer shock. In the benchmark TANK model, the income

shock temporarily increases aggregate demand and economic activity, generating a transitory rise in inflation. However, activity quickly returns to its steady-state level following the monetary policy response. In this framework, the Ricardian household saves most of the additional income, whereas the non-Ricardian household cannot raise consumption beyond the initial period. In contrast, in the THANK model, consumption increases more persistently than in the benchmark economy. This result follows directly from Figure 1 and reflects the fact that both Ricardian and non-Ricardian households now smooth consumption intertemporally. In addition to the stronger response of consumption, investment also rises, as Ricardian households allocate part of the additional resources to capital accumulation, as shown in Figure 2. Together, these mechanisms generate a larger increase in economic activity and inflation, requiring a substantially stronger monetary policy response than in the benchmark case.

FIGURE 3: Transfers Shock Impulse-Responses



The discussion above highlights the implications of transfer shocks for policy responses within the THANK framework. Allowing unconstrained agents to adjust their saving and investment decisions based on their perceptions of future economic conditions introduces an additional source of macroeconomic fluctuations and may amplify the fiscal multiplier beyond what the benchmark model predicts. To further explore these effects, we examine how these mechanisms interact when the economy is simultaneously exposed to multiple shocks. In the next section, we incorporate these mechanisms into a medium-scale DSGE model used for policy analysis (García et al. (2019)). We then show that the persistence of consumption observed during the recovery from the COVID-19 crisis is better captured by the mechanisms embedded in the THANK framework.

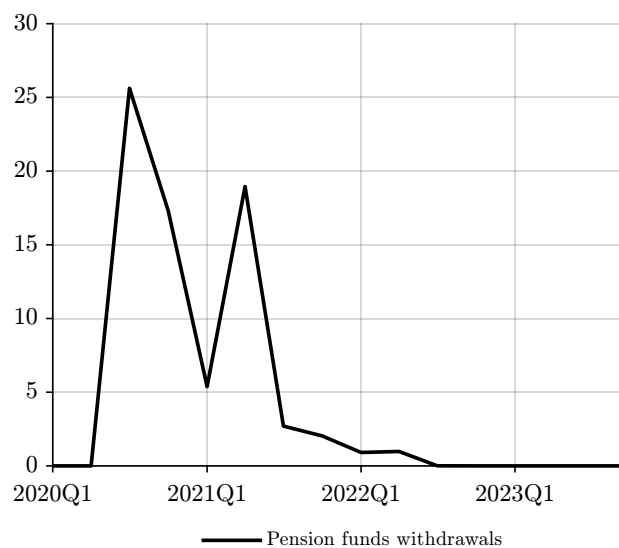
4 An empirical application: Consumption around COVID-19 in Chile

In this section, we show that the mechanism can be easily adapted to more complex models. Allowing for a finer empirical analysis by using more detailed and empirically relevant models. In particular, we will introduce income risk into the XMAS model, the CBCh core model for policy analysis, as detailed in [García et al. \(2019\)](#).

To illustrate the results, we present historical decompositions covering the post-pandemic recovery period. This episode was characterized by unprecedented fiscal transfers and pension fund withdrawals, which together amounted to nearly 10% of GDP (figure 4). These large liquidity injections resulted from the interaction of a severe social crisis, the economic downturn triggered by the pandemic, and political tensions between Congress and the government. At the time these policies were implemented, many economists argued against them because of their potential effects on fiscal sustainability, long-term inflation, interest rates, and the perceived risk of the Chilean economy. However, the adverse consequences proved to be considerably larger than initially anticipated.

In this section, we briefly describe the XMAS model as an example of a TANK framework. We then present the THANK extension of the household problem in Appendix A and discuss its main results.

FIGURE 4: Pension funds withdrawals. Quarterly amounts as a percentage of GDP.



