Monetary Policy and Wealth Inequality—The Role of Entrepreneurs*

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Abstract

We show that rising inequality in US household wealth holdings has come with a shift of wealth from workers to entrepreneurs and ask how this affects the transmission of monetary policy to the real economy, in particular to aggregate investment. We develop a Heterogeneous Agent New Keynesian model in which some households are entrepreneurs who can invest in their private firm with risky returns. In response to expansionary monetary policy, entrepreneurs rebalance their portfolios and expand investment into their firm. The model matches the distribution of returns from private businesses over owners' net worth observed in the Survey of Consumer Finances. This is important because a lower excess return over the risk-free rate leads to stronger portfolio rebalancing towards the private business. Our model attributes a quantitatively important role to entrepreneurs in the transmission of monetary policy. If entrepreneurs do not react to the change in the interest rate, the output response is about 50% smaller. An increase in wealth inequality, modeled as a shift of wealth from workers to entrepreneurs, strengthens the effects of monetary policy. An increase in the top 10% wealth share by one percentage point implies that the aggregate output response to a rate cut increases by 3% to 20%.

Keywords: Wealth distribution, monetary policy, entrepreneurs, investment

JEL Codes: D25, D31, E12, E21, E22, E52

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1 Introduction

Entrepreneurs, private business owners with a tight connection to their firm, form a relatively small fraction of the total US population, approximately 7.5%. However, this small group owns about one third of total US household wealth. Furthermore, their businesses employ close to half of all US workers.[1] Therefore, entrepreneurs' investment response to an interest rate change might be crucial for understanding the transmission of monetary policy to aggregate employment, investment, and GDP. Using data from the Survey of Consumer Finances (SCF), we document that the gap between the average net worth held by entrepreneurs and by the rest of the population has widened since the 1980s. Put differently, there has been a shift of wealth towards the already wealthy group of entrepreneurs. In this paper, we investigate the quantitative importance of entrepreneurs and the consequences of the observed shift of wealth towards them for the transmission of monetary policy.

As our main contribution, we develop a Heterogeneous Agent New Keynesian (HANK) model in which a fraction of households are entrepreneurs who can decide to invest in private businesses with risky returns. We find that, first, entrepreneurs are quantitatively important for the transmission of monetary policy to the real economy, despite being only a small group of households. Second, a more unequal distribution of wealth, caused by a shift of wealth from workers to entrepreneurs leads to larger output effects of monetary policy.

On the household side of our model, we explicitly distinguish between workers and entrepreneurs. All households, i.e., workers and entrepreneurs, can save in a liquid and an illiquid asset. However, entrepreneurs have access to an additional investment opportunity, their private firm. This firm operates a decreasing returns to scale technology using labor and capital as inputs. Production of the private firm is associated with idiosyncratic risk. Since households cannot trade private firms and markets are incomplete, entrepreneurs cannot insure against this idiosyncratic risk. We merge the heterogeneous private firms of entrepreneurs into an otherwise standard New Keynesian supply side.

Of key importance for the transmission of interest rate changes is the resulting portfolio reallocation of entrepreneurs. When monetary policy lowers the interest rate on the government bond, entrepreneurs optimally rebalance their portfolios. They reshuffle parts of their funds into their firm, away from the now lower-yielding bond. Because of decreasing returns to scale in the production function of private firms, an entrepreneur's net worth is a critical determinant of the interest rate elasticity of private firm investment. On the one hand, the elasticity is low for entrepreneurs with little wealth. Returns from investing into their private business are large compared to an investment in the government bond, i.e. they earn high excess returns on private firm investment. An interest rate cut does not increase this excess return much in relative terms, and hence the portfolio reallocation response is small. On the other hand, the investment elasticity is high for wealthy entrepreneurs. On average,

[1] See Cagetti and De Nardi (2006) and De Nardi et al. (2007) and Section 2 below.

they own large firms and thus face a relatively low marginal product of capital within their firm due to decreasing returns to scale. The small excess returns of large firm owners are affected relatively more by the interest rate cut, so their reallocation response is stronger. This portfolio reallocation is a direct effect of monetary policy, i.e., it occurs whenever the central bank changes the interest rate, and it does not require other aggregate variables to be affected.

The poorest entrepreneurs also react strongly to monetary policy, though not because of the just described portfolio reallocation mechanism. They earn high excess returns from investments into their firm so that their marginal propensity to invest is large. Expansionary monetary policy enables them to increase their investment for two main reasons. First, because poor entrepreneurs have strong incentives to grow their firm, they take out debt to grow their business. Expansionary monetary policy makes debt cheaper and thereby generates a positive income effect for this group of entrepreneurs. Second, monetary policy has indirect effects in general equilibrium. In particular, expansionary monetary policy stimulates economic activity and generates higher incomes. Poor entrepreneurs use the additional income to invest heavily into their firm. Taken together, the portfolio reallocation effect, the income effect of an interest rate change and the indirect effects of monetary policy result in an elasticity of private firm investment following an interest rate cut that is u-shaped in net worth, i.e. the poorest and the wealthiest entrepreneurs respond most strongly.

We calibrate our model to the US economy. We target the size of the private business sector in terms of employment, as well as the shares of liquid and illiquid assets held by entrepreneurs and workers respectively. Since the distribution of liquid assets crucially affects the transmission of monetary policy in our model, we additionally target the shares of hand-to-mouth workers and of hand-to-mouth entrepreneurs.

We test key implications of the model using data from the SCF. First, we show that the average return that entrepreneurs receive from private firm investment diminishes with increasing net worth. Our model matches the empirical distribution of returns from private businesses very well, both unconditionally and conditional on net worth, even though these statistics are not targeted in the calibration. Second, we provide direct empirical evidence for the portfolio reallocation mechanism of entrepreneurs. Using identified monetary policy shocks, we document that entrepreneurs increase the share of wealth that they hold in firm capital after a decrease in the federal funds rate. The findings also suggest that this response is heterogeneous across entrepreneurs. In line with our model, both entrepreneurs with low and with high returns react most strongly.

The calibrated model implies an important role for entrepreneurs in the transmission of monetary policy, even though they constitute only a small fraction of all households. To show this, we conduct a counterfactual exercise in which we assume that entrepreneurs are ignorant about changes in prices and aggregate quantities induced by a monetary policy shock. Compared to the baseline, in which entrepreneurs factor in changes in aggregates, the responses of output and aggregate investment are muted by about 50% when entrepreneurs are ignorant. It is especially important that entrepreneurs take into account the change in the interest rate on the government bond, because this stimulates private firm investment. This highlights the importance of the direct effects of monetary policy, specifically the portfolio reallocation effect discussed above.

To understand how wealth inequality affect the transmission of a monetary policy shock, we conduct two experiments. We calibrate both experiments such that the share of wealth owned by the top 10% richest households goes up by one percentage point compared to the initial steady state. In the first experiment we compute the approximate aggregate output response to a change in the interest rate for given equilibrium policy functions. We do this once using the actual steady state distribution and once using a counterfactual distribution that exogenously features higher wealth inequality. This exercise has the advantage that we do not need to take a stance on the underlying driver of the increase in wealth inequality. We change the wealth distribution such that the average entrepreneur becomes richer while the average wealth of workers stays unchanged, in accordance with our empirical observations. Under the high-inequality distribution we obtain a 7 to 10% larger output response to an interest rate change, because a larger share of wealth is now held by rich entrepreneurs who react strongly to monetary policy.

Second, we re-parameterize the model such that it endogenously generates a more unequal steady state wealth distribution. We assume that entrepreneurs are already born with relatively large firms, in contrast to our baseline model in which all households begin their lives with zero wealth. This can be motivated by decreasing estate taxation in the US since the 1980s. We find that the output response to monetary policy is amplified by 3 to 20% relative to the initial economy, depending on how many entrepreneurs are endowed with a positive bequest.

The remainder of this paper is structured as follows. First, we discuss the related literature. In Section 2 we provide empirical evidence that motivates our focus on private business owners. In Section 3 we describe our model, which we calibate in Section 4. In Section 5 we analyze the transmission of monetary policy in the model. In Section 6 we provide empirical evidence on the distribution of entrepreneurial business returns that is consistent with core predictions of our model, as well as evidence from identified monetary policy shocks. We conduct our main experiment in which we investigate the effects of higher wealth inequality on the transmission of monetary policy in Section 7. Section 8 concludes.

Related Literature The importance of entrepreneurs for the US economy has been documented in a number of studies. In particular, Cagetti and De Nardi (2006) and De Nardi et al. (2007) highlight that the average entrepreneur is rich and that entrepreneurs hold about a third of total US wealth. Asker, Farre-Mensa, et al. (2015) estimate that about half of aggregate investment in the US takes place in private firms. Moreover, two recent empirical studies find that entrepreneurs play an important role for monetary policy transmission. First, Bahaj et al. (2020) document that a significant fraction of the aggregate employment response to expansionary monetary policy shocks in the UK is driven by small and medium-sized enterprises, whose owners' collateral constraints relax due to rising house prices. While the precise channel is absent in our model as we abstract from modeling house prices and collateral constraints, this finding demonstrates that business owners feature strong investment responses to interest rate changes, which is in line with our model. Second, Leahy and Thapar (2019) show that US states with a high fraction of middle-aged households display large responses to expansionary monetary policy shocks. They explain this finding with a high likelihood of being an entrepreneur within this age group and therefore stronger effects, because of strongly increasing entrepreneurial activity in a state. To our knowledge, however, our paper is the first to analyze quantitatively the role of private business owners for the transmission of monetary policy in a structural model.

At the same time, a surging literature studies how household heterogeneity affects the transmission of monetary policy, often contrasting heterogeneous agent models with representative agent versions (Bilbiie, 2008, 2020; Werning, 2015). The key distinction between our paper and this strand of literature is that we move beyond a comparison of the polar cases of heterogeneous versus representative agent models. Instead, we ask how in a world with higher inequality, driven by richer entrepreneurs, monetary policy transmission is different than in a world with low inequality.

Kaplan, Moll, et al. (2018) (KMV in all what follows) argue that the distribution of liquid assets matters for the transmission of monetary policy to consumption. While KMV are mostly interested in aggregate consumption, the focus of our paper lies on the aggregate investment response to monetary policy. In addition, on top of workers and a representative firm, which are also present in KMV, we model entrepreneurial households, i.e. private business owners.[2] We emphasize a portfolio reallocation channel that is crucial for the aggregate investment response to monetary policy and its dependence on the wealth distribution. We therefore highlight an important direct effect of monetary policy that is absent if one abstracts from the portfolio choice of entrepreneurs.

We share the focus on the response of aggregate investment to monetary policy in HANK models with a few recent papers and contribute to a further understanding of the investment response by explicitly modeling private business owners. Luetticke (2021) highlights heterogeneity in marginal propensities to invest (MPI) among households and argues that they are high among wealthy individuals. We focus more on the direct effects of monetary policy, in particular the portfolio reallocation following interest rate changes. Auclert et al. (2020) demonstrate that while indirect effects of expansionary monetary policy are sizable in general equilibrium, it is the investment decision of firms that sets in motion the feedback loop between higher output and larger consumption of households with high marginal propensities to consume (MPC). Bilbiie et al. (2020) demonstrate that models which include both heterogeneous households as well as capital feature an important amplification mechanism

[2] We follow KMV in using the methods developed in Achdou et al. (2020) to solve our model, which is framed in continuous time.

caused by income and capital inequality.

Like us, Melcangi and Sterk (2020) study how the wealth distribution affects the transmission of monetary policy transmission. While they focus on stock market participation and portfolio reallocation towards mutual funds as a transmission mechanism of monetary policy, we emphasize the role of private firm investment. Since stock market participation has gone up in the US over time, Melcangi and Sterk (2020) arrive at the same conclusion as we do, namely that monetary policy shocks today have greater effects than in the 1980s.

Lastly, we relate to recent papers by Cloyne et al. (2020), Jeenas (2019), and Ottonello and Winberry (2020) who link the aggregate consequences of monetary policy shocks to the investment activity of heterogeneous firms. These authors concentrate on publicly listed firms, while we focus on privately owned businesses, whose investment decision arguably has a much tighter connection to its owner's balance sheet. The experiment we conduct, changing the distribution of household wealth, is similar to the one in Ottonello and Winberry (2020). They investigate the effects of changing the net worth distribution of firms to one in which default risk is higher because firms hold less net worth. In the spirit of our own results, they find that this dampens the effects of monetary policy shocks. Our paper establishes a connection between these studies on heterogeneous firms and the literature cited above that has stressed the importance of household inequality for the transmission mechanism of monetary policy.

2 Entrepreneurs in the US

In this section we demonstrate the importance of entrepreneurs, i.e. private business owners, for the US economy. We rely on data from the SCF, using 13 waves of the survey between 1983 and 2019. The SCF oversamples wealthy households, which is a crucial benefit for our analysis compared to other publicly available data sources.

We follow Cagetti and De Nardi (2006) and De Nardi et al. (2007) in defining a household as an "entrepreneur" if the household meets all of the following three criteria:

1. The household head is self-employed
2. The household head owns, or at least partly owns, a private business
3. The household head has an active management role in the business

When applying this definition, we find that only a small share of the population, about 7.5%, qualify as entrepreneurs. Moreover, this share has been rather stable over time.[3] Up until 1992 the public-use SCF files provide detailed information on the industry of the entrepreneur's firm and we list the share of firms in different industries in 1992 in Appendix A. Typical examples of the entrepreneurial firms in our sample include law firms, medical

[3]We provide additional graphs, e.g. on the share of entrepreneurs and the aggregate share of wealth held by entrepreneurs over time, in Appendix A.

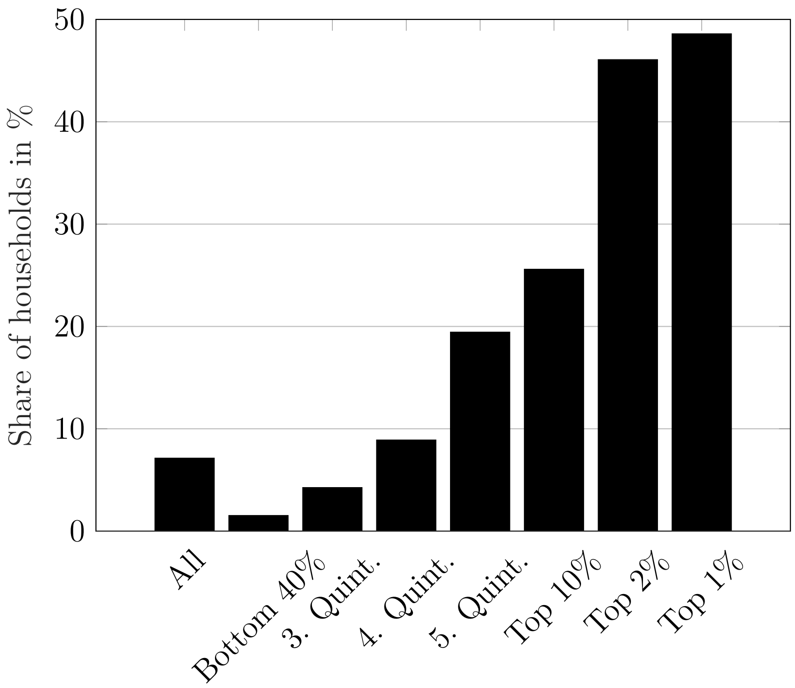

Figure 1: Entrepreneurs as a share of all households in different net worth percentiles (SCF 2019).

practices, architect's or accounting offices, and firms in construction services, retail and wholesale business. The small group of entrepreneurial households plays a disproportionate role for several aggregate statistics in the US, as we will document next.

Net worth The average entrepreneur is wealthy. As has already been pointed out by Cagetti and De Nardi (2006), entrepreneurs hold about 33% of total US net wealth. Figure 1 documents the share of entrepreneurial households in different parts of the US net worth distribution in 2019. In the bottom 40% of the net worth distribution only about 1.5% of households are entrepreneurs according to our definition. In contrast, one in four households are entrepreneurs among the top 10%, and among the wealthiest one percent every second household owns and manages a private business.

