blank

Decory Edwards[*]

2025-06-19

Abstract

Recent empirical evidence of heterogeneity in the rate of return (an important feature of the wealth accumulation process) for individuals provide motivation for an analogous assumption in a standard heterogeneous agent (HA) macroeconomic model. In the infinite horizon setting, a uniform distribution of the rate of return across households is estimated such that empirical moments of wealth (net worth) measured in the Survey of Consumer Finances are matched particularly well by their model counterparts. These findings suggest that heterogeneity in parameters which determine optimal consumption-saving behavior other than the time preference factor can generate meaningful wealth inequality. Factors which explain differences in returns across individuals could be used to endogenize heterogeneity in the rate of return, allowing for a more robust analysis of wealth inequality using macroeconomic models. Furthermore, the finding bolsters the importance of financial literacy efforts for households, which have the potential to move households from the lower end of the return distribution to the higher end through learning.

---

[*]blank

[0]blank

1 Introduction

The unequal distribution of wealth is an extensively documented phenomenon in numerous countries. Regrettably, this feature has not only endured over time but also intensified in recent years. This point is stressed in a recent article from the Institute for Policy Studies (IPS), which revealed that in 2018, the total wealth of the poorest half of Americans was eclipsed by the combined wealth of the three wealthiest men in the nation. The term "richest" denotes one's standing in Forbes magazine's list of the 400 richest individuals. Additionally, the IPS report notes that the combined wealth of the top five richest men on this list skyrocketed by a staggering 123% from March 2020 to October 2021[1].

The unequal distribution of wealth has also been a subject of considerable interest throughout history in various fields. The statistics literature, for instance, focused on linking the distribution of income to the observable skewness in wealth distribution. The economics literature went further by establishing microfoundations for individual wealth outcomes. Similarly, the macroeconomics literature on inequality has seen significant growth, with the distribution of wealth among households offering insight into how the economy as a whole responds to aggregate fiscal shocks. The recent stimulus checks issued during the pandemic serve as a timely example of this phenomenon.

The macroeconomics literature has undergone significant changes in recent years, with the widespread adoption of models that abandon the traditional representative agent assumption in their analysis. Specifically, a model that studies the equilibrium outcomes of an economy composed of individual decision-makers using a single aggregate agent can only have one marginal propensity to consume (MPC). As a result, in response to an aggregate fiscal shock, all households would respond similarly to a one-time stimulus check, which does not align with what transpired during the pandemic[2]. Heterogeneous agent models have emerged as a prominent alternative, offering a more accurate representation of the diversity of economic behaviors and outcomes among households.

The first departure from the representative agent framework entails positing an exogenously determined income process that generates a distribution of income among households. One common approach to incorporating heterogeneity is to adopt Friedman 1957's description of a permanent and transitory component in the income process. To account for business cycle dynamics, one can further assume that individuals face some level of potential unemployment in each period, creating a precautionary savings motive for consumers. Given that such uncertainty cannot be fully insured against, the availability of a riskless asset that partially insures against income risk results in households choosing

---

[1]See Inequality.org articles data November 21, 2022: "Wealth Inequality in the United States" and "Updates: Billionaire Wealth, U.S. Job Losses and Pandemic Profiteers" (date accessed: March 27, 2023)

[2]Parker et al. 2022 note that "In sum, while on average the [economic impact payments] EIPs appear to have gone to many households with incomes that were unharmed by the pandemic, some of the EIPs, mainly in the first round, did support short-term spending for some households, primarily those with low ex ante liquid wealth and those reliant on income that could not be earned by working from home."

to hold different levels of market resources optimally.

Krusell and Smith 1998's seminal work suggests that models assuming heterogeneity in individual income perform well in matching the aggregate capital stock but poorly in matching the distribution of wealth. The resulting optimal consumption function is concave in an individual's wealth holdings, meaning that the marginal propensity to consume out of income is increasingly higher at lower levels of wealth. Therefore, a model that places too many households in the middle of the wealth distribution relative to those at lower levels will struggle to match the average MPC estimated from household data. Since our focus is on the implications of fiscal policy for the entire economy, a macroeconomic model's failure to match the observed wealth distribution in its implied equilibrium is significant.

Moving beyond the standard representative agent framework, the next step is to assume greater heterogeneity among households, leading more households to optimally hold lower levels of wealth. Kaplan and Violante 2022's recent work provides a comprehensive survey of models that reject this assumption, instead utilizing heterogeneous agent, incomplete markets models featuring (i) uninsurable idiosyncratic income risk, (ii) a precautionary savings motive, and (iii) an endogenous wealth distribution.

Carroll et al. 2017 adopt this approach and further extend the baseline setting to allow for ex-ante heterogeneity amongst households. Specifically, they assume different agents have different rates of time preference, which reflects implicit characteristics of households relevant to their lifetime wealth accumulation. The authors find that this assumption of modest heterogeneity in time preferences is sufficient to match both the shape and skewness of the empirical distribution of wealth. Furthermore, while traditional representative agent models generate an aggregate marginal propensity to consume between 0.02 and 0.04, the β-dist model generates an aggregate MPC between 0.2 and 0.4. This range falls within the values estimated across households in the data.

The household's optimal consumption-savings problem contains additional elements that could contribute to disparities in wealth accumulation over the course of one's lifetime. It is worth noting that the time preference factor (β) is one of the key parameters that influences an individual's equilibrium target level of market resources, but it is not directly observable. Therefore, in order to estimate β, one would need to gather data through surveys or other methods that allow for the direct acquisition of information from households.

On the other hand, estimating differences in the rate of return to financial assets across households is possible, as this variable *is* directly observable. Empirical research has been conducted to estimate such differences, with a recent example being the work of Fagereng et al. 2020. They analyzed 12 years of administrative tax records on capital income and wealth stock for all taxpayers in Norway from 2004-2015 to estimate these rates of return.

This paper aims to enhance the computational, heterogeneous agent modelling framework by integrating recent empirical evidence on disparities in rates of return among households. The objective is to better align the observed wealth distribution with the model predictions, thereby generating more realistic esti-

mates of the average marginal propensity to consume among households.

2 Literature Review

2.1 Collecting Data on the Distribution of Wealth

First and foremost, as the primary focus of models in this field is the distribution of wealth, empirical estimates of the skewness in wealth holdings over time provide valuable insights for this paper. Surveys and the imputation of wealth levels using administrative income tax data (sometimes referred to as the *capitalization method*) are the standard ways of collecting household data on the distribution of wealth for empirical analysis.

Wolff 2004 provides an early analysis of measurements of wealth by the Survey of Consumer Finances (SCF)[3] by discussing both the concentration and composition of household wealth 1980s and 1990s. The author's analysis corroborates the story of significant and growing inequality in the distribution of wealth in the U.S. Specifically, although the wealth of the average household grew in the 1990s, most of the gains in wealth and income during this period were enjoyed by the upper 20 percent of the wealth distribution, and especially the top 1 percent. While from 1983 to 2003 the top 1 percent experienced 33 percent of the total growth in net worth (89 percent for the top 20 percent), the average wealth of the poorest 40 percent of households fell by 44 percent during this same time period and had reached roughly $2,900 by 2001.