4.1 A baseline TANK model

Our benchmark model is the Central Bank of Chile’s DSGE model for projections and policy analysis, XMAS [García et al. \(2019\)](#). It extends [Medina and Soto \(2007\)](#) with an endogenous commodity sector, an augmented fiscal block, a search-and-matching labor market, and non-core inflation, on the New Keynesian core of [Christiano et al. \(2005\)](#) and [Smets and Wouters \(2007\)](#) and the open-economy structure of [Adolfson et al. \(2007\)](#). The model features two types of households with identical preferences that differ only in market participation: non-Ricardian (mass $\omega = 0.5$) and Ricardian. Ricardians trade domestic and foreign bonds under a debt-elastic country premium, own capital with variable utilization and investment adjustment costs [Christiano et al. \(2011\)](#); [Justiniano et al. \(2011\)](#), and receive dividends; theirs are the only Euler equations, so the interest-rate channel runs through them alone. Non-Ricardians face the static constraint, which breaks Ricardian equivalence and raises the sensitivity of consumption to current income. Utility is separable in a CES bundle of private and valuable government consumption with habits [Coenen et al. \(2013\)](#), and an endogenous preference shifter à la [Galí et al. \(2012\)](#). Full within-family risk sharing ([Merz \(1995\)](#)) leaves employment status irrelevant for consumption: XMAS is a TANK model with full insurance and no self-insurance margin. Labor adjusts on two margins. On the extensive margin, unemployed workers and posted vacancies meet through a Cobb-Douglas matching function; a fraction of matches then breaks up exogenously and surviving matches whose operating cost exceeds an endogenous threshold are destroyed as well. Wages and hours are set by a single union that negotiates one contract for both household types [Boscá et al. \(2011\)](#), so all workers earn the same wage and work the same hours. Hours equate the marginal product of an hour to the marginal rate of substitution. The hourly wage then splits the match surplus by Nash bargaining and adjusts only partially toward that notional wage (?), which is what makes wages sticky. A wholesale producer combines a core good (capital and labor) with imported oil; domestic, export, and import varieties price à la Calvo with partial indexation, and local-currency pricing delivers imperfect exchange-rate pass-through. Separating core, food, and energy inflation is what allows estimation on the disaggregated CPI. Mining output uses sector-specific capital with adjustment costs and six-quarter time-to-build as [Fornero and Kirchner \(2018\)](#); the government owns a major part of the firm. Endogenizing mining investment allows commodity price shocks to affect investment and the current account, with relevant income effects. Spending covers valuable government consumption, public investment, transfers, and oil-price smoothing, financed by $\tau^C, \tau^W, \tau^K, \tau^D, \tau^{Co}$ and lump-

sum taxes under a structural balance rule [Marcel et al. \(2001\)](#); [Coenen et al. \(2013\)](#). An inertial Taylor rule responds to current and expected future core and headline inflation, as well as to GDP growth. Sectoral technologies and international prices cointegrate with common trends, as in [Schmitt-Grohé and Uribe \(2012\)](#). Log-linearized and estimated by Bayesian methods as [Schorfheide et al. \(2010\)](#) on 23 series for 2001Q3–2017Q2. Calibration and posterior estimates are detailed in the original paper.

4.2 Including income risk: XMAS-THANK

As discussed in the previous section, the THANK block augments the original model with Euler equations for domestic and foreign bonds and a modified capital first-order condition (FOC), all of which incorporate the probability of switching between states. A detailed description of the household problem is provided in [Appendix A](#).

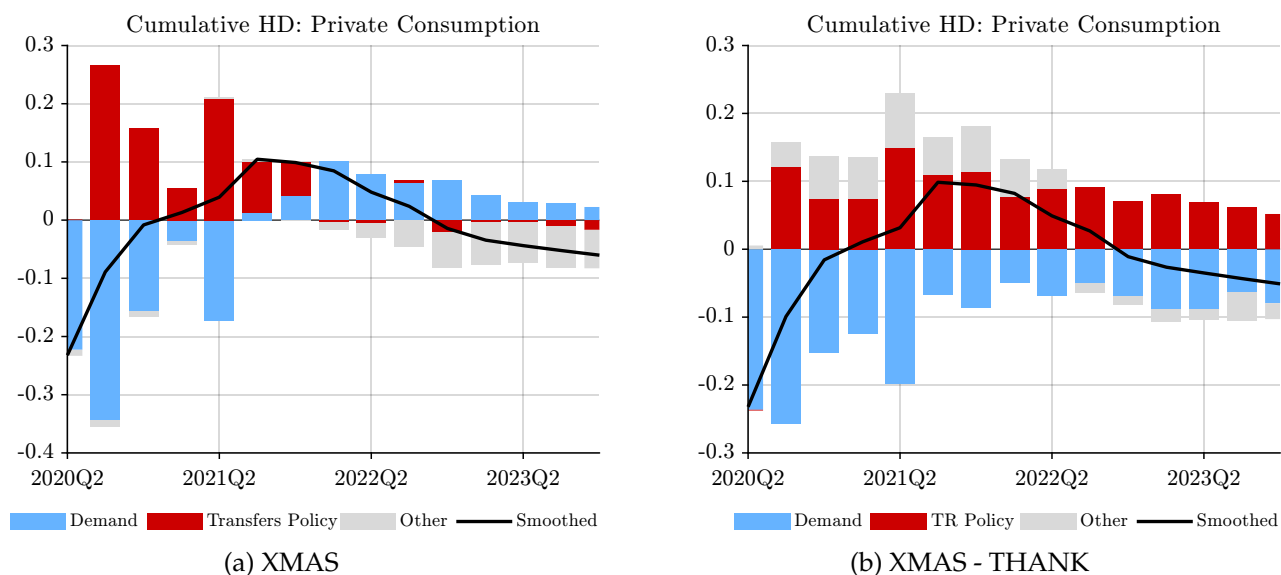
For the purposes of this exercise, both models are re-estimated using Bayesian methods, following [Schorfheide et al. \(2010\)](#). The set of observable variables is extended to include the entire pandemic period through 2023Q4. This extension allows the crisis and subsequent recovery to serve as an additional source of identification for the model parameters. In addition, we incorporate the series shown in [4](#) as an observable variable, making it possible to identify an additional pension-withdrawal shock that is unique to this period. We use the model-implied iMPC to discipline the estimation by incorporating an empirical estimate as a system prior, following [Andrle and Benes \(2013b\)](#). To construct the iMPC and evaluate deviations from the empirical estimate, we employ the same methodology described in [Sections 2.7 and 3.1](#).