Another way to express the fact that entrepreneurs are relatively rich is to consider how much wealthier the average entrepreneur is compared to the average non-entrepreneur. We plot this ratio in Figure 2. Historically, entrepreneurs have been four to eight times wealthier than non-entrepreneurs, highlighting again that they are a rich subgroup of the population. Moreover, this ratio has trended upward over time, implying that while entrepreneurs have always been richer than workers on average, the gap between the average entrepreneur and non-entrepreneur in terms of wealth has been widening. The time trend is statistically significantly different from zero with a p-value of 0.1%. Excluding the data point in 1983, which could be driving the positive slope, the trend is flatter but remains significant with a p-value of 1.0%.

The fact that (rich) entrepreneurs have become even richer compared to the rest of the

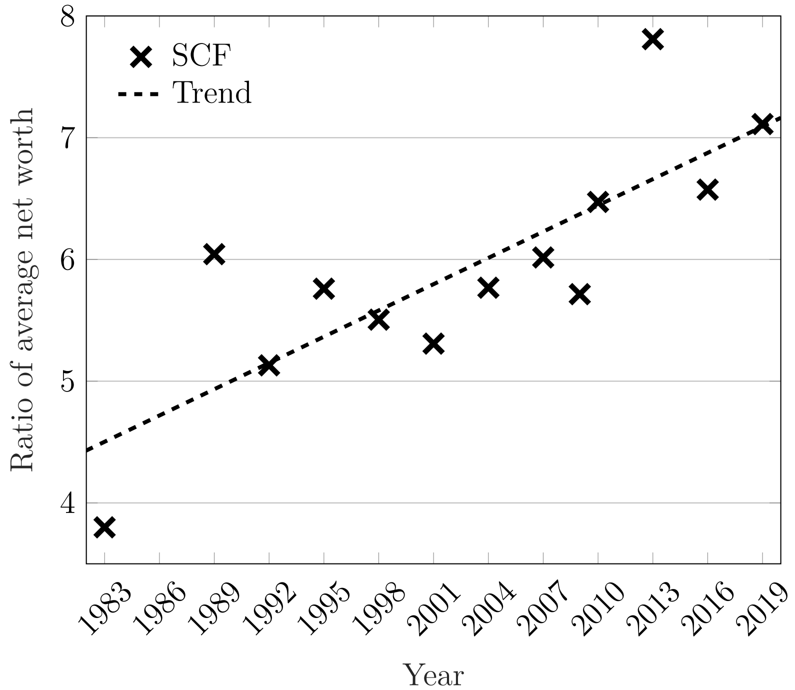

Figure 2: Average wealth of entrepreneurs divided by average wealth of non-entrepreneurs.

population is not surprising, given that wealth inequality in the US has been increasing since the 1980s, as documented, for instance, by Kuhn et al. (2020) and Saez and Zucman (2016).[4] In addition, however, wealth has also become more unequally distributed within the group of entrepreneurs. Figure 16 in the appendix plots the share of total wealth of entrepreneurs held by the wealthiest 10% of entrepreneurs and shows that inequality has gone up over time. In sum, not only has wealth shifted from non-entrepreneurs to entrepreneurs over the recent decades but especially the wealthiest entrepreneurs have become richer.

Employment To further gauge the significance of entrepreneurs and their private businesses for the US economy, we next demonstrate how important these businesses are for aggregate employment. Starting in 1989, the SCF asks entrepreneurs how many people they employ in their businesses. The resulting numbers should be considered as a lower bound of the total employment numbers in the entrepreneurs' firms for two reasons. First, entrepreneurs are only asked about the employment numbers in their businesses for the first two businesses that they own, hence we do not account for employment in any further businesses of the household.[5] Second, the data on employment in privately held businesses is top coded at 5,000 in the public-use SCF files.[6] Another data limitation is that no information on the intensive margin, i.e. hours worked, is given. Instead, households are merely asked how many people they employ in their business. We do not expect our employment figures

[4]Figure 15 in the Appendix documents the trend of rising wealth inequality in the US, as measured by the share of wealth held by the richest 10% of the population.

[5]About 6% of households that we classify as entrepreneurs in the 2019 SCF own more than two firms.

[6]The exact values of the top coding vary over time. While in 1995 to 2019 the upper bound reported in the public files of the SCF is at 5,000 employees, this number is 2,500 in 1989 and 25,000 in 1992.

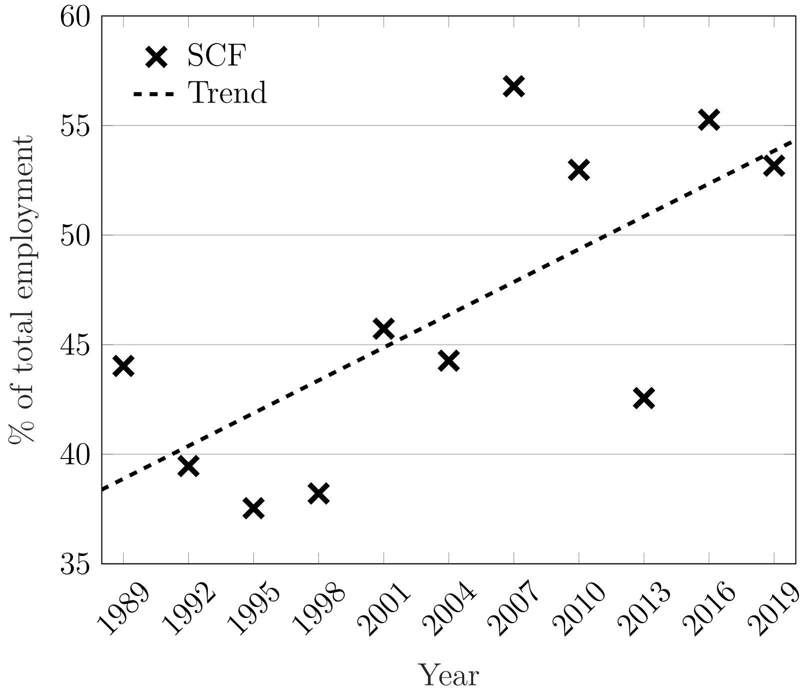

Figure 3: Employment in private firms owned by entrepreneurs divided by total US employment.

to overestimate the true numbers because of this issue, as part-time workers predominantly work in industries with small numbers of entrepreneurial businesses. We discuss this further in Appendix A.

With these caveats in mind, Figure 3 depicts employment in the firms owned by the entrepreneurs in our sample, expressed as a share of total US employment. This share is large, about 46% on average between 1989 and 2019, and similarly to the average wealth ratio displays an upward trend over time (p-value of time trend: 1.5%).[7] While in the late 1980s and early 90s the entrepreneurs' firms contributed to roughly 40% of US employment, this share has risen to approximately 55% in recent years. The time series displays somewhat more volatility than that of the average wealth ratio in Figure 2. This is mostly due to the fact that for aggregating to the overall employment share we multiply the average employee number we obtain from the SCF with the share of entrepreneurial households in the population (Figure 12), which itself displays some volatility.[8] Figure 14 in the Appendix shows that the average employee number is much less volatile and displays a clear upward trend.

[7]If we assume that entrepreneurs who own more than two businesses employ as many workers in all their additional businesses as they do in their second business, the employment share is 51% on average.

[8]In particular, we multiply the average number of employees in the entrepreneurs' firms (corrected for the share of ownership in the respective business) with the share of entrepreneurial households in the population (Figure 12), and then multiply this by total households (TTLHH) divided by employment level (CE16OV). All time series used here are obtained from the Federal Reserve Economic Database.

Investment Unfortunately, the SCF contains no reliable information concerning how much the entrepreneurs invest into their private firms. Asker, Farre-Mensa, et al. (2015) estimate that about 53% of aggregate US investment stems from private firms. By focusing on our relatively restrictively defined group of entrepreneurs, however, we are considering only a subset of all private firms in the US, so this figure should be considered as an upper bound of investment undertaken by the firms in our sample. Similarly, when comparing total US aggregate investment to data on capital expenditure from Compustat which captures only the publicly listed firms (as, for instance, in Gutiérrez and Philippon (2017)), about 40% of aggregate investment is left unexplained and would hence be attributable to private firms.

Firm heterogeneity The average numbers on employment mask significant heterogeneity among entrepreneurial firms, whose distribution is heavily skewed. Put differently, there exist many firms that are very small and a small portion of firms that are very large, both in terms of employment and in terms of sales. Appendix A reports more detailed statistics on the firm size distribution in our sample. It also shows the distribution of legal statuses, sources of funding, and industry for the entrepreneurial firms in our sample.

3 A New Keynesian Model with Entrepreneurs

In this section we describe our model, which closely follows KMV's except for the explicit modeling of entrepreneurs. Since we are interested in how the effects of monetary policy shocks change when the degree of wealth inequality in the population varies, the model features heterogeneous households with a realistic distribution of wealth and a New Keynesian supply side (i.e. a HANK model).

Time t is continuous and runs forever. Our model features two types of households, workers and entrepreneurs.[9] Workers are subject to uninsurable labor income risk and work either for the private firms owned by entrepreneurs or for a representative firm that stands for all publicly listed companies. Entrepreneurs have access to a private production technology, and employ their own capital as well as workers, whom they hire on the labor market, to produce output. Input goods are produced both by the heterogeneous private firms and by the representative firm. These input goods are then transformed into intermediate goods by firms that are subject to a price adjustment cost. The intermediate goods firms (and the profits they generate) are owned by the households. The intermediate goods are bundled into the final consumption good, which is then sold to the households. The government consists of a fiscal authority, which levies taxes on households and distributes transfers to them, and a monetary authority which controls the nominal interest rate. All risk in our model is of idiosyncratic nature, i.e. there is no aggregate risk. The monetary policy shock we consider later on is a one-time, unexpected ("MIT") shock.

[9] We assume that the occupational choice is exogenous and therefore that household types are fixed over their lifetime, mainly for computational tractability.

3.1 Households

At any point in time the economy is populated by a unit mass of households. An exogenous mass s_e of these households are entrepreneurs, and mass $(1-s_e)$ are workers. Each household dies stochastically at rate ζ and is then replaced by a newborn household. These newborn households start their lives with zero assets,[10] a draw from the stationary distribution of the productivity process, and as the same type (worker or entrepreneur) as the household they are replacing.

All households value consumption c_t and dislike labor ℓ_t in the same way. Their preferences are time separable and households discount the future at rate ρ. Taking into account the constant dying intensity ζ, households' preferences over consumption-labor processes $\{c_t,\, \ell_t\}$ are given by the utility function

$$U\left(\{c_t,\, \ell_t\}\right) = \mathbb{E}\int_{t=0}^{\infty} e^{-(\rho+\zeta)t} u(c_t, \ell_t)\mathrm{d}t, \tag{1}$$

where the felicity function $u(c, \ell)$ is additively separable in consumption and labor, monotonically increasing in c and monotonically decreasing in ℓ. It is further strictly concave in both arguments and satisfies $\lim_{\ell\to 0} u_\ell(c, \ell) = 0$ and $\lim_{c\to 0} u_c(c, \ell) = \infty$.

We now turn to a detailed description of the households that are entrepreneurs. Afterwards, we focus on the workers, who face the same problem as in KMV.

3.1.1 Entrepreneurs

Entrepreneurs can invest in three assets. The first is a liquid asset b_t, the second is an illiquid asset a_t, and the third is their private firm of size k_{et}. While the first two are risk-free, investment into the private firm is risky.

We think of the liquid asset as cash and directly held government bonds. The illiquid asset captures houses (net of mortgages), shares in publicly traded firms and pension accounts. Investment in the liquid asset is costless and offers the risk-free return r_t^b. Investment in the illiquid asset is costly. When depositing or withdrawing d_t from the illiquid account of size a_t, the household has to pay a portfolio adjustment cost $\chi^a(d_t, a_t)$. We denote by r_t^a the interest rate earned on the illiquid account. Borrowing is only possible in the liquid asset and only up to a borrowing limit $-\underline{b}$. The interest rate on negative liquid asset holdings exceeds the rate on positive holdings by a constant borrowing wedge κ

$$r_t^b(b_t) = r_t^b + \kappa \cdot \mathbb{1}\{b_t < 0\}.$$

The household cannot hold a negative position of the illiquid asset, $a_t \geq 0$. Due to the adjustment costs, households are only willing to invest in the illiquid account if it yields a higher return, such that in equilibrium we will have $r_t^a > r_t^b$.

[10]This assumption is made for simplicity and follows KMV. In Section 7 we relax this assumption, generating higher wealth inequality in steady state by assuming that entrepreneurs are born with positive assets.

In addition to these two assets, entrepreneurs can invest into their own private firm $k_{et} \geq 0$, whose shares are non-tradable. If an entrepreneur wants to grow or shrink her firm she has to pay capital adjustment costs $\chi^e(f_t, k_{et})$, where positive f_t denote enlarging and negative f_t shrinking the firm. Hence, we think of private business capital as a second illiquid asset in the economy. What distinguishes the illiquid asset a from private firm capital k_e is the associated risk. While investment into a is risk-free, investment into the private firm is risky. We specify the sources of this risk after describing the entrepreneurs' production technology.

In order to produce output, entrepreneurs hire labor n_{et} from workers, whom they pay the real wage w_t. The amount of invested capital k_{et} together with the household's productivity and hired labor then determines production of the entrepreneur according to the decreasing returns to scale production function

$$y_e(y, k_e, n_e) = Z_e \cdot y \cdot \left(k_e^{\alpha} \cdot {n_e}^{1-\alpha}\right)^{\nu},$$

with $\nu \in (0, 1)$. The parameter $Z_e > 0$ governs the productivity of the entrepreneurial sector relative to the representative firm, whose productivity we normalize to one and whom we describe in more detail further below.

The assumption of decreasing returns is common in the literature on entrepreneurship (Cagetti and De Nardi, 2006; Tan, 2020). It is of key importance for the portfolio reallocation mechanism that we will emphasize later on. The assumption goes back to Lucas (1978) who motivates it using diminishing returns on span-of-control. The entrepreneur's ability in managing the firm gets stretched out over ever larger projects, and accordingly, the productivity of the firm suffers.[11] We provide empirical evidence that wealthier entrepreneurs earn lower returns from their firm in Section 6.1.

We assume that there are two sources of idiosyncratic investment risk. The first source is productivity risk. Current productivity of an entrepreneur y_t evolves stochastically according to some process

$$\dot{y}_t = \Phi_y(y_t).$$

The second source of risk is a capital quality shock that affects the capital employed in the firm k_{et}. We assume that firm capital evolves over time according to the following process:

$$\mathrm{d}k_{et} = [f_t - \delta \cdot k_{et}]\, \mathrm{d}t + \sigma_k \cdot k_{et} \cdot \mathrm{d}W_t \ ,$$

where W_t is a Wiener process, σ_k the standard deviation of the capital quality shock and δ denotes depreciation.