Saez and Zucman 2014 employs the capitalization method on tax data from the Internal Revenue Service to estimate the distribution of wealth in the United States for a much longer time period of 1913 to 2012. The usefulness in the authors' approach is that they are able to decompose their measure of wealth and savings into fractiles (i.e. top 1 percent, top 10 percent, bottom 20 percent wealth shares), which allows them to analyze the evolution of wealth over time in a way that is standard in the existing literature on wealth inequality. The authors not only find that inequality in the U.S. wealth distribution is realtively high and has been growing significantly in the later periods of their dataset, but they also attribute this growth primarily to the wealthiest of households. Indeed, they cite that the wealth shares of the top .1 percent of the distribution grew from 7 percent in 1978 to 22 percent in 2012.

2.2 Explaining Inequality in the Distribution of Wealth

Benhabib and Bisin 2018 conducted a notable, thorough review of the literature on the documented skewness in the distribution of wealth. The survey begins with historical accounts of the origins of the shape of the wealth distribution, dating back as early to Pareto and Samuelson. The authors then provide the

---

[3]See Kennickell 2017a for an extensive description of the methodology for sampling the wealthist households in the SCF and Kennickell 2017b for an analysis of the performance of the SCF at measuring the wealth of the top 1 percent.

traditional theoretical explanations of this unequal distribution: (i) skewness in the (exogenous) distribution of earnings, (ii) stochastic returns to wealth and savings, and, importantly, (iii) microfoundations for the evolution of wealth resulting from the consumption and saving behavior of hosueholds[4].

Gabaix et al. 2016 define a notion for the speed of convergence to provide an explanation for observed evolution of income inequality over time, specifically in the upper tail of the distribution in the past 40 years in the United States. Notably, the authors show that, in order to match the empirical dynamics of inequality, one needs to allow for more forms of heterogeneity in the income process for households that are not incorporated in the standard consumption and saving models.[5] The first form is *type dependence* in the income growth rate distribution, which models the case in which some households have a higher average income growth rate. The second form, *scale dependence*, captures the fact that higher income levels are more susceptible to shocks to their income growth. The authors find that former does a good job at explaining this fast rise in income inequality, and the latter can generate infinitely fast transitions in inequality.[6]

De Nardi and Fella 2017 provide another survey of the literature, more focused on the microfoundations for the distribution of wealth. Specifically, the authors note a number of possible extensions of models of household consumption and saving behavior, inspired by observable differences and the demographics of households, which lead to differences in wealth accumulation over time. Earnings and rate of return risk, ex-ante heterogeneity in preferences, medical expenses, bequest motives, and entrepreneurship are all cited as potential avenues to better explain the shape of the distirbution of wealth using the behavior of households.

2.3 Heterogeneous Agents Macroeconomics: Wealth and the Marginal Propensity to Consume

Guvenen 2011 provide an excellent review of the heterogeneous agent models which have become common frameworks of analysis in the macroeconomics literature in the recent decade. The key insights from this survey can be found in its thorough disucssion on the relationship between the complete markets hypothesis and varying degrees of insurance against risk for households. In addition, the authors make a notable distinction between aggregation and representative-agent models; this is important, although the macroeconomics models with incomplete markets and heterogeneous agents of interest may lack

---

[4]As explored in the next section, the emergence of heterogeneous agent models has been a significant development in investigating this issue. Bewley 1983, Aiyagari 1994, and Huggett 1993 are among the earliest examples.

[5]Note that, although this analysis is about the distribution of income, this literature notably asserts that the distirbution of wealth inherits some of its skewness from the distribution of income

[6]As we will see, these notions of "type dependence" and "scale dependence" show up in the literature on household heterogeneity and the wealth and income distributions; most importantly, in the discussion on heterogeneous rates of return to wealth.

a representative-agent counterpart for which the equilibrium analysis is straighforward[7] (since these models can generally be solved analytically), computational and numerical methods may be used to conduct a similar analysis of the equilibrium, aggregate implications of such a model. Lastly, each of these key points of the paper are grounded both in theoretical results regarding static and dynamic economies with optimizing households and firms, and also in empirical evidence on both the inherent risk faced by households and the varying degrees of available insurance against these risks.

Krueger, Mitman, and Perri 2016 provide another review of the heterogeneous agent macroeconomics literature. Here, more emphasis is placed on empirical evidence of heterogeneity across households (in earnings, income, consumption, and wealth) leading up to and during the Great Recession and incorporating features of the business cycle in the model of household consumption and saving to better match the presented cross-sectional data. Furthermore, the authors present an augmented version of the model incorporating demand externalities to analyze the realtionship between the distribution of wealth and the dynamics of aggregate output.

The key insight from the heterogeneous agent macroeconomics literature is in the ability of these models to produce an aggregate marginal propensity to consume which is reasonably close to its empirical counterpart. This is a notable failing of the representative-agent framework. Kaplan and Violante 2022 have conducted an extensive analysis of different classes of models in this area, highlighting their strengths and potential drawbacks. Notably, they find that the heterogeneous agent, incomplete markets framework with a single asset generate a marginal propensity to consume that is too low compared to empirical data. While incorporating ex-ante heterogeneity or behavioral preferences can generate a larger MPC, these models tend to suffer from a "missing middle" problem - an equilibrium distribution that is overly polarized at the extremes and underestimates the wealth held by middle-income households. As a result, it is worth exploring whether a model that includes one asset, a precautionary savings motive, and ex-ante heterogeneous rates of return also exhibits this shortcoming.

Krusell and Smith 1998 have developed a model that considers both idiosyncratic and aggregate risk in a household's optimization problem. As an additional exercise, they incorporate heterogeneity in time preference to explain the shape of the wealth distribution. More recently, Carroll et al. 2017 have updated the model to include income and time preference heterogeneity, with a more realistic income process that accounts for permanent and transitory shocks to household income. The model's analytical framework is flexible enough to accommodate other potential sources of ex-ante heterogeneity, which can be seen in one of its key equilibrium conditions - the *Growth Impatience Condition* (GIC):[8]

---

[7]In fact, as the authors note, some heterogeneous agent models may feature "approximate aggregation" properties, where the aggregate implications of the model are very close to the implications of some representative agent model

[8]Note that β is the time discount factor, ρ is the coefficient of relative risk aversion, $\not{D}$ is

$$\left(\frac{(R\delta)^{1/\rho}\mathbb{E}[\psi^{-1}]\not{D}}{\Gamma} \right) \quad < \quad 1.$$

2.4 Measurements of heterogeneous rates of return

The rationale behind incorporating heterogeneity in rates of return to asset holdings lies in the use of novel datasets in recent empirical research to quantify the differences in returns among individuals. Fagereng et al. 2020 offer an extensive overview of the role that heterogeneous rates of returns play in wealth distribution, as well as conducting their own systematic analysis of return heterogeneity using 12 years of data from Norway's administrative tax records. The authors' findings reveal substantial differences in the average returns to assets for individuals (*type dependence*), that this heterogeneity is found both within and across classes of assets with varying levels of risk, and that returns are positively correlated with wealth (*scale dependence*). Moreover, they futher demonstrate that this discovery of heterogeneous returns exhibits significant persistence over time and are positively correlated across generations. Each of these findings provide not only motivation for the assumption of ex-ante heterogeneous rates of return in the buffer-stock savings model of households, but also provide a benchmark to compare the distribution of rates of return resulting from the estimation procedure aimed at best matching the empirical distirbution of wealth, as in Carroll et al. 2017.