4.3 Results: Historical decomposition

We now turn to the historical decomposition of private consumption implied by both models. [Figure 5](#) presents the dynamics of consumption by separating the contributions of three groups of shocks: (i) transfer policy shocks, including regular transfers and pension fund withdrawals; (ii) demand shocks, represented by preference shocks; and (iii) all other shocks, comprising monetary policy, productivity, labor market, foreign, and migration shocks. In the original XMAS model ([Panel A](#)), the contribution of transfer policy shocks is large but short-lived. This result follows directly from the TANK structure of the model, in which all additional income received by non-Ricardian households is immediately consumed, while Ricardian households save most of the

transfer. In contrast, the THANK version of the model generates a smaller initial impact of transfer policies but a substantially more persistent effect. This persistence arises from the model's persistent iMPC at longer horizons, which is driven by precautionary saving motives. At the same time, the decomposition implied by the original model attributes a large share of the persistence in consumption to preference shocks. In this sense, a significant portion of the observed dynamics remains unexplained by the transmission of transfer policies alone. By contrast, in the THANK model, transfer policy shocks continue to contribute substantially to consumption even three years after the initial shock has materialized. As a result, the THANK framework accounts for a larger share of the observed persistence in consumption through endogenous channels rather than exogenous demand shocks.

FIGURE 5: Cumulative historical decomposition - Private Consumption. QoQ % change.

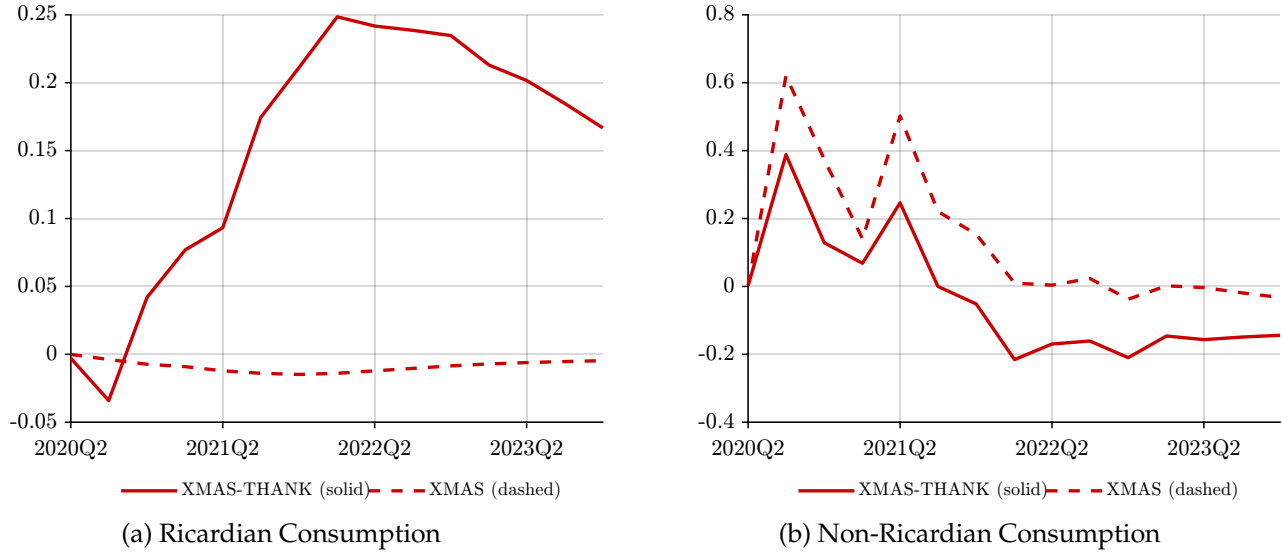


Source: Author's calculations. **Note:** Transfers policy includes regular government transfers plus pension funds withdrawals.