For simplicity, we assume that entrepreneurs themselves work an exogenously fixed

[11] An alternative motivation for arriving at decreasing returns to scale in revenues is to assume constant returns to scale in production and a downward-sloping demand curve for the entrepreneur's output y_e (Asker, Collard-Wexler, et al., 2014; Cooley and Quadrini, 2001).

amount of hours, $\bar{\ell}$, on tasks regarding the management of the firm, i.e. their work input does not enter the production function.[12] They are not paid wages for this work, compensation for their effort is included in the profits that they receive from their firm. Denoting by p_t the real price of output produced by entrepreneurs at time t, we can define entrepreneurial profits before taxes as

$$\Pi_e(k_{et}, y_t) = p_t \cdot y_e(k_{et}, n_{et}^*, y_t) - w_t \cdot n_{et}^* \,.$$

Here, we have already substituted in the optimal labor demand of the entrepreneurs n_{et}^*, which is a static decision and given by

$$n_{et}^* = \left(\frac{p_t \cdot (1-\alpha) \cdot \nu \cdot Z_e \cdot y_t \cdot k_{et}^{\alpha\nu}}{w_t} \right)^{\frac{1}{1-\nu(1-\alpha)}} \,.$$

Taken together, entrepreneurs maximize utility solving the problem

$$\begin{aligned} &\max_{\{c_t, b_t, d_t, f_t\}} U\left(\{c_t, \bar{\ell}\}\right) \qquad (2) \\ \text{subject to:} \quad &\dot{b}_t = (1-\tau_e) \cdot \Pi_e(k_{et}, y_t) + r_t^b(b) \cdot b_t - d_t - f_t + T_t - c_t \\ &\qquad - \chi^a(d_t, a_t) - \chi^e(f_t, k_{et}) + \tau_e \cdot \delta \cdot k_{et} \\ &\dot{a}_t = r_t^a \cdot a_t + d_t \\ &\dot{k}_{et} = f_t - \delta \cdot k_{et} + \sigma_k \cdot k_{et} \cdot \dot{W}_t \\ &b_t \geq -\underline{b}, \; a_t \geq 0, \; k_{et} \geq 0, \end{aligned}$$

given initial conditions. Here, T_t denotes a lump-sum transfer from the government. The proportional tax on business income τ_e only pertains to profits after depreciation, which gives rise to the tax deduction term $\tau_e \cdot \delta \cdot k_{et}$.

Note that we understand the interest rate on each of the three assets as implicitly augmented by ζ. This accounts for the fact that accidental bequests from the dying households are distributed to the living households in proportion to their current assets (i.e. we assume perfect annuity markets).

Firm dynamics As occupational choice is exogenous, there is no endogenous entry and exit of firms in our model. Hence we also abstract from this margin when we later study the response of the economy to a monetary policy shock. The reader be reminded, however, that households die with probability ζ and are then replaced by households of the same type with zero assets in our model. Hence, exogenous entry and exit exists in our model, and we observe both very large and very small firms in equilibrium.

[12]The precise number of hours worked by the entrepreneurs, $\bar{\ell}$, is irrelevant in all what follows, as utility is additively separable in consumption and labor.

3.1.2 Workers

As entrepreneurs, workers can invest in the liquid asset b, and the illiquid asset a, but unlike entrepreneurs they cannot run private firms. Instead, they earn labor income and make a continuous labor supply decision on work hours $\ell_t \in [0, 1]$. They supply this labor to the representative firm or to the private firms and are indifferent between these two options, as they receive the same wage (net of a proportional labor tax τ_l) in both cases. Workers receive idiosyncratic shocks to their labor productivity, whose natural logarithm z_t evolves according to some exogenous stochastic process,

$$\dot{z}_t = \Phi_z(z_t).$$

Workers maximize utility solving the problem

$$\begin{aligned}
&\max_{\{c_t,\ell_t,b_t,d_t\}} U\left(\{c_t,\, \ell_t\}\right) &&& (3)\\
&\text{subject to:} \quad \dot{b}_t = (1-\tau_l)\cdot w_t \cdot \exp(z_t)\cdot \ell_t + r_t^b(b)\cdot b_t - \chi^a(d_t, a_t) - d_t + T_t - c_t,\\
&\qquad\qquad\quad\; \dot{a}_t = r_t^a \cdot a_t + d_t\\
&\qquad\qquad\quad\; b_t \geq -\underline{b},\; a_t \geq 0,
\end{aligned}$$

given initial conditions.

In Appendix C we provide the Hamilton-Jacobi-Bellman equations that characterize the solution to the household problems recursively for the specific process for z_t and y_t described in Section 4 below.

3.2 Production

The economy features a standard New Keynesian supply side with one complication: The first layer of production does not only consist of a representative firm which uses capital and labor to produce an input good. Rather, input goods are produced both by a representative firm and by entrepreneurs (see Figure 4). We assume that all entrepreneurs as well as the representative firm produce input goods that are perfectly substitutable. The input goods are then differentiated by monopolistically competitive intermediate goods producers that are subject to price adjustment costs as in many standard New Keynesian models. Lastly, the intermediate goods are sold to a final goods producer, who bundles them and produces the final good which is used for consumption and investment.

The representative firm employs labor N_{pt} and capital K_{pt} to produce output Y_{pt} which it sells at price p_t. The price it gets for selling its output is the same that the entrepreneurs receive because of our assumption of perfect substitutability between output of the representative firm and entrepreneurial production. We assume that the firm operates a Cobb-Douglas production function

$$Y_{pt} = N_{pt}^{1-\alpha} K_{pt}^{\alpha}.$$

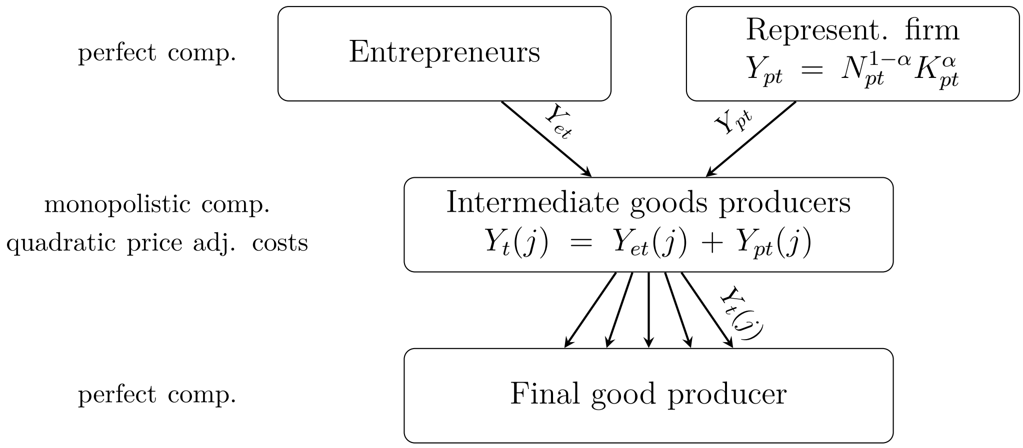

Figure 4: Production flow

Profit maximization requires that factor prices equal marginal products

$$r_t^k = p_t \cdot \alpha \cdot \left(\frac{K_{pt}}{N_{pt}} \right)^{\alpha - 1}$$
$$w_t = p_t \cdot (1 - \alpha) \cdot \left(\frac{K_{pt}}{N_{pt}} \right)^{\alpha}$$

A continuum of mass one of monopolistically competitive intermediate goods producers buys the general input goods from entrepreneurs and the representative firm at price p_t, and differentiates them using a linear production technology

$$Y_t(j) = Y_{et}(j) + Y_{pt}(j) \ .$$

Every intermediate good producer j sets the nominal price $P_t(j)$ at which the intermediate good is sold to maximize the present value of real profits. When setting the price, the intermediate good producer takes into account price adjustment costs and the demand schedule $Y^d \left(\frac{P_t(j)}{P_t} \right)$, where P_t denotes the aggregate price level. Price adjustment costs are of the quadratic form as in Rotemberg (1982)

$$\Theta \left(\frac{\dot{P}_t(j)}{P_t(j)} \right) = \frac{\theta}{2} \cdot \left(\frac{\dot{P}_t(j)}{P_t(j)} \right)^2 \cdot Y_t \ ,$$

where Y_t denotes final output and θ is a parameter determining how high the price adjustment costs are.

We assume that the firm discounts the future at rate r_t^a. This is the rate of return of the mutual fund which owns the firm's shares as described below. The maximization problem of an intermediate goods producer is then

$$\max_{\{P_t(j)\}_{t \geq 0}} \int_{t=0}^{\infty} e^{-\int_0^t r_s^a \mathrm{d}s} \left[\left(\frac{P_t(j)}{P_t} - p_t \right) \cdot Y^d \left(\frac{P_t(j)}{P_t} \right) - \Theta \left(\frac{\dot{P}_t(j)}{P_t(j)} \right) \right] \mathrm{d}t.$$

This notation makes it clear that the price of the input goods p_t acts as the real marginal cost of the intermediate goods producers, i.e. $mc_t \equiv p_t$.

The demand schedule is derived from the profit maximization problem of a final good producing firm which combines the intermediate goods into the final output good Y_t according to the production function

$$Y_t = \left(\int_0^1 Y_t(j)^{1-\frac{1}{\epsilon}} \, \mathrm{d}j \right)^{\frac{\epsilon}{\epsilon-1}} ,$$

where $\epsilon > 0$ governs the demand elasticity. Profit maximization of the final goods producer yields the demand for intermediate goods

$$Y^d \left(\frac{P_t(j)}{P_t} \right) = \left(\frac{P_t(j)}{P_t} \right)^{-\epsilon} \cdot Y_t.$$

We show in Appendix C that this demand function together with the profit maximization problem of the intermediate goods producer yields the New Keynesian Phillips curve

$$\left(r_t^a - \frac{\dot{Y}_t}{Y_t} \right) \pi_t = \frac{\epsilon}{\theta} \left[mc_t - \frac{\epsilon - 1}{\epsilon} \right] + \dot{\pi}_t. \tag{4}$$

where $\pi_t = \frac{\dot{P}_t}{P_t}$ denotes the inflation rate. Per period profits net of price adjustment costs are

$$\Pi_t = (1 - mc_t) \cdot Y_t - \frac{\theta}{2} \cdot \pi_t^2 \cdot Y_t$$

3.3 Mutual fund and profits from intermediate goods producers

We assume that households hand their holdings of the illiquid asset a_t to a mutual fund. The fund rents capital K_{pt} at rate r_t^k to the representative firm and invests in shares of the intermediate goods producers, which trade at price q_t. We normalize the total number of shares to one. Optimality of the portfolio allocation requires that the returns on both investments are the same,

$$\frac{\omega \cdot \frac{Y_{pt}}{Y_t} \cdot \Pi_t + \dot{q}_t}{q_t} = r_t^k - \delta = r_t^a. \tag{5}$$

We assume that only a fraction $\omega \cdot \frac{Y_{pt}}{Y_t}$ of the profits is paid out as dividends to the mutual fund, where $\omega \in [0, 1]$ is a parameter. The fraction $(1 - \omega)$ is paid out to the workers as a transfer into their liquid account, in proportion to their current labor productivity.[13] The remaining share $\omega \cdot \left(1 - \frac{Y_{pt}}{Y_t}\right) = \omega \cdot \frac{Y_{et}}{Y_t}$ of profits are paid into the liquid account of the entrepreneurs in proportion to the output of their firm. Splitting up the profits Π_t in this fashion ensures that investment into the private and into the representative firm are similarly affected by movements of the profits following a monetary policy shock.

[13] This is analogous to the treatment of profits in KMV, where $Y_p = Y$ as they do not model an entrepreneurial sector.

3.4 Government

The government consists of a fiscal and a monetary authority. The fiscal authority collects taxes on labor income (including the part of profits that is paid into the liquid account of workers) and issues real bonds denote by B^S, which assumes a positive value when the government has debt. It pays out transfers to the households and spends an amount G on government expenditures. The government's budget is balanced at each instant

$$G + r_t^b B^S + T_t = \tau_l (w_t N_t + (1-\omega)\Pi_t) + \mathrm{Rev}_{et} \;, \tag{6}$$

where N_t denotes aggregate labor supply (i.e. labor N_{pt} supplied to the representative firm plus labor supplied to all private firms), and Rev_{et} denotes revenues from taxing entrepreneurial profits, all defined in Appendix C.1.

The monetary authority sets the nominal interest rate $i_t = r_t^b + \pi_t$. We assume that it follows a Taylor rule

$$i_t = \bar{r} + \phi \pi_t + \epsilon_t, \tag{7}$$

where ϵ_t denotes a monetary policy shock. It is zero in steady state. Below we consider the effects of an unexpected change of ϵ_t followed by a return back to zero at rate $\eta = 0.5$

$$\epsilon_t = \exp(-\eta t) \cdot \epsilon_0.$$

3.5 Equilibrium

We denote by μ_{wt} the distribution of workers over the state space (b, a, z), and by μ_{et} the distribution of entrepreneurs over (b, a, k_e, y). Both of these distributions integrate to one at every point in time. Let μ_t denote the joint distribution of the two household types. Wherever convenient, we abbreviate by i the set of idiosyncratic state variables, which also includes information about aggregate variables implied by the distribution μ_t. We relegate the definition of the equilibrium to Appendix C.1.

4 Calibration

Wherever possible, our calibration strategy closely follows KMV. We use the same income process for workers and the same values for the externally calibrated parameters and present them in Table 2. We only discuss these briefly in the next subsection. Our strategy for the calibration of the remaining parameters, especially those governing the behavior of entrepreneurs, is described in Section 4.2

Table 1: Parameters of the Income Process

	β_{zj}	λ_{zj}	σ_{zj}
$j=1$	0.761	0.080	1.74
$j=2$	0.009	0.007	1.53

4.1 Externally calibrated parameters and functional forms

The utility function is

$$u(c,\ell) = \frac{c^{1-\sigma}}{1-\sigma} - \varphi\frac{\ell^{1+\gamma}}{1+\gamma} ,$$

where we set both σ and γ equal to 1, and φ to 2.2. These choices ensure a Frisch elasticity of labor supply of one and an average labor supply of approximately 0.5.

Households die at rate $\zeta = \frac{1}{180}$, which implies an average life span of 45 years. The borrowing limit, $\underline{b}$, is set to the average quarterly labor income. The portfolio adjustment cost function for the illiquid asset a is a convex function as in Alves et al. (2020)

$$\chi^a(d,a) = \chi_1^a \cdot \left(\frac{|d|}{a}\right)^{\chi_2^a} \cdot a ,$$

where χ_1^a and χ_2^a are parameters.

The stochastic log productivity process of the workers $\Phi_z(z_t)$ consists of two additive parts, a transitory component $z_{1,it}$ and a more persistent component $z_{2,it}$, where i indexes the (worker) household. Therefore, log productivity is

$$z_{it} = z_{1,it} + z_{2,it} .$$

Each of the two components follows a jump-drift process, with jumps arriving at rate λ_{zj}. At all times, the process drifts toward its mean of zero at rate β_{zj}. Whenever there is a jump, a new productivity state is drawn from a normal distribution, with $z'_{j,it} \sim N(0,\sigma_{zj}^2)$. Hence we have

$$\mathrm{d}z_{j,it} = -\beta_{zj} \cdot z_{j,it} + \mathrm{d}J_{j,it} ,$$

where $\mathrm{d}J_{j,it}$ captures the jumps in the process. The parameters for this process are shown in Table 1. This is the same income process as in KMV and we refer the reader to their paper for a more detailed discussion. Importantly, the income process ensures that the variance and the kurtosis of the innovations of the modeled income process correspond to those estimated from social security data.

The share of capital in production α assumes a value of 0.33, capital depreciates at 7% annually. The parameter governing the fraction of profits that is automatically reinvested into the illiquid account, ω, is set equal to α. This, as KMV show, ensures that the effect of cyclical profits on investment is sterilized. The demand elasticity faced by the intermediate goods producers, ϵ is set to 10. A value of θ of 100 then ensures that the slope of the Phillips curve is 0.1. The parameter governing the response of the central bank to inflation, ϕ is set to 1.25. We set the government bond supply such that the steady state interest rate on the liquid asset is 2% annually. The lump-sum transfer to the households is set to 6% of GDP and the tax rate on labor income τ_l to 30%.

4.2 Entrepreneurial sector

We set s_e to 7.5%, the average share of entrepreneurs in the US population over the previous decades. We take the degree of decreasing returns in production for private firms ν from Tan (2020), who estimates a value of 0.79.[14] Since most of the entrepreneurial businesses in the SCF are sole proprietorships, partnerships or S corporations (see Table 13 in the appendix), which are all subject to pass-through taxation, i.e. business income is not taxed within the company but reported as personal income, we set $\tau_e = \tau_l = 30\%$. Recent evidence in Acemoglu et al. (2020) shows that this is a reasonable approximation for the average tax rate on S corporations and C corporations.