Bach, Calvet, and Sodini 2018 provide more evidence towards the assumption of ex-ante heterogeneity in households' rates of return, as they employ administrative panel data on the balance sheets of Swedish residents to gauge historical and expected returns, as well as risks associated with asset holdings. Like previous studies, they also find that heterogeneous returns play a considerable role in the levels and growth of top wealth shares over time. As their analysis is focused on the portfolio performance of wealthy households, their findings offer more support for the idea that scale dependence is an important feature of the observed heterogeneity in the rate of return for households.

Campbell, Ramadorai, and Ranish 2019 offers a similar conclusion in their analysis by studying wealth held in equity accounts in India between 2002 and 2011. The authors find that heterogeneity in returns to investment, which can be acheived by both the inherent randomness associated with risky investment and differences in the investment strategies of investors, is a main contributor to the increase in inequality of wealth held in equity portfolios during the time period. Here, the authors attribute the scale dependence associated with the returns to equity portfolios to the finding that smaller accounts tend to be poorly diversified relative to their larger account counterparts.

Deuflhard, Georgarakos, and Inderst 2018 provide an important analysis for the heterogeneous agent, incomplete markets model with a precautionary saving

---

the survival probability, $\mathbb{E}[\psi^{-1}]$ is the expectation of receiving permanent shock ψ, $R_t = \daleth + r_t$, where $\daleth$ is the depreciation rate of capital and r_t is the interest rate, and Γ is labor productivity growth.

motive and a *single asset* to partially insure against risk with by studying the performance of households' investments in savings accounts. Not only do they find substantial type dependence in the rate of return to these safe assets, they also attribute the heterogeneity in returns to differences in financial sophistication. As we will see in the next section, providing an explanation for differences in returns to investments for households is a vital step in potentially endogenizing this form of ex-ante heterogeneity among households in future research. Much like the Fagereng et al. 2020, comparing the estimated distirbution of rates of return across households to the results of this paper is crucial, especially since the authors' focus is on heterogeneous returns to safe assets.

Altmejd, Jansson, and Karabulut 2024 is a recent work which provides causal evidence of financial education leading to significant differences in portfolio returns. Using university application data from the Swedish National Archives and data from the Swedish Income and Wealth registry, they show that indivduals marginally admitted to business or economics programs not only hold more money in stocks but earn a higher raw return on these holdings than their counterparts.

2.5   Recent HA models with heterogeneous rates of return

The paper Daminato and Pistaferri 2024 incorporatres heterogeneous returns into the solution of a model of consumption-saving for households. There, they use data from the PSID to document heterogeneity in returns, which they state is comparable to that found in the Norwegian registry data used by Fagereng et al. 2020.

Benhabib, Bisin, and Luo 2019 proposes an overlapping generations model that incorporates intergenerational wealth transfers. There, agents face uncertainty regarding both labor and capital income. Benhabib, Bisin, and Luo 2017 undertake a similar exercise, where household preferences for bequests to the next generation are more explicitly defined. Both papers conclude that the distribution of earnings and differences in rates of savings and bequests are crucial in matching the characteristics of the observed wealth distribution's tail ends.

Guler, Kuruscu, and Robinson 2022 develop a life-cycle model that provides a comprehensive description of households' optimal decision-making to endogenize heterogeneity in the rate of return. In addition to the standard consumption-savings behavior, their model also considers optimal choices regarding housing and mortgage decisions. These modeling choices lead to a structural model that better matches the observable size and skewness of the wealth distribution, using realistic features of the household's decision-making process, as a larger number of individuals actively engage with the housing market than with financial markets. Furthermore, these modeling choices enable the authors to investigate the effects of aggregate fiscal shocks, including one-time stimulus payments and mortgage debt relief programs.

3 Mechanism for returns heterogeneity

There have been a number of potential explanations proposed regarding the persistent component of returns heterogeneity. Among the more common ones is the idea that there are some business owners in the economy, and variability among their entrepreneurial talent leads to even more heterogeneity in labor income than the assumptions about labor income uncertainty that the standard HA models use. Cagetti and De Nardi 2006 and Cagetti and De Nardi 2009 are notable exmaples of explicitly modeling entrepreneurial talent as a compoenent of the consumption-saving problem for households and assesing the ability of such models in matching empirical wealth moments.

Although differences in entreprenuerial talent modeled as variability in labor market productivity allows for the model to better match wealth moments at the upper tail of the distribution, it is an unsavory explanation for the mechanism I have in mind in this paper. Namely, this modeling choice will result in households (firms) with high levels of wealth (capital) earning lower rates of return, and vice versa for households (firms) with low levels of wealth (capital). As mentioned before, Fagereng et al. 2020 documents scale dependece regarding wealth heterogeneity: that returns, as well as the idiosyncratic, persistent component of returns, are positively correlated with wealth.

Another explanation from the literature which is closer to, but still not exactly the same as, the mechanism which allow two households with the same level of assets to earn a different return on them is financial literacy or sophistication. Lusardi and Mitchell 2014 offers a survey on models which explicitly allow for households to make a costly decision to build up a stock of financial literacy, in turn allowing them access to an investment technology offering a higher average return. Lusardi, Michaud, and Mitchell 2017 show that allowing for such endogeneous financial accumulation in the standard consumption-saving framework again allows the model to match wealth moments particularly well, this time through this returns channel (as opposed to the labor income channel associated with entrepreneurial talent).

The costly acquisition of a stock of human capital (i.e. financial knowledge) led to further heterogeneity in the rate of return. Along this line of reason, I investigate another cause for heterogeneity in the rate of return offered on assets by following literature which documents substantial heterogeneity in the banking sector, specifically on rates offered to depositors.

3.1 Deposit rates and bank global integration

As mentioned before, Deuflhard, Georgarakos, and Inderst 2018 and others have shown that there can be substational heterogeniety in rates of return earned by depositors. The key step in incorporating this finding in the standard consumption-saving framework is to identify potential sources of this heterogeniety in banking.

Consider the balance sheet of domestic (U.S. in my example) banks within the financial sector and the problem they face in optimally choosing the rate to

offer on deposits. In an open economy, one can imagine that foreign investors may also demand to hold some of their assets in a domestic bank. In such a setting, the elasticity of deposit rates relative to changes in foreign deposits can be clearly studied. Moreover, if there is a prevailing market interest rate, which is available to both foreign and domestic lenders, there is a clear transmissions channel: market rates may rise, causing the level of foreign deposits to fall wherever the new market rate is substantially larger than the current deposit rate being offered. Ultimately, this should lead to a corresponding reduction in the offered deposit rate, although the change may not be one-to-one. This mechanism is precisely the one found empirically in a recent paper by Ahmed 2025.

The strength of this transmission channel can be viewed as a potential source of heterogeneity in the banking sector, as certain market characteristics would make the deposit rates offered by some banks less sensitive to changes in foreign deposits than other banks. For example, Sarkisyan and Viratyosin 2021 make a distinction between *local* and *globally integrated* banks, and show that "global banks lose much more deposits relative to local banks in response to unexpected changed in the federal funds rate" [9].