We now turn to Figure 6, which decomposes the effects of transfer policies in both models and compares their contributions across household types. Panel (a) displays the contribution to Ricardian consumption, while Panel (b) reports the contribution to non-Ricardian consumption. The dynamics of Ricardian consumption reveal a clear amplification mechanism. The large volume of transfers received during this period may have generated a multiplier effect through increased asset accumulation, enabling households to increase future income streams and sustain higher consumption levels over time. In the THANK model, this channel becomes particularly relevant because Ricardian households adjust both their saving and investment decisions in response to the transfer shock. By contrast, the contribution to non-Ricardian consumption declines more rapidly. This pattern reflects the general-equilibrium effects triggered by the transfer policies, which may erode other sources of disposable income over time. One important

mechanism is the monetary policy response, as higher inflation induces tighter monetary conditions that dampen economic activity and labor income. Consequently, although non-Ricardian households initially benefit from the transfers, part of this gain is gradually offset by the broader macroeconomic adjustment.

FIGURE 6: Cumulative historical decomposition - Transfers policy contribution in Consumption. QoQ % change.



Source: Author's calculations. **Note:** Transfers policy includes regular government transfers plus pension funds withdrawals.

5 Conclusions

In this paper, we include intertemporal marginal propensities to consume (iMPCs) in a small-open-economy DSGE model. Following Bilbiie (2024), we assume households switch stochastically between the Ricardian and the non-Ricardian state, so Ricardian households save for precautionary motives. We extend the analysis in two ways: i) households can self-insure with liquid and illiquid assets, and ii) we match an iMPCs path explicitly along with the rest of the model. Since the model remains linear, we can solve and estimate it at arbitrarily bigger models.

We find that the THANK block generates iMPCs that are large on impact and decay smoothly, as in the data. This happens because the assets Ricardian households accumulate after a transfer finance non-Ricardian households' consumption for several quarters after the shock. The precautionary motive also lowers the steady-state return on liquid assets, and the return on capital also depends on its liquidity cost. When we embed the block into XMAS, the historical decomposition of private consumption over the COVID-19 period assigns a substantially larger role to transfers and pension withdrawals, and a smaller role to autonomous consumption shocks than the original model. We reach this without deteriorating the fit of consumption, output, and core inflation.

The main lesson for policy analysis is that the timing of the consumption response to income matters for evaluating fiscal transfers: a model with front-loaded iMPCs understates the persistence of the demand they generate and attributes it to shocks the model does not explain. Since the mechanism modifies only the household block, it can be added to

any medium-scale DSGE model at low cost. Future work could exploit the cyclical switching probability to study how income risk interacts with fiscal and monetary transmission in an open economy, and use the same partial-equilibrium device to target the intertemporal propensities to invest and to save.