Stochastic productivity process $\Phi_y(y_t)$ We assume that productivity y of the entrepreneurs can take on two values. We interpret the low productivity state, y_l, as being a low-talent or subsistence entrepreneur (Poschke, 2013). The other state, y_h, captures highly talented entrepreneurs (i.e. opportunity entrepreneurs). We normalize $\mathbb{E}[y] = 1$, keeping in mind that the parameter Z_e captures overall productivity of the entrepreneurial sector.

Transitions between the two states happen stochastically, at Poisson rate $\lambda_{y,lh}$ from low to high, and at rate $\lambda_{y,hl}$ from high to low state. Given our interpretation of the two states, we assume that switches between the two types take place only very infrequently, similar to the persistent component z_2 of the labor productivity of workers, whose jumps KMV refer to as "career shocks". Accordingly, we calibrate the transition intensities between the two states to occur on average every 38 years.[15] We further assume that 12.3% of entrepreneurs are of the low (subsistence) type, a number we take from Poschke (2013). This then uniquely pins down the transition intensities, $\lambda_{y,lh} = 0.04$ and $\lambda_{y,hl} = 0.006$. At the end of this section we verify that the business income process faced by entrepreneurs in our model is comparable to its analogue in the data, as estimated in DeBacker et al. (2018).

[14] Strictly speaking, Tan (2020) estimates this value using detailed data on private start-ups, i.e. by construction relatively young firms. We also experimented with a value of $\nu = 0.88$, which is the value used by Cagetti and De Nardi (2006), but results are largely unchanged.

[15] This is as often as a jump takes place on average between persistent worker productivity states, i.e. we impose $\pi_l \cdot 1/\lambda_{y,lh} + (1 - \pi_l) \cdot 1/\lambda_{y,hl} = 1/\lambda_{z2}$, where π_l denotes the mass of entrepreneurs of the low type in the stationary distribution.

Table 2: Externally calibrated parameters.

Parameter	Value	Description	Source or Target
s_e	7.5%	share entrepreneurs	SCF
ζ	$1/(4 \cdot 45)$	death rate	avg. lifetime 45 years
σ	1	rel. risk aversion	KMV
φ	2.2	labor disutil.	avg. labor time 8h/day
γ	1	elast. labor supply	KMV
$\underline{b}$	avg. qrtl. lab. inc.	borrowing limit	KMV
α	0.33	capital share	KMV
ω	0.33	dividend ratio	$= \alpha$
ϕ	1.25	infl. response	KMV
ϵ	10	intermed. dem. elast.	mark-up 11%
θ	100	price adj. cost	slope of Phill. Curve 0.1
δ	0.07/4	depreciation rate	KMV
τ_l	0.3	labor tax rate	KMV
T_t	$0.06 \cdot Y_t$	lump-sum transf.	KMV
τ_e	0.3	entrepr. tax rate	$= \tau_l$
$\bar{r}$	0.02/4	steady state int. rate	KMV
ν	0.79	decr. returns to prod.	Tan (2020)

Notes: Rates are expressed as quarterly values.

Capital adjustment costs We assume that the entrepreneurial capital adjustment cost function is of a standard quadratic form

$$\chi^e(f, k_e) = \chi_1^e \cdot \left(\frac{f - \delta \cdot k_e}{k_e}\right)^2 \cdot k_e \ ,$$

where χ_1^e is a parameter. This specification ensures that replacing depreciated capital entails no adjustment cost for the entrepreneur.

4.3 Calibration targets

This leaves us with eight parameters to be calibrated. We target the ratio of liquid assets to GDP (0.26), the ratio of illiquid assets to GDP (2.92), the fraction of poor hand-to-mouth households (i.e. those with few liquid and no illiquid assets, 10%), and the fraction of wealthy hand-to-mouth households (few liquid but positive illiquid assets, 20%)[16] to pin down the discount rate ρ, the borrowing wedge κ, and the portfolio adjustment cost function parameters χ_1^a, χ_2^a. We take these targets from KMV.[17]

The remaining four parameters are specific to the entrepreneurial sector in our model. These are the parameters governing the productivity of the entrepreneurial sector, Z_e, the

[16] These hand-to-mouth shares include households of both occupations, i.e. workers and entrepreneurs.

[17] In fact, KMV calibrate an additional third parameter in the portfolio adjustment cost function (χ_0^a). Alves et al. (2020) abstract from this third parameter and we follow them in doing so, as this reduces the numbers of parameters we need to calibrate from nine to eight.

productivity gap between low and high talent types, y_h/y_l, the standard deviation of the capital quality shock, σ_k, and the capital adjustment cost function parameter, χ_1^e.

We use the average employment share of 46% that we found in the SCF to pin down productivity in the entrepreneurial sector. We also want to get the portfolio composition of entrepreneurs correct, at least on average, as portfolios and portfolio reallocation following a monetary policy shock are key to our analysis. To this end, we target the share of liquid assets (b) in the US economy that are held by entrepreneurs (average of 22% across all SCF waves), the share of illiquid assets (a, i.e. not counting private firms) held by entrepreneurs (also 22%), and the share of entrepreneurs that are hand-to-mouth (16%).[18]

While the identification of any single parameter cannot be traced back to one single target, there still exist tight linkages between our targets and the calibrated parameters. Capital quality shocks occur frequently in our model, and hence entrepreneurs use liquid assets to insure against them. Hence, the share of liquid assets they hold informs σ_k. In contrast, talent shocks occur very infrequently, and thus entrepreneurs insure against these shocks using the illiquid asset a. This makes the share of illiquid assets held by entrepreneurs a useful target to inform y_h/y_l. Lastly, when capital adjustment costs are high, entrepreneurs grow their firm relatively slowly at the beginning of their lives, hence relatively few of them are up against the borrowing constraint $\underline{b}$.[19] If adjusting capital is cheap, growing the firm quickly in the beginning, all the while facing binding borrowing constraint, becomes more attractive. Therefore, the share of hand-to-mouth entrepreneurs informs χ_1^e.

Table 3 lists the calibrated parameters. The first four, also calibrated in KMV, are very close to the values that they find. In terms of parameters regarding the entrepreneurial sector, we find that more productive entrepreneurs (y_h) are about twice as productive as the low-productive ones (y_l). There exists considerable short-term income and investment risk for entrepreneurs, as a capital quality shock of one standard deviation implies a 12% lower or higher capital stock. Lastly, the capital adjustment cost parameter χ_1^e is in the same range as the linear component of the portfolio adjustment cost function, χ_1^a.[20] Given these calibrated values, Table 4 documents that we hit the eight targets relatively well.

4.4 Untargeted moments

In Table 5 we compare the joint distribution of occupation and wealth, which was untargeted in our calibration, between our model steady state and data from the SCF (the values for the SCF correspond to those shown in Figure 1). Conditional on picking a random household from a given part of the wealth distribution, we match the probability that the household is an entrepreneur relatively well, though we overstate the likelihood of entrepreneurs appearing

[18]We construct hand-to-mouth shares in the SCF following the procedure in Kaplan, Violante, et al. (2014).

[19]As mentioned before, all entrepreneurs start their lives with a firm of size $k_e = 0$.

[20]Be reminded, however, that in order to conserve on parameters to be calibrated we have set the parameter governing the convexity of the capital adjustment cost function $\chi^e(\cdot)$ to 2. This is higher than the calibrated convexity parameter of the portfolio adjustment cost function, χ_2^a.

Table 3: Internally calibrated parameters

Parameter	Value	Description	Target
ρ	0.018	discount rate	Liquid assets to GDP
κ	0.015	bor. wedge	Illiquid assets to GDP
χ_1^a	0.84	portf. adj. costs	Share wealthy HtM
χ_2^a	1.45	–	Share poor HtM
Z_e	2.01	avg. entre. talent	Empl. share in entrep. firms
y_h/y_l	1.86	spread entre. talent.	Share illiq. assets held by entrep.
σ_k	0.12	capital qual. shock	Share liq. assets held by entrep.
χ_1^e	0.50	adj. costs firm	Share HtM entrep.

Table 4: Targeted moments

	$\frac{K}{Y}$	$\frac{B}{Y}$	pHtm	wHtm	Lab. at e.	Liq. e.	Illiq. e.	Htm e.
Data	2.92	0.26	0.10	0.20	0.46	0.22	0.22	0.16
Model	2.65	0.27	0.10	0.20	0.41	0.21	0.24	0.16

Notes: $\frac{K}{Y}$ is the capital to output ratio, $\frac{B}{Y}$ liquid assets to output, *pHtm* and *wHtm* are the shares of households who are poor and wealthy hand-to-mouth respectively, *Lab at e.* is the share of labor at private businesses, *Liq e.* and *Illiq e.* are the shares of liquid (b) and illiquid (a) assets held by entrepreneurs respectively, *Htm e.* is the share of entrepreneurs who are hand-to-mouth.

at the very top of the wealth distribution. For this reason, the ratio of average wealth held by entrepreneurs and by workers is higher (approximately eleven) in our model than it is in the data (six on average). In terms of overall wealth inequality in our model economy we perform relatively well, as Table 6 reveals.

We used the parameters of the income process for entrepreneurs, in particular the standard deviation of the capital quality shock σ_k and the spread between the productivity of high- and low-productivity entrepreneurs, to hit aggregate targets in our calibration. It is therefore crucial to ask whether the income process in our model resembles that of actual entrepreneurs in the US economy. Most suited for such a comparison are recent results by DeBacker et al. (2018), who use a large confidential panel of US income tax returns to scrutinize the business income risk faced by households. Their definition of business income includes the sum of income generated from sole proprietorships, partnerships, and S corporations, and refers to the net profit or loss from business operations after all expenses, costs, and deductions have been subtracted. They do not require households to be actively

Table 5: Share of entrepreneurs by net worth percentiles, in %.

	All	1.+2. Quint.	3. Q.	4. Q.	5. Q.	Top 10%	Top 2%	Top 1%
Model	7.5	0.9	2.2	4.8	28.8	43.9	60.9	65.9
SCF 2019	7.1	1.5	4.2	8.9	19.4	25.6	46.1	48.6

Table 6: Shares of wealth held by different groups of the net worth distribution, in %.

	Bottom 50%	Top 20%	Top 10%	Top 1%
Model	0.2	92.5	81.5	36.1
SCF 2019	0.1	87.4	76.5	37.2

Table 7: Annual transition matrix of business income (Model/Data), in %.

	1. Quint.	2. Quint.	3. Quint.	4. Quint.	5. Quint.
1. Quint.	40 / 63	24 / 19	14 / 8	11 / 5	11 / 5
2. Quint.	19 / 18	39 / 49	23 / 21	13 / 8	6 / 4
3. Quint.	13 / 7	19 / 20	33 / 47	22 / 22	12 / 4
4. Quint.	12 / 5	13 / 7	19 / 18	34 / 53	23 / 16
5. Quint.	15 / 5	5 / 3	10 / 4	21 / 14	49 / 75

Notes: The table reports the probability, in percent, of being in the row quintile of business income in a certain year, and in the column quintile in the following year. The data (right values) are from DeBacker et al. (2018). We use the values from their Table 1. We delete their first row and column (corresponding to zero earnings), reweigh the remaining entries such that rows sum to one again, and then consolidate deciles into quintiles. Values from our model (left) are based on a simulation of 10,000 entrepreneurs over two years. We measure business income as $[\Pi_e(k_{et}, y_t) - f_t] \cdot \mathrm{d}t + \mathrm{d}k_{et}$, i.e. as profits net of costs and depreciation.

managing or owning a business, as we do, but we still find it worthwhile to compare the results on income dynamics they report to those generated from our model.

In particular, DeBacker et al. (2018) report how likely it is for households within a given decile of the business income distribution to end up in another decile in the following year. Table 7 shows these numbers, as well as the analogous statistics simulated from our model. For better readability we reduce the dimensionality of their matrix from ten deciles to five quintiles. Also, unlike in their dataset, we do not have the status "no business income" for our entrepreneurs, so we reweight their original transition matrix, deleting the zero income state. In sum, we find that the income process in our model is similar to that in the data, though ours features somewhat more volatility. Even in the data, as highlighted by DeBacker et al. (2018), households face substantial fluctuations in business income, represented by relatively small probabilities of staying in the same earnings quintile year-on-year. The immobility ratio, i.e. the average of the diagonal elements of the transition matrix, is 39% in our model and 57% in the data.

The last untargeted moments that we compare to the data are the returns that entrepreneurs receive from investing into their firm. This is important as a core prediction of our model is that poor entrepreneurs earn higher returns on average than wealthy entrepreneurs. We defer an in-depth discussion of this issue to Section 6.1, but we already point out here that this prediction of the model is indeed borne out by the data. We also demonstrate that the model matches the level of returns both unconditionally, and conditional on net worth. We view this as a success, since nothing in our calibration has directly targeted these statistics.

5 Quantitative Analysis of Monetary Policy

We now analyze the response of the economy to an interest rate change. Our focus is on aggregate investment, in particular the investment response of entrepreneurs and how it depends on the wealth of entrepreneurs and its distribution.

The solid black lines in Figure 5 plot the response of the key aggregate variables to an expansionary monetary policy shock. Specifically, we consider an unexpected one time innovation of −100 basis points annually to the Taylor rule (7). Owing to the endogenous reaction of the central bank in our model, this leads to a drop in the liquid rate r^b on impact of about 36 basis points. The economy responds in a way that is familiar from the literature on the effects of monetary policy.[21] Output, investment, consumption, labor, and inflation all rise in response to a cut in the interest rate. Output increases by about 1.4% on impact. This number is in line with (though at the upper end of) empirical estimates of the effects of monetary policy shocks (Christiano et al., 2005; Ramey, 2016).[22] Total investment, including that into private firms as well as into the representative firm, rises by 4.1% in our model.

Entrepreneurs, even though they only comprise a small fraction of the total population, are important for setting in motion the general equilibrium feedback loop between higher income and higher consumption demand that naturally arises in any HANK model. To see this, we first break down the aggregate output response on impact after the shock into its two most important components, aggregate consumption and investment. Table 8 shows that aggregate investment accounts for 56.5% of the overall increase in output while consumption makes up 26.5% (the remaining 17% are accounted for mostly by an increase in price adjustment costs). While entrepreneurs do not contribute significantly to the increase in consumption demand directly, they are responsible for about half of the total increase in investment. Two thirds of their additional investment is directed towards their private businesses, but entrepreneurs also account for about a quarter of the additional investment into the mutual fund and thus capital employed by the representative firm. The expansion in entrepreneurial investment in turn leads to more labor demand and hence higher wages for workers, causing consumption demand to rise further.

Next, we conduct two counterfactual exercises. In both, we assume that entrepreneurs are ignorant about the evolution of a subset of aggregate variables. First, we solve for the dynamics after the monetary policy shock when entrepreneurs do not take into account

[21] The lack of persistence in the responses to monetary policy shock is a common feature of HANK models. See Auclert et al. (2020) for a discussion.

[22] Scaling the impulse responses to an impact drop in the real liquid rate r^b of 100 basis points would imply an increase in output of 3.9%.