With this in mind, the next step is to extend the standard HA model describing household consumption-saving decisions by explicitly modeling a banking sector with local and globally integrated banks. In this setting, it will be clear how heterogeneity in returns may arise for households which are otherwise the same.

4   Model

Here I present a small, open economy with banks and households as the optimizing agents in the model. This will be a partial equilibrium analysis since the world interest rate is being taken as given. That said, I present a simple framework for describing the optimal behavior for banks setting deposit rates. By assuming that there is a cobb-douglas aggregate production function, I will find the marginal product of capital (less depreciation) that is consistent with the capital to output ratio from the model which matches its empirical counterpart. This effective interest rate will be considered the world or "market" interest rate and will be used along with the estimated distribution of heterogeneous returns to back out esetimated values for elasticites of foreign deposits to the deposit rates for each of the banks in the model.

4.1   Banking sector

There are a continuum of banks, deemed either globally integrated or local. Whether or not a bank falls within a given category depends solely on the

---

[9]Adrien d'Avernas, Andrea L. Eisfeldt, Can Huang, Richard Stanton, Nancy Wallace 2024 show a similar finding regarding heterogeneity in deposit rates, but for largers vs smaller banks

elasticity of their offered deposit rate to changes in the level of foreign deposits.

The model is static in that, I assume that the level of foreign deposits at either bank type is constant across all periods. Additionally, a given bank cannot take actions to increase the number of depositors (foreign or domestic) at their given institution [10].

Lastly, in this simple version of the model, I assume that households do not endogenously choose a bank type to do business with. Clearly, this would lead us towards the literature on costly human capital acquisition and financial literacy. Instead, I assume that a bank type, either globally integrated or local, is assigned to a household at birth with some probability. The household is "stuck" with this bank assignment until death.

This means that I will need to think carefully about how I will allocate households to banks (i.e. by ad-hoc means or using available data) in the calibration and simulation of the model.

4.1.1 Decision problem for banks accepting foreign deposits

Note that we may view the distinction between globally integrated and local banks as a source of bank heterogeneity, indexed by ε_i. This will be the source of returns heterogeneity in the model. With this in mind, I propose a simple version of a model of monopolistic competition among hetergoeneous banks introduced by Monti 1972 and Klein 1971.

Let R^m be the market rate of return, $R^d d$ be the rate of return offered on deposits, and $S(R^d)$ be the level of foreign deposits held at a given bank. Banks solve the following optimization problem

$$\max(R^m - R_i^d)S_i(R^d)$$

subject to the constraint that foreign deposit demand is given by the function $S_i(R^d) = A_i(R_i^d)^{\varepsilon_i}$, where A_i is some constant.

Importantly, the first order condition implies that the optimal deposit rate for the i-th bank is given by

$$R_i^d = \frac{\varepsilon_i}{1 + \varepsilon_i} R^m$$

. This is crucial for the model in that, so long as we calibrate the model for a particular value of R^m, estimating a uniform distribution of returns using the simulated method of moments will imply a corresponding distribution of elasticities (the one that minimizes the distance between simulated and lorenz wealth moments.) In this way, the 7 discretized points capturing 7 different deposit rates offered corresponds to 7 different bank types, which can be distinguished as either global or local based on their elasticities since, from the expression above, banks with higher values of ε_i (i.e. global banks) must set R_i^d closer to R^m. The reverse would be true for local banks.[11]

---

[10]For example, compare a bank in a suburb area of Montana (local) versus a bank near downtown Houston, Texas (globally integrated).

[11]IN the conclusion, I discuss in detail two major drawbacks on my simple version of a source for returns heterogeneity in this model, which could be exploted in future work.

4.2 Households

4.2.1 Defining the stochastic income process

Each household's income (y_t) during a given period depends on three main factors. The first factor is the aggregate wage rate (W_t) that all households in the economy face. The second factor is the permanent income component (p_t), which represents an agent's present discounted value of human wealth. Lastly, the transitory shock component (ξ_t) reflects the potential risks that households may face in receiving their income payment during that period. Thus, household income can be expressed as the following:

$$y_t = p_t \xi_t W_t.$$

The level of permanent income for each household is subject to a stochastic process. In line with Friedman 1957's description of the labor income process, we assume that this process follows a geometric random walk, which can be expressed as:

$$p_t = p_{t-1}\psi_t,$$

The white noise permanent shock to income with a mean of one is represented by ψ_t, which is a significant component of household income. The probability of receiving income during a given period is determined by the transitory component, which is modeled to reflect the potential risks associated with becoming unemployed. Specifically, if the probability of becoming unemployed is $\mho$, the agent will receive unemployment insurance payments of $\mu > 0$. On the other hand, if the agent is employed, which occurs with a probability of $1 - \mho$, the model allows for tax payments τ_t to be collected as insurance for periods of unemployment. The transitory component is then represented as:

$$\xi_t = \begin{cases} \mu & \text{with probability } \mho, \\ (1 - \tau_t)l\theta_t & \text{with probability } 1 - \mho, \end{cases}$$

where l is the time worked per agent and the parameter θ captures the white noise component of the transitory shock.

4.2.2 Decision problem for households

This paragraph presents the baseline version of the household's optimization problem for consumption-savings decisions, assuming no ex-ante heterogeneity. In this case, each household aims to maximize its expected discounted utility of consumption $u(c) = \frac{c^{1-\rho}}{1-\rho}$ by solving the following:

$$\max \mathbb{E}_t \sum_{n=0}^{\infty} (\cancel{D}\beta)^n u(c_{t+n}).$$

It's worth noting that the setting described here follows a perpetual youth model of buffer stock savings, similar to the seminal work of Krusell and Smith

1998. To solve this problem, we use the bellman equation, which means that the sequence of consumption functions $\{c_{t+n}\}_{n=0}^{\infty}$ associated with a household's optimal choice over a lifetime must satisfy[12]

$$
\begin{aligned}
v(m_t) &= \max_{c_t} u(c_t(m_t)) + \beta \cancel{D} \mathbb{E}_t[\psi_{t+1}^{1-\rho} v(m_{t+1})] \\
&\text{s.t.} \\
a_t &= m_t - c_t(m_t), \\
k_{t+1} &= \frac{a_t}{\cancel{D}\psi_{t+1}}, \\
m_{t+1} &= (\daleth + r_t)k_{t+1} + \xi_{t+1}, \\
a_t &\geq 0.
\end{aligned}
$$

5 Results

5.0.1 The model with no returns heterogeneity

To solve and simulate the model, I follow the calibration scheme captured in table 1.