References

- Adolfson, M., Laseen, S., Linde, J., and Villani, M. (2007). Bayesian estimation of an open economy DSGE model with incomplete pass-through. *Journal of International Economics*, 72(2):481–511.
- Andrle, M. and Benes, J. (2013a). System priors: Formulating priors about dsge models' properties. *IMF Working Papers*, 2013(257):1.
- Andrle, M. and Benes, J. (2013b). *System priors: formulating priors about DSGE models' properties*. Number Working Paper No. 13/257 in IMF Working Papers. International Monetary Fund, Washington, D.C.
- Auclert, A., Rognlie, M., and Straub, L. (2018). The Intertemporal Keynesian Cross. Technical Report w25020, National Bureau of Economic Research, Cambridge, MA.
- Auclert, A., Rognlie, M., and Straub, L. (2020). Micro jumps, macro humps: Monetary policy and business cycles in an estimated hank model. Working paper.
- Auclert, A., Rognlie, M., and Straub, L. (2024). The Intertemporal Keynesian Cross. *Journal of Political Economy*, pages 000–000.
- Bilbiie, F. (2008). Limited Asset Markets Participation, Monetary Policy and (Inverted) Aggregate Demand Logic. *Journal of Economic Theory*, 140(1):162–196.
- Bilbiie, F., Primiceri, G., and Tambalotti, A. (2023). Inequality and Business Cycles. Technical Report w31729, National Bureau of Economic Research, Cambridge, MA.
- Bilbiie, F. O. (2024). Monetary Policy and Heterogeneity: An Analytical Framework. *Review of Economic Studies*, page rdae066.
- Boscá, J. E., Domenech, R., and Ferri, J. (2011). Search, Nash bargaining and rule-of-thumb consumers. *European Economic Review*, 55(7):927–942. Publisher: Elsevier.
- Broer, T., Harbo Hansen, N.-J., Krusell, P., and Öberg, E. (2019). The New Keynesian Transmission Mechanism: A Heterogeneous-Agent Perspective. *The Review of Economic Studies*. eprint: <http://oup.prod.sis.lan/restud/advance-article-pdf/doi/10.1093/restud/rdy060/28297531/rdy060.pdf>.
- Christiano, L. J., Eichenbaum, M., and Evans, C. L. (2005). Nominal Rigidities and the Dynamic Effects of a Shock to Monetary Policy. *Journal of Political Economy*, 113(1):1–45. Publisher: The University of Chicago Press.
- Christiano, L. J., Trabandt, M., and Walentin, K. (2011). Introducing financial frictions and unemployment into a small open economy model. *Journal of Economic Dynamics and Control*, 35(12):1999–2041.
- Coenen, G., Straub, R., and Trabandt, M. (2013). Gauging the effects of fiscal stimulus packages in the euro area. *Journal of Economic Dynamics and Control*, 37(2):367–386. Publisher: Elsevier.
- Debortoli, D. and Galí, J. (2017). Monetary Policy with Heterogeneous Agents: Insights from TANK models. Working Paper, CREI. Series: CREI mimeo.

- Fagereng, A., Holm, M. B., and Natvik, G. J. (2021). Mpc heterogeneity and household balance sheets. *American Economic Journal: Macroeconomics*, 13(4):1–54.
- Fornero, J. and Kirchner, M. (2018). Learning about Commodity Cycles and Saving-Investment Dynamics in a Commodity-Exporting Economy. *International Journal of Central Banking*, 14(2).
- Galí, J. (2015). *Monetary Policy, Inflation, and the Business Cycle: An Introduction to the New Keynesian Framework and Its Applications - Second Edition*. Princeton University Press.
- Galí, J., López-Salido, J. D., and Vallés, J. (2007). Understanding the effects of government spending on consumption. *Journal of the European Economic Association*, 5(1):227–270. Publisher: Wiley Online Library.
- Galí, J. and Monacelli, T. (2005). Monetary policy and exchange rate volatility in a small open economy. *The Review of Economic Studies*, 72(3):707–734.
- Galí, J., Smets, F., and Wouters, R. (2012). Unemployment in an estimated new keynesian model. *NBER Macroeconomics Annual*, 26(1):329–360. Publisher: University of Chicago Press Chicago, IL.
- García, B., Giarda, M., and Lizama, C. (2023). The Role of Progressivity on the Economic Impact of Fiscal Transfers: A HANK for Chile.
- García, B., Guarda, S., Kirchner, M., and Tranamil, R. (2019). Xmas: An extended model for analysis and simulations. Working Paper 833, Central Bank of Chile.
- Gertler, M., Sala, L., and Trigari, A. (2008). An Estimated Monetary DSGE Model with Unemployment and Staggered Nominal Wage Bargaining. *Journal of Money, Credit and Banking*, 40(8):1713–1764.
- Justiniano, A., Primiceri, G., and Tambalotti, A. (2011). Investment Shocks and the Relative Price of Investment. *Review of Economic Dynamics*, 14(1):101–121.
- Kaplan, G., Moll, B., and Violante, G. L. (2018). Monetary Policy According to HANK. *American Economic Review*, 108(3):697–743.
- Kaplan, G., Violante, G. L., and Weidner, J. (2014). The Wealthy Hand-to-Mouth. *Brookings Papers on Economic Activity*, 45(1 (Spring)):77–153.
- Krusell, P. and Smith, A. (1998). Income and Wealth Heterogeneity in the Macroeconomy. *Journal of Political Economy*, 106(5):867–896. eprint: <https://doi.org/10.1086/250034>.
- Luetticke, R. (2019). Transmission of Monetary Policy with Heterogeneity in Household Portfolios. *Forthcoming in AER: Macroeconomics*.
- Luetticke, R. (2021). Transmission of Monetary Policy with Heterogeneity in Household Portfolios. *American Economic Journal: Macroeconomics*, 13(2):1–25.
- Marcel, M., Tokman, M., Valdés, R. O., Benavides, P., and others (2001). Structural budget balance: The pillar of the new Chilean fiscal policy rule. *Journal Economía Chilena (The Chilean Economy)*, 4(3):15–27.