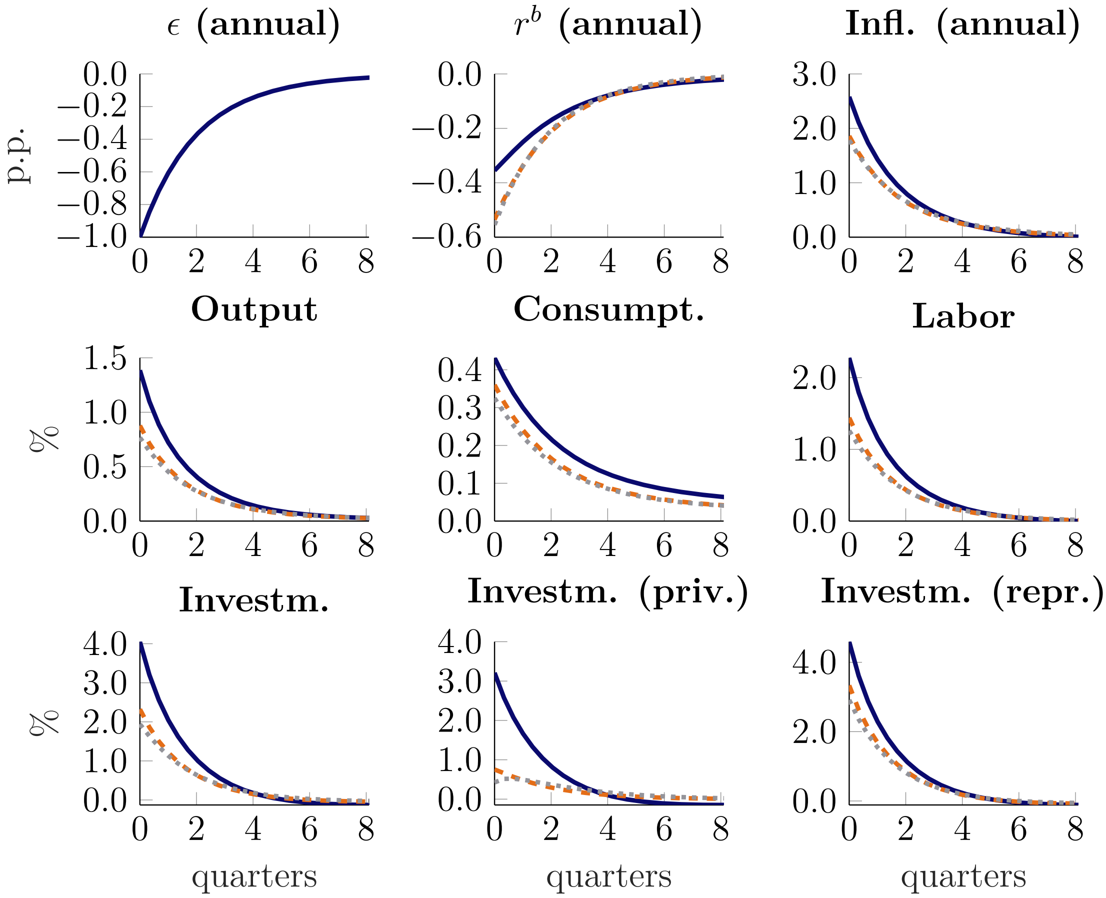

Figure 5: Response of aggregate variables to an expansionary monetary policy shock.
Notes: Depicted are deviations from steady state values. The solid blue line shows the model's response to the shock. The dashed orange line shows the response when entrepreneurs (but not workers) are ignorant about changes in all aggregate variables. The dotted grey line shows the response when entrepreneurs are ignorant only about the change in the liquid rate r^b.

Table 8: Absolute change in consumption and investment relative to absolute output change (on impact), in %.

	Cons.	Inv. (total)	Inv. (priv.)	Inv. (rep.)
Total	26.5	56.5	17.5	38.9
Workers	24.6	29.5	-	29.5
Entrep.	1.9	26.9	17.5	9.4

changes in any of the aggregate variables induced by the shock. We assume that they believe that aggregates are at their steady state values at all times and that they make their consumption and investment decisions accordingly. Importantly, entrepreneurs' assets still evolve according to actual prices. This implies that entrepreneurs still face income changes due to the monetary policy shock and all factor markets clear at all times. In the second case, we assume that entrepreneurs take into account changes in all aggregate variables except of the liquid interest rate r^b, about which they believe that it is constant at its steady state value at all times.[23] This addresses how important the direct effect of monetary policy on entrepreneurs is for the economy's response.

The orange lines in Figure 5 correspond to the first experiment in which entrepreneurs are ignorant about all aggregate variables. In this case, the aggregate dynamics following the monetary policy shock are significantly muted. The responses of output and investment to the interest rate change are only about half as large as in the baseline scenario. The investment response is dampened particularly strongly, which highlights again the importance of entrepreneurs for aggregate investment. Note also that if we were to rescale the impulse responses to imply the same drop in the liquid rate r^b, these results would become even more pronounced. The dotted grey line shows the results for the second experiment, in which entrepreneurs take into account changes in all aggregate variables except that of the liquid rate r^b. The grey lines lie almost on top of the orange lines. Hence it appears crucial to analyze the direct response of entrepreneurs to the change in the liquid interest rate to better understand the transmission of monetary policy in our model. For that, we next turn to the investment responses of entrepreneurs over the net worth distribution.

Heterogeneity among entrepreneurs Entrepreneurs as a group are important for the evolution of aggregate investment in response to the shock, as we have just seen, but there is considerable heterogeneity within the group of entrepreneurs. Depending on the size of their firm and their net worth entrepreneurs respond to the interest rate change very differently.

The solid blue line in Figure 6 depicts the total change in the entrepreneurs' private firm investment relative to their capital stock across the net worth distribution. We show the response on impact, i.e. immediately after the expansionary monetary policy shock hits the economy. The line exhibits an approximate u-shape. Relatively poor entrepreneurs respond strongly to monetary policy by expanding their investment. The response is smallest for entrepreneurs with a net worth of around \$3 million. For entrepreneurs with net worth above \$3 million, the response increases with net worth and then plateaus, so that wealthy entrepreneurs respond relatively strongly.

To better understand what causes this heterogeneity, and guided by the decomposition of the aggregate responses we performed in Figure 5, we follow the previous literature on

[23]The aggregate variables that are relevant for the decisions of entrepreneurs are r^b, r^a, w, p, T, Y_e and Π. The first experiment holds entrepreneurs' believes about all of these constant at steady state values, the second experiment only holds believes about r^b constant.

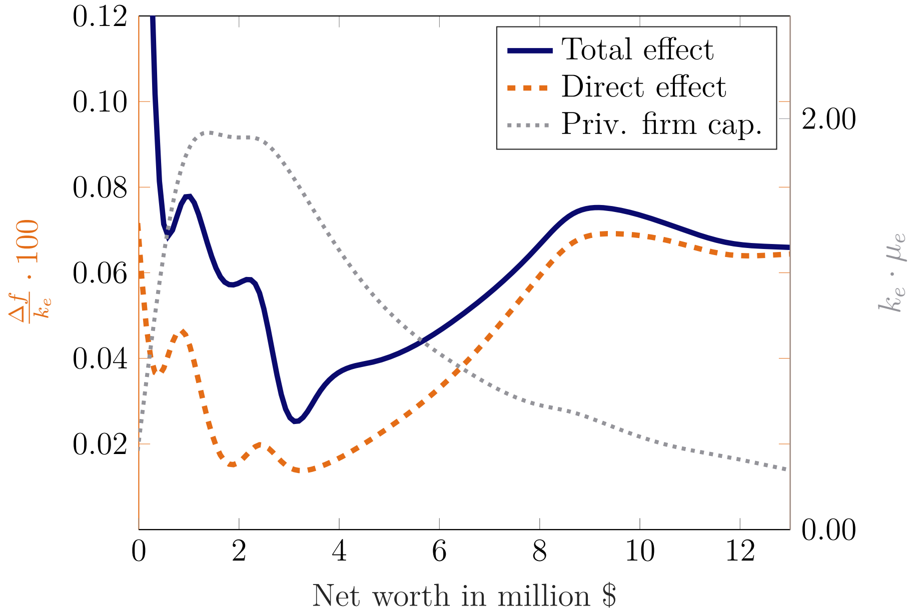

Figure 6: Heterogeneous private firm investment response after monetary policy shock.
Notes: Blue solid line: Total change in private firm investment relative to private firm capital in response to monetary policy shock on impact (left y-axis). Orange dashed line: Change in firm investment caused by direct effect, i.e. only liquid rate changes, other prices held fix (left y-axis). Grey dotted line: Share of private firm capital $k_e \cdot \mu_e$ (right y-axis). All lines show averages within small bins of net worth.

monetary policy shocks in HANK models and distinguish between direct and indirect effects of the interest rate change. Turning to the direct effects first, the orange dashed line in Figure 6 depicts the response of firm investment that is due solely to the interest rate change, i.e. keeping all other prices constant. We obtain it by asking how entrepreneurs respond if only the liquid interest rate r^b evolves as it does in Figure 5, while all other aggregate variables stay at their steady state levels.[24] The response is smaller than the general equilibrium effect but the overall shape looks very similar. All firm owners invest more into their firm when the liquid rate r^b decreases, optimally reweighting their portfolio and reducing their exposure to the now lower-yielding liquid bond.

The magnitude of this reallocation effect varies greatly with the net worth of a firm's entrepreneur. For the poorest firm owners, at the very left border of the graph, investment elasticities are very large. These are entrepreneurs, who take on debt to grow their firm, as the marginal return from their firm is very large. Once r^b is reduced, they experience a positive income effect as they have to pay lower interest rates on their debt, and hence they invest additional resources into their firm. In terms of aggregate investment, however, these entrepreneurs are of minor importance, as they hold a negligible share of the overall capital stock. This is illustrated by the grey dotted line, which plots the share of business capital held at respective points of the net worth distribution, i.e. $k_e \cdot \mu_e$.[25] A large number

[24]In contrast to the decompositions we performed in Figure 5, this is a partial equilibrium exercise. We simply ask how entrepreneurs would react to the interest rate path shown in Figure 5. We do not ask how prices would have to respond to support the resulting choices as equilibrium outcomes.

[25]The line integrates to the aggregate private firm capital stock $K_e = \int k_e \mu_e(i) di$. To obtain it, we average the private firm capital share within small bins of net worth.

indicates that entrepreneurs at this level of net worth hold a large share of total private business capital.

Entrepreneurs with an intermediate amount of net worth do not rely on debt to finance the firm, but their firm still offers relatively high marginal returns. Put differently, the excess return of their firm investment over the riskless bond is large. When monetary policy changes r^b, this excess return is therefore not affected much in relative terms, and hence they rebalance their portfolio relatively little. Wealthy entrepreneurs who own large firms do not reap such high returns from their business. For them, the excess return over r^b is close to zero. Therefore, a change in r^b affects their excess return more significantly, and they reshuffle their portfolio much more than owners of smaller firms to implement the optimal combination of business risk and excess return over the risk-free rate.

Next, we turn to the indirect effects of the interest rate cut on entrepreneurial investment that work through changes in prices and income. The indirect effect on firm investment is the difference between the dashed and the solid line in Figure 6, i.e. it is the additional investment that is not due to the interest rate change itself. For most entrepreneurs, the indirect effects are smaller in magnitude than the direct effects. In particular, this is the case for wealthy entrepreneurs. To them the private firm is similar to any other asset in their portfolio. Therefore, they spend additional income almost proportionally on investment into the different assets and on consumption, and hence the indirect effect on private business investment is small. For entrepreneurs with little wealth, who own small firms, however, the indirect effects are large. These are households with highly profitable businesses who lack the resources to expand their firm. The rise in income induced by monetary policy allows them to grow their business and they seize this opportunity.[26]

We summarize our results as follows. First, the aggregate output response is affected significantly by the investment decision of entrepreneurs. Second, investment of wealthy entrepreneurs responds more strongly than that of entrepreneurs in the middle of the wealth distribution due to a stronger portfolio reallocation effect. The decreasing returns to scale imply that wealthy entrepreneurs earn a low excess return over the risk-free rate. When the risk-free interest rate falls, they expand investment strongly to restore the optimal excess return. It is therefore crucial that our model produces a realistic distribution of excess returns over net worth. In the next section we look at data from the SCF to argue that it does. Third, poor entrepreneurs also respond strongly to monetary policy because of large indirect effects. However, by definition, they only hold a small fraction of the total capital stock, which mutes their importance for aggregate investment.

[26] Corroborating these results, Figure 19 in the appendix plots the marginal propensity to invest into the private business out of a transfer of \$500 into the liquid account as a function of net worth.

6 Implications of the Model: Empirical Evidence

In this section we test two key implications of our model. We do so by relying on data from the SCF, as we did in Section 2.[27] We include households in the sample whose head is aged 25–65, and who have positive net worth and business wealth. Also, as will become clear momentarily, valuations of businesses that are positive but very close to zero result in estimated returns that are very large. We therefore purge the sample of households with the largest 5% of business returns, as defined momentarily.[28] We exclude the SCF wave of 1983 as the variables needed for computing the business returns are only available starting in 1989. Table 17 in the appendix reports summary statistics for business returns, net worth and business wealth for the remaining sample over all SCF waves.

6.1 Business returns over net worth

One implication of our quantitative model is that richer entrepreneurs receive smaller returns from their private businesses. To assess this in the data we first need a measure of the business return. Following the baseline definition in De Nardi et al. (2007), we define it as the inverse price to earnings ratio

$$r^e_{it} = \frac{\text{business income}_{it}}{\text{business value}_{it}} \, .$$

Here, households are indexed by i, the year by t. Business income is the wage or salary income from the main job of the household's head plus business profits paid out to the household (all before taxes).[29] If the head's spouse works at the business we also add wage and salary income of the spouse. For the business value we rely on the answer of households to the question "What is the net worth of (your share of) this business?", i.e. we use the market value of the business.

Figure 7 shows the median business return in each decile of the net worth distribution of entrepreneurs for all SCF waves as well as for the most recent wave of 2019. The picture looks very similar for both samples. Returns are substantially lower in higher deciles of the net worth distribution than in lower deciles. Entrepreneurs in the first decile earn an annual return of 110% (all waves) and those in the highest decile of 10%.

The returns for entrepreneurs in the lower net worth deciles appear quite large. One explanation is that the value of their businesses is small and most of the return is actually labor income instead of capital income from their investment. Note that we include wages of the entrepreneur in our definition of business income to be consistent with our model, in which we also do not distinguish between the part of entrepreneurial business income that

[27] Wherever necessary, we deflate nominal values to 2019 US dollars using the CPI-U-RS (all items) series obtained from the Bureau of Labor Statistics.

[28] We consider different subsamples below, in particular, we look at the 2019 wave of the SCF and at all waves together. We drop the largest 5% over all waves when we consider all waves and the largest 5% in the 2019 wave when we consider the 2019 wave.

[29] By definition of entrepreneurs the head's main job is at the privately owned and managed business.

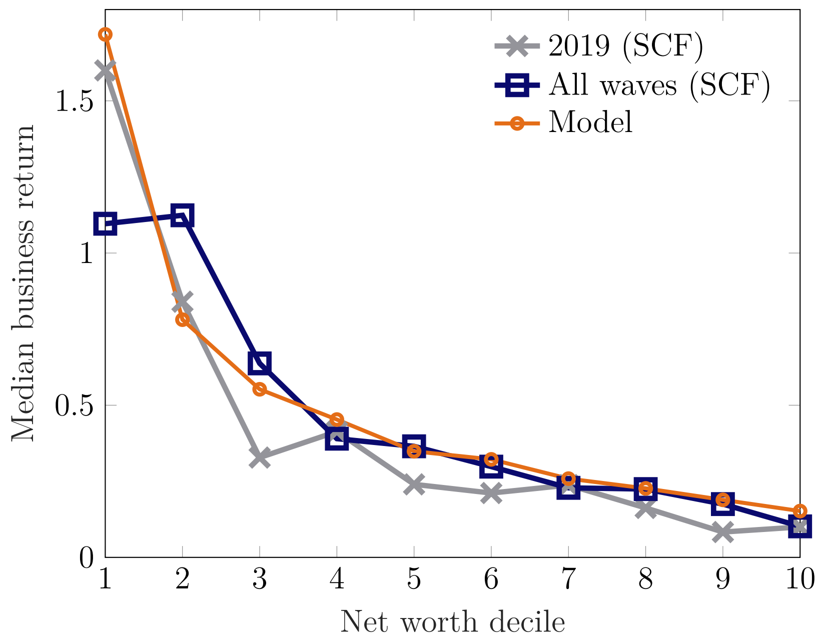

Figure 7: Median business returns by decile of the net worth distribution of entrepreneurs. *Notes:* Depicted are returns from SCF data only for 2019 (grey), over all waves (blue), and steady state returns from our model (orange).

comes from entrepreneurs' capital investment and the part that comes from their labor input. It is a defining characteristic of entrepreneurship that the two are difficult to distinguish. Lastly, be reminded that all returns shown here correspond to business income before taxes, and hence returns after taxes would be smaller.