Description	Parameter	Value	Source
Time discount factor	β	0.99^4	Den Haan, Judd, and Juillard 2010
CRRA	ρ	1	Den Haan, Judd, and Juillard 2010
Capital share	α	0.36	Den Haan, Judd, and Juillard 2010
Depreciation rate	δ	0.025	Den Haan, Judd, and Juillard 2010
Time worked per employee	ℓ	$1/.09$	Den Haan, Judd, and Juillard 2010
Wage rate	W	2.37	Den Haan, Judd, and Juillard 2010
Unempl. insurance payment	μ	0.15	Den Haan, Judd, and Juillard 2010
Probability of survival	$\cancel{D}$	$(1 - 0.00625)^4$	Yields 40-year working life
Std. dev of $\log \theta_{t,i}$	σ_θ^2	$0.010 \times 4 \times \sqrt{4}$	Carroll 1992,
			Carroll, Slacalek, and Tokuoka 2015
Std. dev of $\log \psi_{t,i}$	σ_ψ^2	$0.010 \times 4/11 \times \sqrt{4}$	Carroll 1992,
			Debacker et al. 2013,
			Carroll, Slacalek, and Tokuoka 2015
Unemployment rate	$\mho$	0.07	Mean in Den Haan, Judd, and Juillard 2010

Table 1: Parameter values (annual frequency) for the perpetual youth model.

The solution of the model with no heterogeneity in returns (the R-point model) is the one which finds the value for the rate of return R which minimizes the distance between the simulated and empirical wealth shares at the 20th, 40th, 60th, and 80th percentiles. The empirical targets are computed using the 2004 SCF data on household wealth. The estimation procedure finds this optimal value to be $R = 1.0602$.

5.0.2 Incorporating heterogeneous returns

As noted above, recent studies by Fagereng et al. 2020 and Bach, Calvet, and Sodini 2018 have not only estimated the rate of return on asset holdings but

---

[12]Here, each of the relevant variables have been normalized by the level of permanent income ($c_t = \frac{C_t}{p_t}$, and so on). This is the standard state-space reduction of the problem for numerical tractibility.

have also uncovered significant heterogeneity across households. With this in mind, the next estimation (the R-dist model) assumes the existence of multiple types of agents, each earning a distinct rate of return on their assets.

I follow closely the procedure outlined by Carroll et al. 2017. Specifically, I assume that different types of households have a time preference factor drawn from a uniform distribution on the interval $(\grave{R} - \nabla, \grave{R} + \nabla)$, where ∇ represents the level of dispersion. Afterward, the model is simulated to estimate the values of both $\grave{R}$ and ∇ so that the model matches the inequality in the wealth distribution. To achieve this, the following minimization problem is solved:

$$\{\grave{R}, \nabla\} = \arg\min_{R, \nabla} \left(\sum_{i=20,40,60,80} (w_i(R, \nabla) - \omega_i)^2 \right)^{\frac{1}{2}}$$

subject to the constraint that the aggregate capital-to-output ratio in this model matches the calibrated value 5. This is towards the upper bound on plausibly calibrated values for the capital-to-output ratio, as much of the literature chooses values between $2 - 3$.

Note that w_i and ω_i give the porportion of total aggregate net worth held by the top i percent in the model and in the data, respectively.

The estimation procedure finds this optimal values of $R = 1.0212$ and $\nabla = 0.06728$. These parameter values pin down the estimated uniform distribution. In the model, I've chosen to discretize that distribution to 7 chosen points. The performance of the estimation of both the R-point and R-dist models, measured by their ability to match the SCF data, is compared in figure 1.
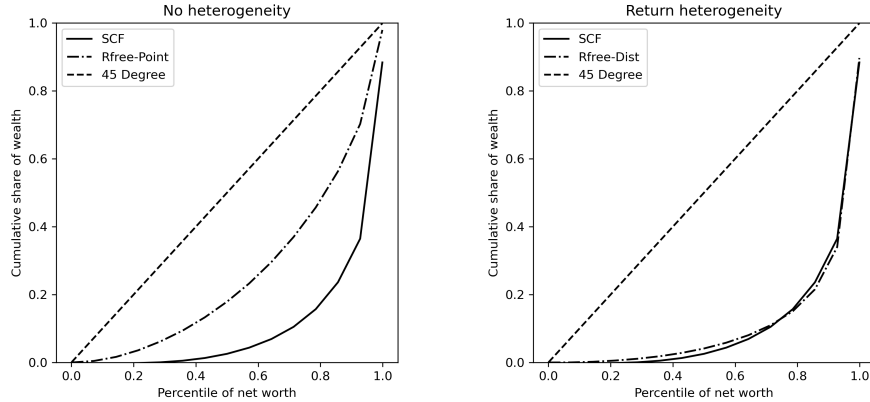

Figure 1: Comparison of R-Point and R-Dist Models.

5.1   Incorporating life cycle dynamics into the model

More realistic assumptions regarding the age and education level of households can have important implications for the income and mortality process of house-

holds. Here, I extend the model to incorporate these life cycle dynamics.

Households enter the economy at time t aged 24 years old and are endowed with an education level $e \in \{D, HS, C\}$, and initial permanent income level $\mathbf{p}_0$, and a capital stock k_0. The life cycle version of household income is given by:

$$y_t = \xi_t \mathbf{p}_t = (1 - \tau)\theta_t \mathbf{p}_t,$$

where $\mathbf{p}_t = \psi_t \bar{\psi}_{es} \mathbf{p}_{t-1}$ and $\bar{\psi}_{es}$ captures the age-education-specific average growth factor. Households that have lived for s periods have permanent shocks drawn from a lognormal distribution with mean 1 and variance $\sigma^2_{\psi s}$ and transitory shocks drawn from a lognormal distribution with mean $\frac{1}{\not{\theta}}$ and variance $\sigma^2_{\theta s}$ with probability $\not{\theta} = (1 - \mho)$ and μ with probability $\mho$.

The normalized version of the age-education-specific consumption-saving problem for households is given by

$$
\begin{aligned}
v_{es}(m_t) &= \max_{c_t} u(c_t(m_t)) + \beta \not{D}_{es} \mathbb{E}_t[\psi_{t+1}^{1-\rho} v_{es+1}(m_{t+1})] \\
&\text{s.t.} \\
a_t &= m_t - c_t, \\
k_{t+1} &= \frac{a_t}{\psi_{t+1}}, \\
m_{t+1} &= (\daleth + r_t)k_{t+1} + \xi_{t+1}, \\
a_t &\geq 0.
\end{aligned}
$$

The additional parameters necessary to calibrate the life cycle version of the model are given in table 2.

Description	Parameter	Value
Population growth rate	N	0.0025
Technological growth rate	Γ	0.0037
Rate of high school dropouts	θ_D	0.11
Rate of high school graduates	θ_{HS}	0.55
Rate of college graduates	θ_C	0.34
Labor income tax rate	τ	0.0942

Table 2: Parameter values (annual frequency) for the lifecycle model.

The estimation procedure finds this optimal value to be $R = 1.0414$ for the R-point model in this setting. The estimation procedure for the R-dist model in the life cycle setting finds optimal values of $R = 1.0343$ and $\nabla = 0.03557$. Notice the improved performance of the estimation in matching the data displayed in figure 2.