- Medina, J. P. and Soto, C. (2007). The Chilean Business Cycles Through the Lens of a Stochastic General Equilibrium Model. Working Papers Central Bank of Chile 457, Central Bank of Chile.
- Merz, M. (1995). Search in the labor market and the real business cycle. *Journal of monetary Economics*, 36(2):269–300. Publisher: Elsevier.
- Ravn, M. and Sterk, V. (2018). Macroeconomic Fluctuations with HANK & SAM: an Analytical Approach. mimeo.
- Schmitt-Grohé, S. and Uribe, M. (2003). Closing small open economy models. *Journal of International Economics*, 61(1):163–185.
- Schmitt-Grohé, S. and Uribe, M. (2012). What’s news in business cycles. *Econometrica*, 80(6):2733–2764. Publisher: Wiley Online Library.
- Schorfheide, F., Sill, K., and Kryshko, M. (2010). DSGE model-based forecasting of non-modelled variables. *International Journal of Forecasting*, 26(2):348–373.
- Smets, F. and Wouters, R. (2007). Shocks and Frictions in US Business Cycles: A Bayesian DSGE Approach. *American Economic Review*, 97(3):586–606.
- Werning, I. (2015). Incomplete Markets and Aggregate Demand. *National Bureau of Economic Research*, (Working Paper 21448).

A XMAS as a THANK model

In this section we briefly show more details about the *THANK* application to the XMAS model. This modification only has implications for the household block. All other blocks remain equivalent to what is shown in [García et al. \(2019\)](#).

A.1 Household optimization problem

For households of type $j = \{R, NR\}$, instantaneous utility in period t depends on consumption $(\hat{C}_t^j)^2$ and the amount of hours worked (h_t) by the household's employed members (n_t):

$$E_t \sum_{s=0}^{\infty} \beta^s \varrho_{t+s} \left[\frac{1}{1-\sigma} \left(\hat{C}_{t+s}^j \right)^{1-\sigma} - n_{t+s} \ell_{t+s}^j \right], \quad j \in \{R, NR\} \quad (29)$$

Where $\ell_t^j = \ell(h_t)$ is the disutility of work of an employed household member³, ϱ_t is an exogenous preference shock. Consumption is equal among all members of the same type of household $j = \{R, NR\}$, independent of employment status.

A.1.1 Ricardian Households

Ricardian households can save in risk-free bonds denominated in both domestic and foreign currency (B_t and B_t^*), which yield gross interest rates of r_{t+1} and r_{t+1}^* , respectively. They also invest in physical capital, K_t , which is rented to firms at a rental rate r_t^K , depreciates at rate δ , and incurs maintenance costs proportional to its utilization rate, $\bar{u}_t$.

In addition, Ricardian households own domestic firms—from which they receive dividends D_t —as well as firms operating abroad, which entitle them to a flow of foreign-currency-denominated income, REN_t^{R*} . Labor income is earned at an hourly wage rate W_t^R for working members, while non-working members receive UB_t as unemployment benefits. Taxes are paid on consumption (τ_t^C), labor income (τ_t^L), capital rental income net of depreciation and maintenance costs (τ_t^K), and dividends (τ_t^D). They also face a quarterly lump-sum tax T_t^R , and receive government transfers amounting to TR_t^R .

In the same way as the model in the body of this paper, we define the transfers from Ricardian to non-Ricardian due to the switching states and the α_k parameter that expresses the liquidity costs of capital. Taking all into account, the budget constraint can be expressed as

$$\begin{aligned} B_t^R - B_{t-1}^R + rer_t (B_t^{R*} - B_{t-1}^{R*}) &= rer_t REN_t^{R*} + TR_t^R + (1 - \tau_t^L) W_t^R h_t n_t + (1 - n_t) UB_t \\ &\quad + (r_t - 1) B_{t-1}^R + (r_t^* - 1) rer_t B_{t-1}^{R*} + (1 - \tau_t^D) D_t^R \\ &\quad + K_{t-1}^R \left[r_t^K \bar{u}_t (1 - \tau_t^K) + \tau_t^K p_t^I (\delta + \phi_{\bar{u}}(\bar{u}_t)) \right] \\ &\quad - (1 + \tau_t^C) C_t^R - p_t^I (I_t^R + K_{t-1}^R \phi_{\bar{u}}(\bar{u}_t)) - T_t^R - TR_t^{R \rightarrow NR} \end{aligned} \quad (30)$$

where

²The consumption bundle $\hat{C}_t^j \equiv \hat{C} (C_t^j - \varsigma \check{C}_{t-1}^j, C_t^G)$ is specified as a constant elasticity of substitution (CES) aggregate of the households' purchases for consumption purposes (C_t^j) and government consumption (C_t^G).