We also plot the implied average returns from our model steady state in Figure 7, and find that they fit the data surprisingly well, both in terms of levels and in terms of evolution over net worth (the model analogue of net worth is $k_e + a + b$). We view this as a great success of our model to capture a relevant dimension of firm heterogeneity, as nothing in our calibration directly targets either the overall level of returns or the returns conditional on net worth deciles.

The negative relationship between wealth and returns to entrepreneurship we uncover is in line with recent empirical evidence provided in other studies. Xavier (2021) uses SCF data as we do, and finds that within the asset class of private businesses returns decline at the top of the wealth distribution. While we observe a largely monotone relationship in the data she discovers an inverse u-shape, with returns largest within the 90th to 97th percentile of the population-wide net worth distribution (in the 2019 SCF, the 90th percentile of the overall net worth distribution corresponds to the 64th percentile of the entrepreneurial net worth distribution, which we use when plotting Figure 7). The difference between her results and ours stem from the fact that she does not include the entrepreneurs' labor income in her measure of business profits, which, as we have just argued, tends to raise our measure of profits especially for smaller firms. In addition to this, Smith et al. (2021) document falling returns to private business capital among the highest percentiles of the wealth distribution using administrative income tax data.

The results so far indicate an unconditional correlation between net worth and business returns. In Appendix B we study the relationship between these two variables in more detail. First, we estimate their relationship non-parametrically. Second, we estimate linear regressions in which we control for a large number of observable household characteristics. In both cases a robust negative relationship between net worth and returns emerges. We also discuss potential problems of our analysis and investigate the relationship between business wealth and returns as well as that of business wealth and portfolio shares.

6.2 Portfolio response to monetary policy shocks

To answer how entrepreneurs adjust their portfolios in response to monetary policy, we would ideally observe a panel of entrepreneurial households, preferably at quarterly or even higher frequency, and trace their reaction to identified monetary policy shocks. Unfortunately, the SCF is neither a panel nor does it feature such high frequency, as the data is only collected every three years. We therefore follow an approach similar to Luetticke (2021) who faces the same challenges as we do.

First, for each wave of the SCF we estimate the portfolio share of firm capital, i.e. the ratio of business value to net worth, for each percentile p of the business return distribution and denote the log of this portfolio share by $\gamma_{p,t}$, where t denotes the year of the SCF wave. We non-parametrically estimate these portfolio shares using local linear regressions, effectively using information about the portfolio shares in percentile p and in those percentiles that lie close to p to estimate $\gamma_{p,t}$. Appendix D lays out the details of this procedure.

We then use local projections in the spirit of Jordà (2005) to estimate the effect of monetary policy shocks on the estimated portfolio shares. Specifically, to estimate the effects of an interest rate movement at time t on portfolio shares at $t+h$, we use the regression

$$\gamma_{p,t+h} = \alpha + \beta_{p,h} \cdot FF_t + \delta^{Y}_{p,h} \cdot \ln(Y_{t-1}) + \delta^{FF}_{p,h} \cdot FF_{t-1} + u_{t+h} \ , \tag{8}$$

where α is a constant, FF denotes the Federal funds rate, Y is GDP, and u is an error term with $\mathbb{E}[u_t] = 0$. The estimate of interest is $\beta_{p,h}$ and it captures the response at horizon h of the log portfolio share in firm capital to a 100 basis point increase in the interest rate at time t for the p'th percentile of the return distribution.

Since the federal funds rate is endogenous, we instrument it using an identified monetary policy shock series, i.e. we estimate IV local projections. Specifically, we use the narratively identified shock series, denoted ϵ^{y}_{t}, from C. Romer and D. Romer (2004) which was extended until 2007 by Ramey (2016). As the shock series ends in 2007, we only use SCF waves 1989 to 2007 in this section. In Appendix D we describe how we convert the monthly shock series into an annual series, and we also document our results when using the shock series from Gertler and Karadi (2015). They exploit high-frequency financial markets data to construct their shocks, which are available from 1990 to 2012.

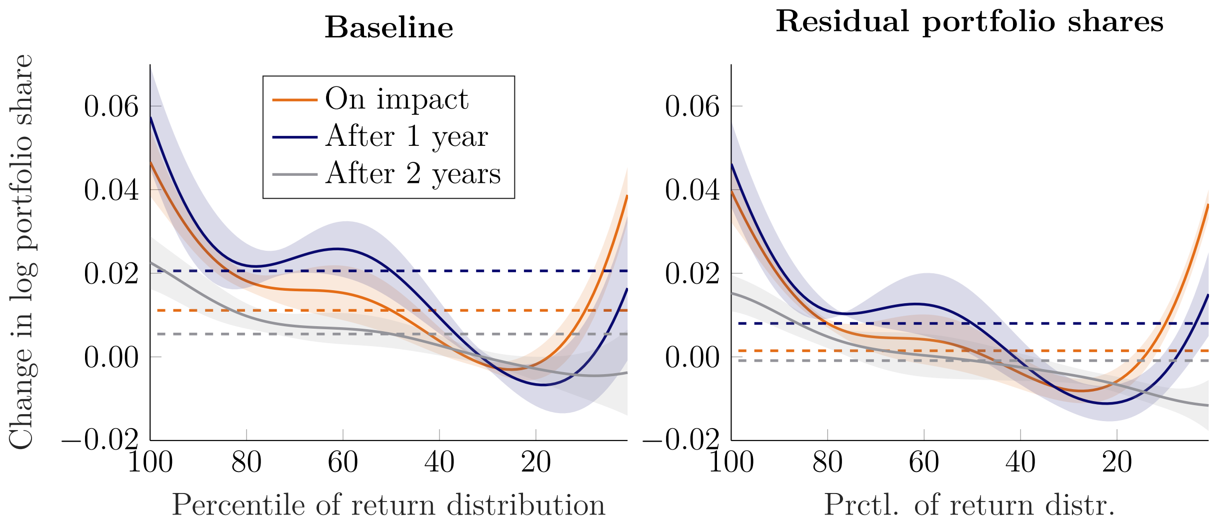

Figure 8: Impulse responses of portfolio shares to monetary policy shock.

Notes: Change in the logarithm of portfolio shares following a 25 basis points expansionary monetary policy shock by business return percentile. The dashed lines depict the responses at the median of the return distribution. Confidence bands are at the 66% level.

The left panel of Figure 8 depicts our baseline estimates of $\hat{\beta}_{p,h}$ for $h = 0, 1, 2$. Consider the orange solid line first. It depicts the estimated portfolio response on impact to an exogenous 25 basis point cut in the interest rate for each percentile p of the return distribution, i.e. $-\hat{\beta}_{p,0}/4$. We order percentiles in decreasing order on the x-axis, as we have shown above that high returns typically correspond to the poorest entrepreneurs.

At most percentiles the response is positive, lending evidence to the portfolio reallocation channel that is also present in our model. In particular, the response is positive and statistically significant from zero for entrepreneurs at the median of the return distribution, depicted by the dashed line. In terms of magnitudes the estimates indicate that in response to the cut in the interest rate, the median entrepreneur increases her exposure to the firm by one to two percent in the first two years after the shock. While the blue solid line shows that the response after one year is similar to the one on impact, the grey line indicates that after two years the response is a bit smaller.

Turning to heterogeneity, there is suggestive evidence that entrepreneurs at both extremes of the return distribution react relatively strongly on impact as well as one year after the shock. Through the lens of our model, and in accordance with Figure 6, this could be interpreted as strong direct effects for entrepreneurs with large firms and hence small returns, and large responses of entrepreneurs with small firms and hence large returns. This u-shape, however, disappears in the second year after the shock. While our model does not imply a decline in the portfolio share after two years for firm owners with low returns, as is indicated by the grey line, we would indeed expect the reallocation towards firm capital to be strongest right after the shock materializes, i.e. on impact and one year after the shock. We defer a critical discussion of the results of this subsection, and also of the right panel of Figure 8, to Appendix D.

7 Consequences of Higher Wealth Inequality

The wealth distribution is endogenous in our model. To study how higher wealth inequality affects the transmission of monetary policy, in principle we need to take a stance on what has been the exogenous force that has raised wealth inequality to a new, higher level.

Before doing so, however, in Subsection 7.1 we follow a different approach. In particular, we ask how changing the distribution affects the transmission of a cut in the interest rate, keeping all policy functions fixed at their steady state values. This allows us to stay silent on the driver of increasing wealth inequality in the recent decades. The results therefore apply to the effects of higher wealth inequality on monetary policy transmission regardless of the concrete source of elevated inequality. The disadvantage of the approach is that we can only study a static approximation to the general equilibrium response which lacks important dynamic elements, as we will discuss below.

In Subsection 7.2 we re-parameterize our model to generate a steady state with higher wealth inequality. Motivated by the decline in estate taxation in the US in recent decades, we achieve this by assuming that entrepreneurs are born with positive (inherited) wealth. We then compare the effects of monetary policy across the two model specifications, one with low and one with high inequality.

7.1 Fixed policy functions

We begin by calculating an approximate general equilibrium response to a change in the interest rate. Let Y denote aggregate output, C aggregate consumption, I aggregate investment (both into capital of private firms $\int k_e$ and into capital of the representative firm K_p), and G government expenditures. In this section, we assume that

$$Y = C(Y, r^b) + I(Y, r^b) + G(Y, r^b) \ , \tag{9}$$

i.e. for simplicity we ignore parts of output here that are relatively small, in particular price, portfolio and capital adjustment as well as financial intermediation costs. Taking the total differential of (9), we have

$$\mathrm{d}Y = \left[\frac{\partial C}{\partial Y} + \frac{\partial I}{\partial Y} + \frac{\partial G}{\partial Y}\right] \mathrm{d}Y + \left[\frac{\partial C}{\partial r^b} + \frac{\partial I}{\partial r^b} + \frac{\partial G}{\partial r^b}\right] \mathrm{d}r^b \ .$$

Rearranging yields

$$\frac{\mathrm{d}Y}{\mathrm{d}r^b} = \frac{\frac{\partial(C+I+G)}{\partial r^b}}{1 - \frac{\partial(C+I+G)}{\partial Y}} = \frac{\frac{\partial(\int_i (c_i^* + d_i^* + f_i^*)\mu(i)\ \mathrm{d}i\ + G)}{\partial r^b}}{1 - \frac{\partial(\int_i (c_i^* + d_i^* + f_i^*)\mu(i)\ \mathrm{d}i\ + G)}{\partial Y}} \ , \tag{10}$$

where the last fraction expresses the aggregate effect in terms of individual households' optimal decision rules. The term on the right-hand-side of (10) has an intuitive interpretation.

The general equilibrium change in aggregate output upon a change in the interest rate is the direct effect of the interest rate change (the numerator) divided by one minus the marginal propensity to spend an additional dollar on consumption, investment or government spending (the denominator). The goal of this section is to evaluate (10) once with the true steady state distribution, μ^{steady} and once with a distribution that features higher wealth inequality, μ^{high}, holding the policy functions fixed.

Importantly, this approximation is static, i.e. only contemporaneous variables enter. Dynamic effects on today's household decisions, e.g. higher consumption today caused by looser borrowing constraints in the future due to elevated labor income, are shut off. We still find the approximation useful as a starting point of our analysis.

To calculate the denominator of (10), we need to make an assumption on how individual household income, which we denote by y_i, fluctuates with aggregate income. To see this, rewrite

$$\frac{\partial c_i}{\partial Y} = \frac{\partial c_i}{\partial y_i}\frac{\partial y_i}{\partial Y}$$

and analogously for investment. We assume that $\forall i$, $\frac{\partial y_i}{\partial Y} = \frac{y_i}{Y}$, i.e. individual income fluctuates proportionally to aggregate income for all households.[30]

Next, we approximate the derivatives $\frac{\partial c_i}{\partial y_i}$ (MPC), $\frac{\partial f_i}{\partial y_i}$ (MPI in private firm capital) and $\frac{\partial d_i}{\partial y_i}$ (MPI in representative firm capital) as the fraction of a 500$ transfer into the liquid account that households would spend on c, f and d respectively within one quarter.[31] To calculate $\frac{\partial G}{\partial Y}$, we assume that households finance government expenditures in proportion to their income. Given the proportional tax on labor income τ_l, this is a good approximation. Formally, we assume that $\frac{\partial G}{\partial Y} = \frac{\partial\left(\int_i g_i \, \mathrm{d}i\right)}{\partial Y}$ and that $\frac{\partial g_i}{\partial Y} = \frac{\partial g_i}{\partial y_i}\frac{\partial y_i}{\partial Y} = \frac{g_i}{y_i}\frac{y_i}{Y}$, where g_i corresponds to government spending financed by household i, i.e. her taxes paid minus transfers received.

Turning to the numerator of (10) we require knowledge of how households react to a change in the interest rate r^b. For this, we use the results from the direct effect to the monetary policy shock in Section 5, which we plotted in Figure 6 for the case of private firm investment. We obtained these results from exposing households to an isolated change in the interest rate (the one that is depicted in Figure 5), keeping all other aggregate variables at their steady state levels. We use the impact responses of household investment and consumption respectively. From the government budget constraint we further know that $\frac{\partial G}{\partial r^b} = -B^S$.

The first row in Table 9 shows the results of the approximation (10) using the steady state distribution of households. The cut in the interest rate leads to an increase in output of 1.09%, which is a bit smaller than the response in Section 5 of 1.39%. This is not surprising, given that in the approximation we implicitly turned off all *dynamic* general equilibrium forces affecting the households' decision. In a full dynamic general equilibrium

[30] We therefore abstract from unequal incidence of aggregate income movements, in contrast, for instance, to Patterson (2019). In the next section this assumption is relaxed, as disposable income will be varying differently for different households following a monetary policy shock.

[31] In doing so, we use the same approach that KMV propose to calculate MPCs in their model.

Table 9: Response to persistent decrease in the liquid interest rate r^b under steady state wealth distribution and distribution with higher inequality.

	Top 10% wealth share	$\frac{\mathrm{d}Y}{Y}$	$\frac{\partial(C+I+G)}{\partial r^b}\mathrm{d}r^b$	$\frac{\partial(C+I+G)}{\partial Y}$	$\frac{\partial I_e}{\partial r^b}\frac{\mathrm{d}r^b}{I_e}$
Steady state	81.5%	1.09%	.0102	.5024	2.49%
High inequality	82.5%	1.17%	.0116	.4978	2.84%
Relative change	1%	7%	13%	-1%	14%

setting households realize that economic activity is stimulated and hence income is higher for several quarters. This moves households further away from the borrowing constraints, leading to less precautionary saving, which in turn results in even more aggregate demand (see Auclert et al. (2018) for a formal discussion of this argument). Our static approximation abstracts from this dynamic effect.