5.2 The implied distribution of bank heterogeneity

First, recall that we provided a simple model for the bank's decision problem, where profits depend only on the dispersion between the market interest rate
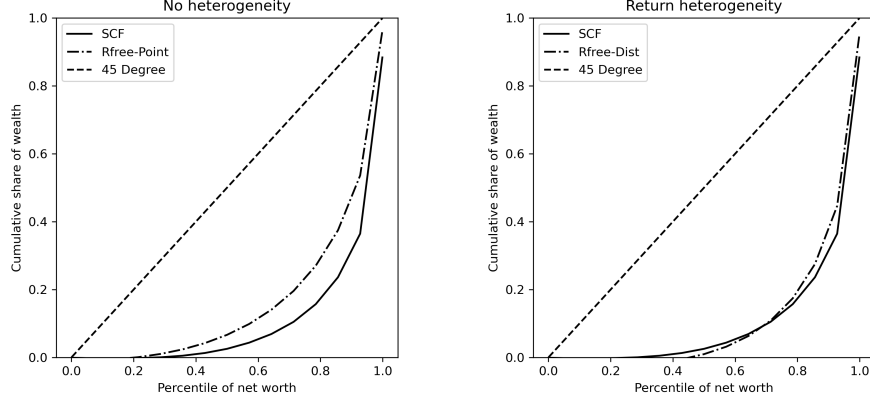
Figure 2: Comparison of R-Point and R-Dist Models in the Life-Cycle Setting.

R^m and the offered deposit rate R^d and the level of foreign deposits that the banks hold. Since I chose to model the demand for foreign deposits with an isoelastic demand function $S_i(R^d) = A_i(R_i^d)^{\varepsilon_i}$, this implies that the *elasticity of foreign deposits to the interest rate* is given by

$$\varepsilon_i = \frac{\partial S_i(R^d)}{\partial R^d} \frac{R^d}{S_i(R^d)} \tag{1}$$

for each bank i. Thus, since I've estimated the distribution of returns which matches the wealth moements, I can use this feature of the model to back out an implied distribution of ε, which will describe how the banks differ in their sensitivities to foreign deposit outflows, ultimately affecting their optimal choice of the offered deposit rates.

To do this, I assume that the aggregate production function is Cobb-douglas, so that the marginal product of capital can be written as $\alpha \frac{Y}{K}$. With the calibrated values $\delta = .025$, $\alpha = .36$, and the capital to output ratio 3 matched by using the 2004 SCF, this setting has an effective interest rate of $R^m = 1.095$ which can be used as the market interest rate.

Since the model with heterogeneity (i.e. the R-dist model) has 7 estimated points for the uniform distribution, the implied, estimated points for ε are given by $[0.0423, 0.1731, 0.3414, 0.5661, 0.8812, 1.3551, 2.1482]$. Following the logic of the elasticity of foreign deposits to the interest rate in the work by Sarkisyan and Viratyosin 2021, globally integrated banks would face larger foregin deposit outflows when the offered deposit rate is significantly further than the market interest rate. These would be precisely the banks with higher elasticities – in my descritized model with 7 points, this would suggest that the last two banks may be interpreted as globally integrated. The individuals "stuck" with banking at this institution (since I assume that households cannot switch banks) would be

15

relatively better of than their counterparts, as they will receive a higher offered deposit rate.

5.3 Untargeted moments

It is well-documented in the literature on heterogeneous agent modeling that, adding a source of (ex-ante) heterogeneous beyond the addition of labor income uncertainty to the representative agent framework will allow the simulated distribution of wealth to match moments of the empirical wealth distribution particularly well. So, although it is useful to see that the model with heterogeneous returns does a good job of matching the given lorenz targets, we need another way to assess the model's performance.

For this reason, I include age-dependent wealth moments from the same wave of the SCF to serve as untargeted moments 3. These can be found in the following table 3.

Empirical Lorenz Shares (10-Year)

age	20th	40th	60th	80th
25-30	-0.0723	-0.0657	-0.0266	0.1099
30-40	-0.008	0.0054	0.057	0.1813
40-50	-0.0001	0.0187	0.0776	0.2178
50-60	0.0018	0.0215	0.0766	0.2126
60-70	0.0011	0.0188	0.0726	0.2081

Figure 3: Empirical Lorenz Curve Targets from the 2004 SCF.

The next two tables present the simulated version of the untargeted moments for the model without heterogeneity 6, and then with heterogeneity 7. As you can see from the tables 6 and 7 below, the age-dependent Lorenz targets that arise from the model again fit the data much better when returns heterogeneity is present versus when it is absent.

Simulated Lorenz Shares (10-Year)

age	20th	40th	60th	80th
25-30	0.0016	0.0325	0.0978	0.2372
30-40	-0.0003	0.039	0.1227	0.2947
40-50	0.0134	0.0639	0.1626	0.3536
50-60	0.0233	0.0809	0.1859	0.3776
60-70	0.0227	0.0779	0.18	0.3684

Figure 4: Simulated Untargeted Moments without Heterogeneity (R-point).

Simulated Lorenz Shares (10-Year)

age	20th	40th	60th	80th
25-30	-0.0043	0.023	0.0858	0.2252
30-40	-0.0227	-0.0014	0.066	0.2317
40-50	-0.0135	0.0063	0.0727	0.2451
50-60	0.002	0.0295	0.1025	0.2757
60-70	0.0038	0.0325	0.1052	0.2748

Figure 5: Simulated Untargeted Moments with Heterogeneity (R-dist).

6 Conclusion

In this paper I find the ex-ante heterogeneity in rates of return needed to match wealth moments, which is a common practice in heterogeneous agent macroeconomics. The model sits well with other deviations from the representative agent framework in that it does a good job of producing a simulated distribution of wealth with significant skewness when compared to its empirical counterpart.

This paper is slightly different from the literature which intersects HA models and evidence of a persistent component to returns in that I focus less on common explanations for the latter (like entrepreneurial talent and financial sophistication). Instead, I focus more on heterogeneity in the banking sector, which follows nicely with literature on monopolistic competition in the banking sector. I incorporate that literature in the standard HA framework with a simple, but realistic story in that many households may be "stuck" with the bank in or around their neighborhood. That bank has complex financial decisions to make, which ultimately trickles down to the household through the channel of verying deposit rates offered.

Although I leave out the possibility of households switching to one bank or another, this story has a similar essence to the financial literacy story when attempting to explain how returns may be heterogeneous across individuals. However, it leaves out the risk associated with portfolio choice. This is a nice feature, since (i) untangling how much of the persistent component of returns comes from risk preferences and from financial sophistication is not so straightforward and (ii) there is significant heterogeneity in returns even when individuals hold no risky assets.

6.1 Drawbacks of the model of bank heterogeneity

First, this is still a partial equilibrium model. The market interest rate is being taken as given. It is not determined by some market clearing condition.

I view my model as the simplest implementation of a potential source of heterogeneity. With that in mind, in the simulation of the model and the resulting SMM estimation, I do not add banks as an agent type. Thus, the bank is not responding in every period to the level of deposits they receive after they set the optimal deposit rate based on the demand for foreign deposits that they face. This also means that I avoid choosing a particular scheme of allocating agents in the model to a particular bank. In this way, there are 7 types of banks just as there are 7 types of returns that an agent may receive.

6.1.1 Equilibrium deposit rates and bank owners

After proposing a profit-maximization problem for banks, a natural question is: where do the profits of the banks go?

The answer can be seen in the following scenario. Consider the case where there are only two bank, one globally integrated and one local. The globally integrated bank has an elasticity of deposit rates which is very elastic, and the

local bank has an elastcity which is extremely inelastic. This suggests that the former will need to offer a deposit rate which is close to the prevailing world interest rate, else they will face a large reduction in their foreign deposit holdings. The latter will offer a deposit rate which is significantly lower than the world interest rate since they do not face this issue.