³By assumption, unemployed members do not derive any labor related disutility.

$$TR_t^{R \rightarrow NR} = (1 - \varphi_t) \left[r_t B_{t-1}^R + r_t^* \text{rer}_t B_{t-1}^{R*} + \alpha_k q_t K_{t-1}^R \right] \quad (31)$$

As on [García et al. \(2019\)](#) Ricardian households can invest on private capital. The law of motion of capital is as follows:

$$K_t^R = (1 - \delta) K_{t-1}^R + \left[1 - \phi_I \left(\frac{I_t^R}{I_{t-1}^R} \right) \right] \tilde{\omega} I_t^R \quad (32)$$

With depreciation rate $\delta \in (0, 1)$, where $\tilde{\omega}_t$ is an investment shock that captures changes in the efficiency of the investment process, I_t^R denotes capital augmenting investment expenditures, and $\phi_I = (I_t^R / I_{t-1}^R) \equiv (\Phi_I / 2) (I_t^R / I_{t-1}^R - a)^2$ are convex investment adjustment costs with elasticity $\Phi_I = \phi''(a) \geq 0$.

A.1.2 Non Ricardian Households

Similar to the baseline model the non-Ricardian consumption budget is given by

$$(1 + \tau_t^C) C_t^{NR} = (1 - \tau_t^L) W_t h_t n_t + (1 - n_t) U B_t + TR_t^{NR} - T_t^{NR} + \frac{1 - \omega}{\omega} TR_t^{R \rightarrow NR} \quad (33)$$

A.1.3 The Family Head's Problem

For arithmetic convenience, and following [Bilbiie \(2024\)](#), we assume the existence of a single utilitarian family head that makes the consumption and savings decisions for all household members, regardless of their types. The family head faces limits to risk sharing: can freely transfer resources across members of the same household group but not across groups. With this, the family head problem will maximize the utility of both household groups, subject to both budget restrictions and the law of motion of capital. Thus, the household head problem is

$$\begin{aligned} \max \quad & E_t \sum_{t=0}^{\infty} \beta^s \left\{ (1 - \omega) u_t(C_t^{NR}) + \omega u_t(C_t^R) \right\} \\ \text{s.t.} \quad & (4), (5), (6), (7) \end{aligned}$$

The family head will choose $\hat{C}_t^R, \hat{C}_t^{NR}, I_t^R, B_t^R, B_t^{R*}, K_t^R$, taking all the rest of the variables as given (complete).

The intertemporal family head's problem yields to the following Lagrangean:

$$\begin{aligned}
\mathcal{L}_t^H = E_t \sum_{s=0}^{\infty} (1-\omega)\beta^s \varrho_{t+s} & \left\{ \frac{1}{1-\sigma} \left(\widehat{C}_{t+s}^R \right)^{1-\sigma} - n_{t+s} \ell_{t+s}^R \right. \\
& + \Lambda_{t+s}^R \left[rer_{t+s} REN_{t+s}^{R*} + TR_{t+s}^R + (1-\tau_{t+s}^L) W_{t+s} h_{t+s} n_{t+s} + (1-n_{t+s}) U B_{t+s} \right. \\
& + K_{t+s-1}^R \left[r_{t+s}^k \bar{u}_{t+s} (1-\tau_{t+s}^k) + \tau_{t+s}^K p_{t+s}^I (\delta + \phi_{\bar{u}}(\bar{u}_{t+s})) \right] \\
& + (1-\tau_{t+s}^D) D_{t+s}^R + \left(rer_{t+s} r_{t+s}^* B_{t+s-1}^{R*} + r_{t+s} B_{t+s-1}^R \right) - B_{t+s}^R - rer_{t+s} B_{t+s}^{R*} \\
& + (1-\tau_{t+s}^C) C_{t+s}^R - p_{t+s}^I (I_{t+s}^R + K_{t+s-1}^R \phi_{\bar{u}}(\bar{u}_{t+s})) - T_{t+s}^R - TR_{t+s}^{R,NR} \left. \right] \\
& \Lambda_{t+s}^R q_{t+s} \left[(1-\delta) K_{t+s-1}^R + (1-\phi_I(I_{t+s}^R/I_{t+s-1}^R)) \varpi_{t+s} I_{t+s}^R - K_{t+s}^R \right] \left. \right\} \\
& + E_t \sum_{s=0}^{\infty} \omega \beta^s \varrho_{t+s} \left\{ \frac{1}{1-\sigma} \left(\widehat{C}_{t+s}^{NR} \right)^{1-\sigma} - n_{t+s} \ell_{t+s}^{NR} \right. \\
& + \Lambda_{t+s}^{NR} \left[- (1+\tau_{t+s}^C) C_{t+s}^{NR} + (1-\tau_{t+s}^L) W_{t+s} h_{t+s} n_{t+s} + (1-n_{t+s}) U B_{t+s} \right. \\
& + TR_{t+s}^{NR} - T_{t+s}^{NR} + \frac{1-\omega}{\omega} TR_t^{R,NR} \left. \right] \left. \right\}
\end{aligned} \tag{34}$$