To construct a high-inequality wealth distribution μ^{high} we proceed as follows. Guided by the empirical evidence in Section 2, we want to increase the wealth of the average entrepreneur relative to the average worker, and in doing so generate higher wealth inequality. To focus on the role of entrepreneurs most clearly, we leave the distribution of wealth among workers μ_w unaltered, and only change the distribution of wealth for entrepreneurs μ_e. In particular, we multiply the size of each entrepreneur's private firm by a factor of $1 + x$. We choose $x = 27\%$, which generates an increase in the overall top 10% wealth share of one percentage point. This is a relatively mild increase in wealth inequality. Figure 15 in the appendix shows that between the early 1980s and today the top 10% wealth share has gone up by about ten percentage points. However, assuming the supply of labor in the economy remains unchanged, the employment share in the private firms significantly increases, from 41% in the steady state distribution to 46% in the new distribution which features larger private firms. We therefore view the considered experiment as a reasonable representation of the shift of wealth from workers to entrepreneurs that actually occurred in the US between 1980 and today.

The core result of this section is that once we move to the distribution that features higher wealth inequality, the output response is strengthened, in our experiment by 0.08 percentage points (second row of Table 9). This represents an increase of the aggregate output response of 7% compared to the response implied by the original steady state distribution. Strikingly, as the relative changes in the last row reveal, the entire increase of the effects on real activity stem from the direct effect of monetary policy, i.e. from a change in the numerator of (10). The average marginal propensity to consume and invest in the economy (second to last column) is almost unaltered by changing the distribution.[32]

[32]There are two counteracting effects on the denominator of (10). Higher inequality leads to smaller aggregate marginal propensities to invest because of a *within*-occupation effect. Small firm owners have higher propensities to invest additional income into their firms as large firm owners, and when more capital is in the hand of the large firm owners, overall MPIs decline. Higher inequality leads to larger aggregate marginal propensities to invest, however, because of a *between*-occupation effect. The average entrepreneur

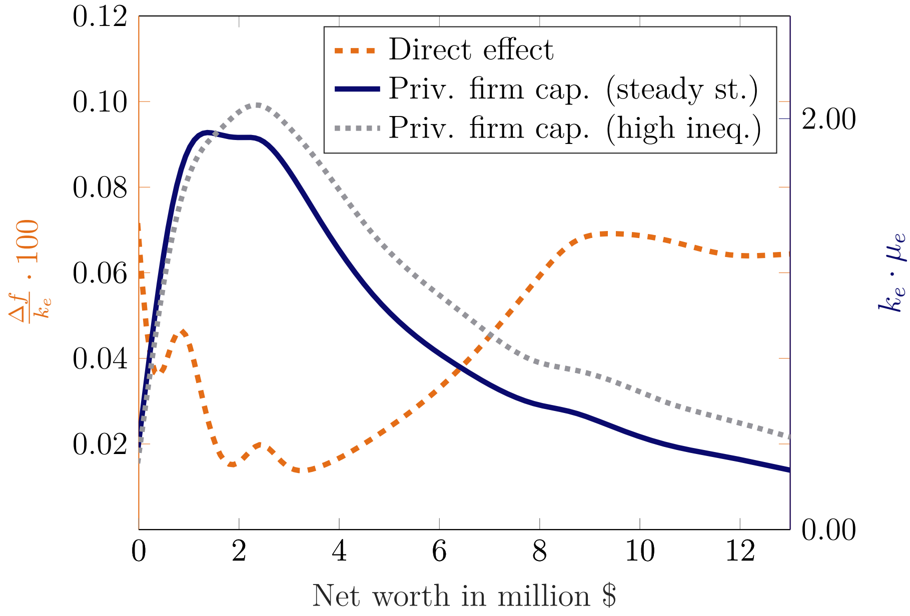

Figure 9: Direct effect and distributions of firm capital under low and high inequality.
Notes: Orange dashed line (left y-axis): Change in firm investment caused by direct effect, i.e. only by change in liquid interest rate r^b, other prices fixed. Blue solid line (right y-axis): Share of private firm capital $k_e \cdot \mu_e$ in steady state. Grey dotted line (right y-axis): Share of private firm capital $k_e \cdot \mu_e$ under counterfactual distribution with higher wealth inequality.

The larger effects under higher inequality can be explained with the mechanisms discussed in Section 5. A shift towards a distribution that features higher wealth inequality puts more wealth into the hands of entrepreneurs with a strong portfolio reallocation response. This can be seen in Figure 9, where the orange dashed line shows the direct effect of the change in the interest rate $\{r_t^b\}$ on firm investment (this is the same as in Figure 6). Under the new distribution with higher inequality, as the distribution of firm capital is shifted to the right, there exist more entrepreneurs owning large firms. Since these entrepreneurs exhibit a large elasticity of firm investment, monetary policy has stronger effects. In sum, the direct effect of the shock on aggregate private firm investment rises by 14% when moving from the low- to the high-inequality distribution, as the last column of Table 9 shows.

One caveat of the results so far is that wealth inequality within the group of entrepreneurs *declines* in our experiment. For instance, the wealth held by the richest ten percent of entrepreneurs relative to the wealth held by all entrepreneurs decreases by about 2.5 percentage points. This stands in contrast to our empirical findings in Section 2, which indicate that inequality among entrepreneurs has actually risen since the 1980s. To account for this, we consider a second high-inequality distribution μ^{high}. This time, instead of multiplying the firm size of all entrepreneurs by $1 + x$ we only increase the firms of the top 10% richest entrepreneurs, more precisely of those whose firms are among the 10% largest. We choose $x = 47\%$, again to generate an increase in the top 10% wealth share across all occupations of one percentage point. In contrast to before, such a shift of wealth leads to an increase

features a higher MPI than the average worker, and in our experiment we increase the share of wealth held by the entrepreneurs. These two effects approximately cancel out in our calibration.

in inequality even among entrepreneurs: the top 10% share among entrepreneurs rises by about 2.5 percentage points. The output response in this case is 10% larger compared to the baseline scenario with μ^{steady}. The relatively stronger amplification compared to that shown in Table 9 is intuitive, as now the shift of wealth towards the (high-elasticity) wealthy entrepreneurs is even more pronounced than it was in the first experiment.

7.2 General equilibrium response under higher wealth inequality

We now turn to the full dynamic general equilibrium analysis which shows that the results obtained from the approximation in the previous subsection carry over when taking into account dynamic effects. In principle, there are many ways to endogenously create more inequality in the steady state of our model. Here, we opt for one that leads only to a small deviation from the original model. This makes it possible to most clearly attribute the differential responses we find under the new specification to higher wealth inequality.[33] In particular, we assume that entrepreneurs are born with a positive amount of assets, unlike in the initial version of our model, in which we assumed that all households were born with zero assets. We find that this small change to the model is enough to endogenously generate a higher degree of wealth inequality in steady state.

One can interpret this modification as decreasing progressivity of the US tax system, well-known to have taken place since the 1980s (see, for instance, Hubmer et al. (2021)). More specifically, our experiment can be interpreted as a decrease in estate taxation, leading to higher initial endowments of wealthy households' heirs. Federal estate taxation has become less broad-based since the 1980s. For instance, while in 1982 2.8% of the US adult population had assets exceeding the threshold that made them subject to estate taxation upon death (assets greater than 325,000\$, or 808,000\$ in 2016 terms), this fraction decreased to only 0.32% in 2016 (assets greater than 5,450,000\$). At the same time, the top bracket tax rate applied to these estates has declined, from 70% in the early 1980s to 40% today.[34]

We make the following adjustment to our quantitative model to implement this modification. Instead of assuming that entrepreneurs are born with zero wealth, we now assume that they own positive wealth $w' = \{b', a', k_e{}'\}$ right from the start of their lives. We only allow entrepreneurs, not workers, to be born with positive wealth in order to identify most clearly the effect of the shift in wealth towards the private entrepreneurs that we observe in the data. We also refrain for simplicity from making any adjustment to the preferences of the households, implicitly assuming that they do not derive utility from bequeathing wealth to their offspring. The difference between the exercise conducted here and the one

[33] Another approach would be to re-calibrate the model, targeting for instance a higher employment share in private firms. Then, however, all calibrated parameters would change, and it would be less clear which changes are driving our results.

[34] These numbers are taken from information provided by the Internal Revenue Service, in particular from SOI Bulletin articles by Barnes (2021), Jacobson et al. (2007), and Schwartz (1988), as well as from information provided on the IRS website, accessed on Nov 29, 2020, at https://www.irs.gov/businesses/small-businesses-self-employed/whats-new-estate-and-gift-tax.

in the previous section is that this time the steady state distribution (and with it all prices) endogenously adjust in response to the new environment.

To make our results here comparable to the exercise in Section 7.1, we calibrate the amount of inherited wealth w' such that, as above, we obtain an increase in the top 10% wealth share of one percentage point in the new steady state. It turns out that we require entrepreneurs to be born with about \$590,000 to achieve this.[35]

We now expose the re-parameterized model to the same monetary policy shock as before. To be able to compare the responses under the two scenarios, we rescale them to imply the same peak response of the interest rate r^b. Figure 10 plots the IRFs both for the economy with low and with high inequality. In order to make the differences between the two economies clearly visible the figure only displays the responses for the first two quarters after the shock.

As in Section 7.1, we find that the real effects of monetary policy are amplified by higher wealth inequality. The output response goes up from 1.39% under low inequality to 1.67% under high inequality, i.e. we find that the effects are magnified by about 20% of the initial response. This corroborates our previous finding, namely that increasing wealth inequality, by putting more wealth into the hands of wealthy entrepreneurs, strengthens the effects of monetary policy in general equilibrium.

At first sight, Figure 10 seems to indicate that private firm investment is not the most influential driver behind the stronger output effects, as its response under high and low inequality are similar. To better understand the reasons for this, Figure 11 plots the firm capital share distribution in the initial steady state (blue solid) and its counterpart when entrepreneurs are born with positive bequests (grey dotted), as well as the direct effect on firm investment in the initial steady state. While the considered experiment does increase the firm capital of rich entrepreneurs with large direct effects, it increases to an even bigger extent the amount of firm capital held by medium-wealthy entrepreneurs with small investment elasticities.

Why do we still obtain larger responses of aggregate investment and output under high than under low inequality? To develop an answer, consider Table 10. The first row captures the initial (low-inequality) steady state of our model. Here, entrepreneurs do not receive bequests and the share of workers employed in the private firms is 41%. The second row corresponds to the high inequality steady state, in which all newborn entrepreneurs receive bequests of \$590,000. The share of labor employed in the private firms rises to 48% and the initial output response to the monetary policy shock gets amplified by 20% as shown in Figure 10.

The last three columns split the direct effect of the interest rate change on impact by type of investment: total investment, private firm investment and representative firm investment.

[35] We assume that the endowed wealth w' is composed entirely of private firm capital, i.e. $b' = a' = 0$\$. We found this assumption to be inconsequential for the main results of this section. In order to account for the non-zero bequests, we make the corresponding adjustments to the interest rates in our model. In particular, we assume that the interest rates on all three assets are proportionally adjusted downward by the same factor in order to finance the endowments of newborn entrepreneurs.

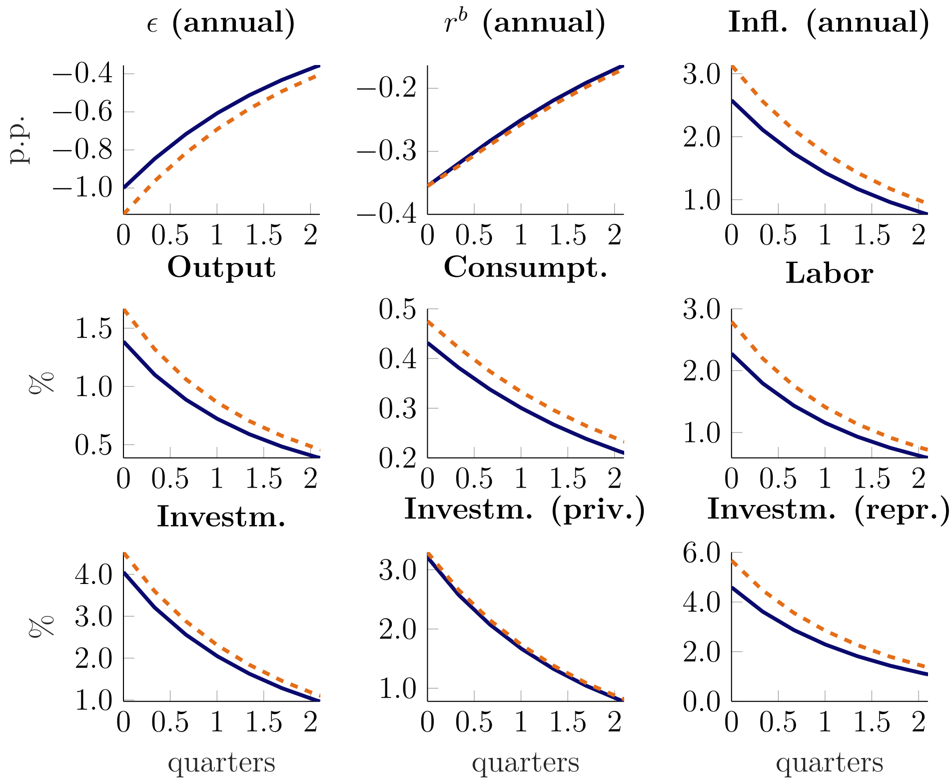

Figure 10: Response of aggregate variables to an expansionary monetary policy shock under low and high wealth inequality.

Notes: Depicted are deviations from steady state values. The solid blue line shows the response to the shock under the original steady state distribution. The dashed orange line shows the response when newborn entrepreneurs are born with positive wealth w', which leads to higher wealth inequality in steady state. All high-inequality responses are rescaled to imply the same impact drop of r^b as under low inequality.

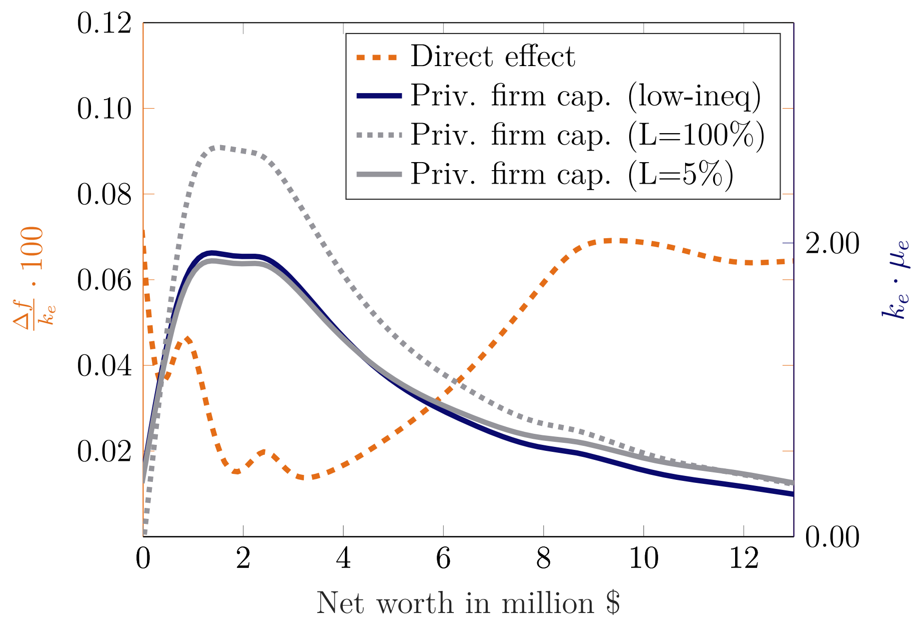

Figure 11: Direct effect and different private firm capital distributions.

Notes: Left y-axis: Change in firm investment caused by direct effect, i.e. only by change in r^b (evaluated in the initial steady state) (orange dashed). Right y-axis: Share of private firm capital $k_e \cdot \mu_e$. Blue solid: initial steady state distribution; grey dotted: high-inequality distribution when all entrepreneurs receive bequests; grey solid: high-inequality distribution when $L = 5\%$ of entrepreneurs receive bequests.

Table 10: Responses to interest rate changes under different bequest regimes.