In this scenario, the globally integrated bank will earn a profit that can be normalized to 1, and the local bank will earn a profit that can be normalized to a value that is strictly greater than 1 in each period. This implies that the stream of revenue for the entire period (or infinity horizon) for the local bank is strictly higher than the stream of revenue associated with the globally integrated bank. Furthermore, from the literature on asset pricing, we know that a setting such as this will result in a share price for owning the local bank which is strictly larger than the share price for owning the globally integrated bank, so that the ratio of revenue stream to share price is equal for the two bank types.

References

Adrien d'Avernas, Andrea L. Eisfeldt, Can Huang, Richard Stanton, Nancy Wallace (Aug. 2024). *The Deposit Business at Large vs. Small Banks*. URL: `https://www.fdic.gov/system/files/2024-09/wallace-paper-091224.pdf`.

Ahmed, Rashad (Feb. 2025). *Foreign-borne Interest Rate Risk*. URL: `https://download.ssrn.com/2025/2/10/4753135.pdf`.

Aiyagari, S Rao (1994). "Uninsured idiosyncratic risk and aggregate saving". In: *The Quarterly Journal of Economics* 109.3, pp. 659–684.

Altmejd, Adam, Thomas Jansson, and Yigitcan Karabulut (2024). *Business education and portfolio returns*. IZA-Institute of Labor Economics.

Bach, Laurent, Laurent E. Calvet, and Paolo Sodini (2018). "Rich Pickings? Risk, Return, and Skill in Household Wealth". In: *American Economic Review* 110.9, pp. 2703–47. DOI: `10.1257/aer.20170666`. URL: `https://www.aeaweb.org/articles?id=10.1257/aer.20170666`.

Benhabib, Jess and Alberto Bisin (2018). "Skewed Wealth Distributions: Theory and Empirics". In: *Journal of Economic Literature* 56.4, pp. 1261–91. DOI: `10.1257/jel.20161390`. URL: `https://www.aeaweb.org/articles?id=10.1257/jel.20161390`.

Benhabib, Jess, Alberto Bisin, and Mi Luo (2017). "Earnings Inequality and Other Determinants of Wealth Inequality". In: *American Economic Review* 107.5, pp. 593–97. DOI: `10.1257/aer.p20171005`. URL: `https://www.aeaweb.org/articles?id=10.1257/aer.p20171005`.

— (May 2019). "Wealth Distribution and Social Mobility in the US: A Quantitative Approach". In: *Am. Econ. Rev.* 109.5, pp. 1623–1647. ISSN: 0002-8282. DOI: `10.1257/aer.20151684`. URL: `https://www.aeaweb.org/doi/10.1257/aer.20151684`.

Bewley, Truman (1983). "A difficulty with the optimum quantity of money". In: *Econometrica: Journal of the Econometric Society*, pp. 1485–1504.

Cagetti, Marco and Mariacristina De Nardi (Oct. 2006). "Entrepreneurship, Frictions, and Wealth". In: *J. Polit. Econ.* 114.5, pp. 835–870. ISSN: 0022-3808,1537-534X. DOI: 10.1086/508032. URL: https://doi.org/10.1086/508032.

— (Mar. 2009). "Estate Taxation, Entrepreneurship, and Wealth". In: *Am. Econ. Rev.* 99.1, pp. 85–111. ISSN: 0002-8282. DOI: 10.1257/aer.99.1.85. URL: https://www.aeaweb.org/articles?id=10.1257/aer.99.1.85.

Campbell, John Y, Tarun Ramadorai, and Benjamin Ranish (Sept. 2019). "Do the Rich Get Richer in the Stock Market? Evidence from India". In: *American Economic Review: Insights* 1.2, pp. 225–240. DOI: 10.1257/aeri.20180158. URL: https://www.aeaweb.org/articles?id=10.1257/aeri.20180158.

Carroll, Christopher et al. (2017). "The distribution of wealth and the marginal propensity to consume". In: *Quantitative Economics* 8.3, pp. 977–1020. DOI: https://doi.org/10.3982/QE694. eprint: https://onlinelibrary.wiley.com/doi/pdf/10.3982/QE694. URL: https://onlinelibrary.wiley.com/doi/abs/10.3982/QE694.

Carroll, Christopher D (1992). "The Buffer-Stock Theory of Saving: Some Macroeconomic Evidence". In: *Brookings Pap. Econ. Act.* 1992.2, pp. 61–156. ISSN: 0007-2303.

Carroll, Christopher D, Jiri Slacalek, and Kiichi Tokuoka (July 2015). "Buffer-stock saving in a Krusell–Smith world". In: *Econ. Lett.* 132, pp. 97–100. ISSN: 0165-1765. DOI: 10.1016/j.econlet.2015.04.021. URL: https://www.sciencedirect.com/science/article/pii/S016517651500172X.

Daminato, Claudio and Luigi Pistaferri (May 2024). "Returns Heterogeneity and Consumption Inequality Over the Life Cycle". DOI: 10.3386/w32490. URL: http://www.nber.org/papers/w32490.

De Nardi, Mariacristina and Giulio Fella (Oct. 2017). "Saving and wealth inequality". In: *Rev. Econ. Dyn.* 26, pp. 280–300. ISSN: 1094-2025. DOI: 10.1016/j.red.2017.06.002. URL: https://www.sciencedirect.com/science/article/pii/S1094202517300546.

Debacker, Jason et al. (2013). "Rising Inequality: Transitory or Persistent? New Evidence from a Panel of U.S. Tax Returns". In: *Brookings Pap. Econ. Act.*, pp. 67–122. ISSN: 0007-2303, 1533-4465. URL: http://www.jstor.org/stable/23594863.

Den Haan, Wouter J, Kenneth L Judd, and Michel Juillard (Jan. 2010). "Computational suite of models with heterogeneous agents: Incomplete markets and aggregate uncertainty". In: *J. Econ. Dyn. Control* 34.1, pp. 1–3. ISSN: 0165-1889. DOI: 10.1016/j.jedc.2009.07.001. URL: https://www.sciencedirect.com/science/article/pii/S0165188909001286.

Deuflhard, Florian, Dimitris Georgarakos, and Roman Inderst (Apr. 2018). "Financial Literacy and Savings Account Returns". en. In: *J. Eur. Econ. Assoc.* 17.1, pp. 131–164. ISSN: 1542-4766. DOI: 10.1093/jeea/jvy003. URL: https://academic.oup.com/jeea/article-abstract/17/1/131/4981453.

Fagereng, Andreas et al. (2020). "Heterogeneity and Persistence in Returns to Wealth". In: *Econometrica* 88.1, pp. 115–170. DOI: https://doi.org/10.3982/ECTA14835. eprint: https://onlinelibrary.wiley.com/doi/pdf/

10.3982/ECTA14835. URL: https://onlinelibrary.wiley.com/doi/abs/10.3982/ECTA14835.

Friedman, Milton (1957). *Theory of the Consumption Function*. Princeton University Press. URL: http://www.jstor.org/stable/j.ctv39x7zh (visited on 03/21/2023).