Where $\Lambda_{t+s}^R, \Lambda_{t+s}^{NR}, q_{t+s}$ represent the discount factor of the Ricardian household, the non-Ricardian household, and the capital discount factor of the Ricardian household, respectively.

Ricardian and non Ricardian consumption FOC's Consumption itself is not affected the cyclical risk and remain the same as [García et al. \(2019\)](#)

$$\begin{aligned}
\Lambda_t^R &= \frac{1}{1+\tau_t^c} (\widehat{C}_t^R)^{-\sigma} \left(\frac{(1-o_{\widehat{C}}) \widehat{C}_t^R}{C_t^R - \varsigma \widehat{C}_{t-1}^R} \right)^{\frac{1}{\eta_{\widehat{C}}}} \\
\Lambda_t^{NR} &= \frac{1}{1+\tau_t^c} (\widehat{C}_t^{NR})^{-\sigma} \left(\frac{(1-o_{\widehat{C}}) \widehat{C}_t^{NR}}{C_t^{NR} - \varsigma \widehat{C}_{t-1}^{NR}} \right)^{\frac{1}{\eta_{\widehat{C}}}}
\end{aligned}$$

Local and foreign Bonds FOC . From the local and foreign bonds we derived the following Euler equations.

$$\Lambda_t^R = E_t \beta \left\{ \frac{\varrho_{t+1}}{\varrho_t} r_{t+1} \left(\varphi_{t+1} \Lambda_{t+1}^R + (1-\varphi_{t+1}) \Lambda_{t+1}^{NR} \right) \right\} \tag{35}$$

$$\Lambda_t^R = E_t \beta \left\{ \frac{\varrho_{t+1}}{\varrho_t} \frac{rer_{t+1}}{rer_t} r_{t+1} \left(\varphi_{t+1} \Lambda_{t+1}^R + (1-\varphi_{t+1}) \Lambda_{t+1}^{NR} \right) \right\} \tag{36}$$

Capital FOC. As contrary on what is in [Bilbie \(2024\)](#) capital FOC it is also modified. This is implied by the fact that we include capital as part of the Ricardian assets, which can liquidate to bring it to its non-Ricardian period. With this the capital FOC is as follows:

$$\begin{aligned}
q_t = E_t \beta \frac{\varrho_{t+1}}{\varrho_t} & \left\{ \frac{\Lambda_{t+1}^R}{\Lambda_t^R} \left[r_{t+1}^K \bar{u}_{t+1} (1 - \tau_{t+1}^K) + p_{t+1}^I \left[\tau_{t+1}^K \delta - \phi_{\bar{u}}(\bar{u}_{t+1}) (1 - \tau_{t+1}^K) \right] + q_{t+1} (1 - \delta) \right] \right\} \\
& + E_t \beta \frac{\varrho_{t+1}}{\varrho_t} \left\{ \alpha_k (1 - \varphi_t) q_{t+1} \frac{\Lambda_{t+1}^{NR} - \Lambda_{t+1}^R}{\Lambda_t^R} \right\}
\end{aligned} \tag{37}$$

These two FOCs are not different from [García et al. \(2019\)](#):

$$\varpi_t \left[1 - \phi_I' \left(\frac{I_t^R}{I_{t-1}^R} \right) \frac{I_t^R}{I_{t-1}^R} - \phi_I \left(\frac{I_t^R}{I_{t-1}^R} \right) \right] + E_t \beta \left\{ \frac{q_{t+1}}{q_t} \frac{\varrho_{t+1}}{\varrho_t} \frac{\Lambda_{t+1}^R}{\Lambda_t^R} \phi_I' \left(\frac{I_{t+1}^R}{I_t^R} \right) \left(\frac{I_{t+1}^R}{I_t^R} \right)^2 \varpi_{t+1} \right\} = \frac{p_t^I}{q_t}$$

$$r_t^K = \phi_{\bar{u}}'(\bar{u}_t) p_t^I$$