Gabaix, X et al. (2016). "The dynamics of inequality". In: *Econometrica*. ISSN: 0012-9682. DOI: 10.3982/ECTA13569. URL: https://onlinelibrary.wiley.com/doi/abs/10.3982/ECTA13569?casa_token=9ibahWJ9lG4AAAAA:0dYLGnKViEPFH4QjzOkhrmrwUun5w7L47DXcniNeYOAnQM5FIFHG5164k1_OLkoZNmHKtLN4v9HI5TA.

Guler, Bulent, Burhan Kuruscu, and Baxter Robinson (2022). *The composition and distribution of wealth and aggregate consumption dynamics*. https://events.bse.eu/live/files/4096-gkrdraftv31submitpdf. Accessed: 2023-9-6. URL: https://events.bse.eu/live/files/4096-gkrdraftv31submitpdf.

Guvenen, Fatih (Nov. 2011). *Macroeconomics With Heterogeneity: A Practical Guide*. NBER Working Papers 17622. National Bureau of Economic Research, Inc. URL: https://ideas.repec.org/p/nbr/nberwo/17622.html.

Huggett, Mark (1993). "The risk-free rate in heterogeneous-agent incomplete-insurance economies". In: *Journal of economic Dynamics and Control* 17.5-6, pp. 953–969.

Kaplan, Greg and Giovanni L Violante (2022). *The Marginal Propensity to Consume in Heterogeneous Agent Models*. Working Paper 30013. National Bureau of Economic Research. DOI: 10.3386/w30013. URL: http://www.nber.org/papers/w30013.

Kennickell, Arthur B (Mar. 2017a). "Getting to the top: Reaching wealthy respondents in the SCF". In: *Stat. J. IAOS* 33.1, pp. 113–123. ISSN: 1874-7655, 1875-9254. DOI: 10.3233/sji-160295. URL: https://content.iospress.com/articles/statistical-journal-of-the-iaos/sji160295.

— (Mar. 2017b). "Lining up: Survey and administrative data estimates of wealth concentration". In: *Stat. J. IAOS* 33.1, pp. 59–79. ISSN: 1874-7655, 1875-9254. DOI: 10.3233/sji-170349. URL: https://content.iospress.com/articles/statistical-journal-of-the-iaos/sji170349.

Klein, Michael A (May 1971). "A theory of the banking firm". In: *Journal of Money, Credit and Banking* 3, p. 205. DOI: 10.2307/1991279. URL: https://www.jstor.org/stable/1991279.

Krueger, Dirk, Kurt Mitman, and Fabrizio Perri (June 2016). "Macroeconomics and Household Heterogeneity". URL: http://www.nber.org/papers/w22319.

Krusell, Per and Anthony Smith (1998). "Income and Wealth Heterogeneity in the Macroeconomy". In: *Journal of Political Economy* 106.5, pp. 867–896. DOI: 10.1086/250034. URL: https://ideas.repec.org/a/ucp/jpolec/v106y1998i5p867-896.html.

Lusardi, Annamaria, Pierre-Carl Michaud, and Olivia S. Mitchell (2017). "Optimal Financial Knowledge and Wealth Inequality". In: *Journal of Political Economy* 125.2, pp. 431–477. DOI: 10.1086/690950. eprint: https://doi.org/10.1086/690950. URL: https://doi.org/10.1086/690950.

Lusardi, Annamaria and Olivia S Mitchell (Mar. 2014). "The Economic Importance of Financial Literacy: Theory and Evidence". en. In: *J. Econ. Lit.* 52.1, pp. 5–44. ISSN: 0022-0515. DOI: 10.1257/jel.52.1.5. URL: http://dx.doi.org/10.1257/jel.52.1.5.

Monti, M (1972). "Deposits, Credit and Interest Rate Determination under Alternative Bank Objectives. Szego, GP & Shell, K. Edition. Mathematical Methods in Investment ..." In: URL: https://scholar.google.com/citations?user=FtjxNk4AAAAJ&hl=en&oi=sra.

Parker, Jonathan A et al. (2022). *Economic Impact Payments and Household Spending During the Pandemic.* Tech. rep. National Bureau of Economic Research.

Saez, Emmanuel and Gabriel Zucman (2014). *Wealth Inequality in the United States since 1913: Evidence from Capitalized Income Tax Data.* Working Paper 20625. National Bureau of Economic Research. DOI: 10.3386/w20625. URL: http://www.nber.org/papers/w20625.

Sarkisyan, Sergey and Tasaneeya Viratyosin (2021). "The impact of the deposit channel on the international transmission of monetary shocks". en. In: *SSRN Electron. J.* ISSN: 1556-5068. DOI: 10.2139/ssrn.3938284. URL: http://dx.doi.org/10.2139/ssrn.3938284.

Wolff, Edward N (2004). *Changes in Household Wealth in the 1980s and 1990s in the US.* Tech. rep. working paper. URL: https://www.econstor.eu/bitstream/10419/31563/1/504002554.pdf.

A   Results from the perpetual youth model

A.1   Implied distribution of bank heterogeneity

The simple model of the bank's optimization problem, where the bank cares only about the difference between the market rate R^m and their chosen level of deposit rate to offer R^d and the level of foreign deposits $S_i(R^d)$, runs into a dilemma for the infinite horizon version of the model. That is, the results of the SMM estimation leave us with 7 discretized points for the uniform distribution of returns $[0.9635, 0.9828, 1.002, 1.0212, 1.0404, 1.0596, 1.0789]$, where the first two points imply a negative return on assets (an issue that does not arise during the estimation of the life-cycle model).

Thus, when we inspect the optimal behavior for offered deposit rates and the calibrated value of the market return using the Cobb-douglas production function, we see that the implied elasticities for the first two banks will be negative, which cannot occur. Although it is conceivable for an individual to earn a negative return on their deposits (i.e. the intersection of low offered deposit rates and potentially high banking/overdraft fees), I leave out the computation of the elasticites for this version of the model. Perhaps are more robust description of the bank's optimization problem would allow the infinite horizon setting to not only match the capital-to-output ratio and chosen wealth moements, but also lead to an implied distribution of elasticities with positive

support post-estimation.

A.2 Untargeted moments

These two tables present the simulated version of the untargeted moments for the infinite horizon version of the model without heterogeneity 6, and then with heterogeneity 7.

Simulated Lorenz Shares (10-Year)

age	20th	40th	60th	80th
25-30	0.0016	0.0325	0.0978	0.2372
30-40	-0.0003	0.039	0.1227	0.2947
40-50	0.0134	0.0639	0.1626	0.3536
50-60	0.0233	0.0809	0.1859	0.3776
60-70	0.0227	0.0779	0.18	0.3684

Figure 6: Simulated Untargeted Moments without Heterogeneity (R-point).

Simulated Lorenz Shares (10-Year)

age	20th	40th	60th	80th
25-30	-0.0043	0.023	0.0858	0.2252
30-40	-0.0227	-0.0014	0.066	0.2317
40-50	-0.0135	0.0063	0.0727	0.2451
50-60	0.002	0.0295	0.1025	0.2757
60-70	0.0038	0.0325	0.1052	0.2748

Figure 7: Simulated Untargeted Moments with Heterogeneity (R-dist).