(1) L	(2) Bequest size (M$)	(3) Y response increase	(4) Labor at entre.	(5) Top 10% wl. share	(6) Direct effect on Inv. $\frac{\partial I}{\partial r^b}\frac{\mathrm{d}r^b}{I}$	(7) $\frac{\partial I_e}{\partial r^b}\frac{\mathrm{d}r^b}{I_e}$	(8) $\frac{\partial I_r}{\partial r^b}\frac{\mathrm{d}r^b}{I_r}$
0%	-	-	41%	81.5%	1.42%	2.49%	0.73%
100%	0.59	20%	48%	82.5%	1.53%	2.40%	0.72%
50%	1.18	12%	46%	82.9%	1.48%	2.37%	0.71%
10%	5.89	8%	43%	83.3%	1.48%	2.52%	0.71%
5%	11.79	5%	42%	83.1%	1.47%	2.53%	0.72%

Notes: The first row represents the initial steady state, the second to last rows vary the bequests received by entrepreneurs. Column (1) shows the fraction of entrepreneurs who receive bequests. Column (2) shows the bequeathed amount per bequest in million \$. Column (3) shows by how much the impact output response is increased compared to the baseline. Column (4) indicates the fraction of workers employed in the private firms in steady state, column (5) the top 10% wealth share. The last three columns correspond to the impact change in total investment (6), in private firm investment (7) and in investment into the representative firm (8) that is due to the direct effect, i.e. when all prices are at their steady state level and only $\{r_t^b\}$ evolves as in Figure 5.

To obtain these numbers we compute the reaction of all households in the economy to the path of the interest rate $\{r_t^b\}$ depicted in Figure 5, exactly like we did before in Section 5. The direct effect on private firm investment (second to last column) is indeed smaller under high inequality (second row) than under low inequality (first row), just like Figure 11 suggested. Total investment still responds more strongly, however, since in the new steady state a larger share of it goes into private firm capital. Since private firm investment features a higher elasticity than investment into the representative firm, the direct effect on total investment becomes larger. This in turn causes incomes to rise more strongly under high inequality, thereby inducing second-round (indirect) effects that in sum lead to the larger output response shown in Figure 10.

The result that the direct effect on private firm investment *decreases* under high inequality, contrary to the experiment in Subsection 7.1, is however sensitive to the precise implementation of the change in estate taxation. Suppose only a "lucky" fraction L of entrepreneurs receives bequests, and the fraction $1-L$ is born with zero assets as in the initial steady state. We continue to assume that the total amount of bequests is the same as before, \$590,000 per entrepreneur. Hence, when the share of lucky entrepreneurs is higher, bequests are more concentrated. Fewer entrepreneurs receive bequests, but for those who do the bequest is larger.

A graphical illustration of the steady state firm capital distribution with $L = 5\%$ is depicted in Figure 11 (grey solid line). The difference compared to the initial distribution in this case is smaller than when $L = 100\%$. The reason is that when $L = 5\%$ the few entrepreneurs who are lucky recipients of bequests diversify the substantial wealth they inherit across the three assets relatively quickly, and therefore the increase in aggregate private firm capital compared to the baseline is limited. In contrast, when $L = 100\%$ the individual bequests are much smaller and because returns on private firm capital are high for small firms, newborn entrepreneurs leave the inherited wealth predominantly in firm capital. Figure 11 also shows that, in contrast to the case where we assumed bequests for all entrepreneurs, when $L = 5\%$ only the right tail of the firm capital distribution becomes notably fatter, indicating the presence of a larger share of entrepreneurs with a strong direct investment response to interest rate changes.

The last three columns of Table 10 echo these observations. The fraction of workers employed in the private firms falls as L decreases, because the higher the bequests the more newborn entrepreneurs invest the inherited wealth in a diversified portfolio. The direct effect of private firm investment increases relative to the initial steady state when only a small fraction of entrepreneurs is born wealthy, because the share of high-elasticity entrepreneurs grows.[36] In sum, the output response is amplified in all experiments under higher inequality. When rescaled to imply an increase in the overall top 10% wealth share of one percentage point, the magnitude of amplification varies between 3% and 20%.

8 Conclusion

Entrepreneurs constitute a small fraction of all households, but they hold a large share of total wealth, and their firms employ a larger share of the workforce. In addition, the gap between average wealth held by entrepreneurs and by workers has increased over the recent decades. We highlighted these facts using survey data from the SCF. Together with a well-documented rise in wealth inequality in the US since the 1980s, these observations motivated our research questions: How important are entrepreneurs for the transmission of monetary policy to the real economy? How does the observed shift in wealth towards entrepreneurs affect the transmission of monetary policy?

We built a HANK model with entrepreneurs to provide answers to these questions. Upon a cut in the interest rate on liquid assets, entrepreneurs increase the portfolio share of their private firms. The strength of this portfolio reallocation effect is heterogeneous across the net worth distribution. Wealthy entrepreneurs own large firms and earn business returns that are only slightly above the risk-free rate, both in our model and in the data. When monetary policy changes the risk-free rate, their excess return is therefore affected significantly in relative terms. Hence, they rebalance their portfolio more strongly than entrepreneurs with low net worth, whose excess returns are high and therefore affected relatively little by a change in the interest rate. We presented empirical evidence that two key implications of our model, decreasing business returns in net worth and a heterogeneous portfolio reallocation

[36] The former case corresponds relatively better to the empirical observation that wealth inequality among entrepreneurs has increased over time. While the experiments in this subsection do not account for this additional feature of the data, the top 10% share within the group of entrepreneurs in fact decreases compared to the initial steady state when all newborn entrepreneurs receive bequests. In contrast, in the case in which only very few entrepreneurs receive bequests, inequality among them stays nearly unchanged. Hence, in this regard the latter case is relatively more in line with the empirical evidence than the former.

effect, are supported by the data.

In our model, entrepreneurs are quantitatively important for the impact of monetary policy on the real economy. If entrepreneurs do not respond to changes in prices and aggregate quantities, the output response to an interest rate cut is approximately 50% smaller. Moreover, our model implies that an increase in the top 10% wealth share by one percentage point—a mild increase in wealth inequality—amplifies the aggregate output response by 3 to 20%.

There are additional aspects of entrepreneurial investment that could be important for the transmission of monetary policy. We did not model entry and exit from entrepreneurship, that might in addition vary over the business cycle (see Levine and Rubinstein, 2020, and references therein). Here, we focused on the intensive margin of entrepreneurial investment. We also did not allow for collateralized borrowing or financing through outside equity. We partly did so because the predominant share of entrepreneurs relies on their own funds to finance their firm (Table 14). Lastly, we ruled out the possibility of running multiple businesses at a time, which could have implications for the level and variance of returns that firm owners obtain from their total business wealth. We are confident that the portfolio reallocation mechanism we highlighted continues to be important when accounting for these additional aspects.

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A Empirical Evidence on Entrepreneurs and Wealth Inequality

Aggregate statistics This subsection provides additional empirical evidence on entrepreneurial households and their firms. Figure 12 plots the share of households that we classify as entrepreneurs over time. Figures 2 and 14 in the main text documented the ratio of average wealth held by entrepreneurs and non-entrepreneurs, as well as average employment per firm respectively. Figures 13 and 3 display the same information, only this time in terms of aggregate statistics. Figure 13 shows that over the recent decades, on average a third of wealth was held by the entrepreneurs in the economy. Furthermore, the same upward time trend that was visible in the plots of the main text is visible here as well. As was the case for the average wealth ratios in the main text, one might be worried that this result is driven exclusively by the data point in 1983 which displays a very low entrepreneurial wealth share. To alleviate this worry, we again conduct a t-test asking whether the linear time trend is statistically different from zero. We find that even when excluding the observation in 1983, the time trend is still positive and statistically significant with a p-value of 1.5%.

Figure 3 in the main text documented the share of employment in the entrepreneurial firms of all employment in the US. The share is large (on average 46%) and growing over time. We already mentioned in the main text that we lack information on the intensive margin of labor supplied in the entrepreneurial firms. One might therefore be worried that we overestimate the share of employment in the entrepreneurial firms if private firms were systematically more likely to employ people on a part-time basis. However, we believe that this should not be a major problem here. According to the Bureau of Labor Statistics (BLS), in January 2019, about 17% of all US workers were considered to be working part-time, the large majority of them (13%) for non-economic reasons. Of the wage and salary workers among those who worked part-time for non-economic reasons more than 50% worked in industries such as retail trade, food services and drinking places, and private educational services.[37] While data on industry affiliation of our entrepreneurs' firms in the more recent waves of the SCF is too coarse to be informative, data on industries up until 1992 is fine enough to gain some insight. In 1992, the four industries most often mentioned as the industry of their first firm by our entrepreneurs were (see also Table 15)

- Professional practice, incl. law, medicine, architecture; accounting; bookkeeping (17%)
- Contracting; construction services; plastering; painting; plumbing (14%)
- Retail and/or wholesale business excluding restaurants, bars, direct sales (e.g. Tupperware), gas stations, and food and liquor stores (10%)

[37] https://www.bls.gov/opub/mlr/2018/article/who-chooses-part-time-work-and-why.htm , accessed on Nov 7, 2021.

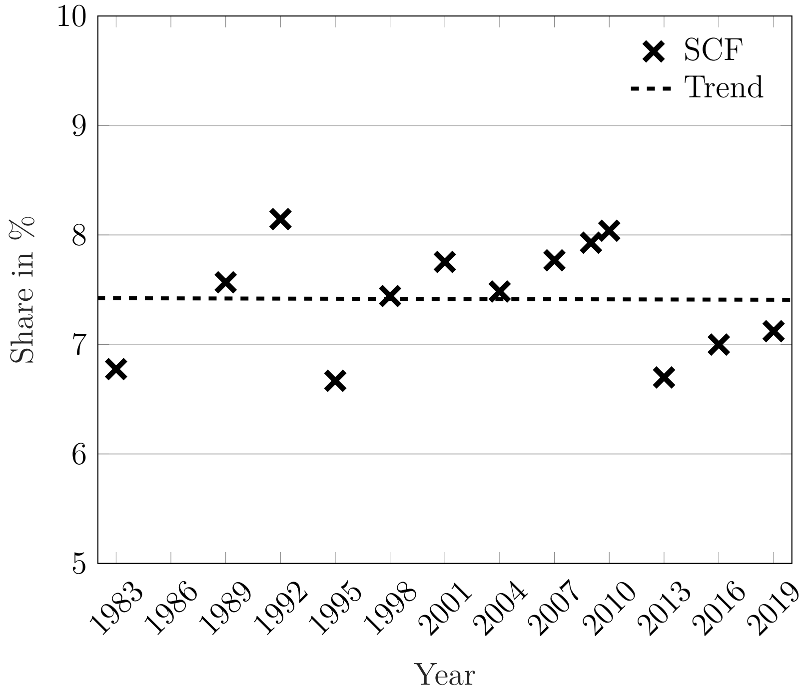

Figure 12: Entrepreneurs as a share of all households.

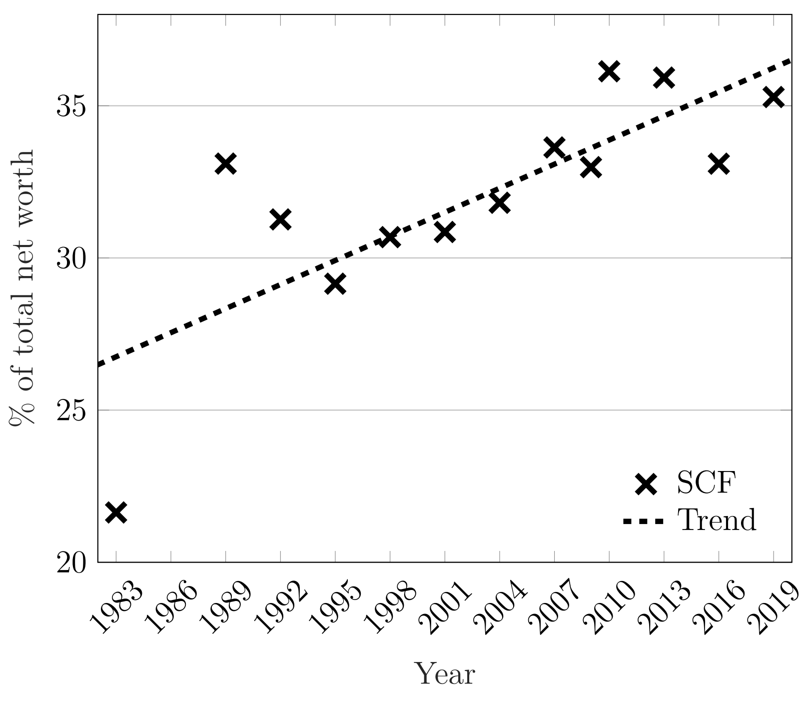

Figure 13: Share of total US wealth held by entrepreneurs.

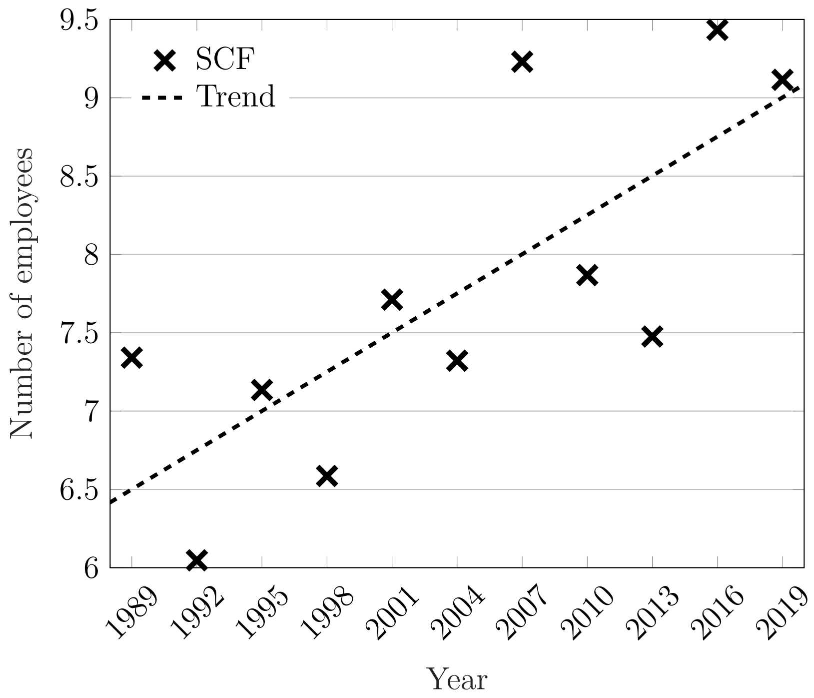

Figure 14: Average number of employees in firms owned by entrepreneurs.

- Farm; nursery; train dogs; forest management; agricultural services; landscaping; fisheries (9%)

Hence we conclude that the overlap between those industries that feature lots of entrepreneurial activity and those in which much part-time work is reported does not appear to be a major concern.

Firm size distribution Table 11 documents the firm size distribution in 2019 by employment. The distribution is highly skewed: A large fraction of firms is very small in terms of employment, and only few are very large. However, as can be seen in the second column of the table, the few large firms are quite important when accounting for the overall employment in the entrepreneurial firms. More than three quarters of all employment in the private businesses is due to firms that employ ten or more workers. A similar pattern emerges from Table 12, which reports the firm size distribution in terms of gross sales. Lastly, Tables 12, 14 and 15 show the distribution of entrepreneurial firms across different legal statuses, sources of funding and industry respectively.

Wealth inequality As pointed out in the main text, several authors have found that wealth inequality has been rising in the US since the 1980s (Hubmer et al., 2021; Kuhn et al., 2020; Saez and Zucman, 2016). Figure 15 shows this using the share of wealth held by the richest 10% of the population as a measure of wealth inequality. Moreover, even when conditioning on the group of entrepreneurs inequality has increased, as Figure 16 shows.

Table 11: Firm size distribution by employment (SCF 2019)

Employees	Share of firms (in %)	Share of employment (in %)
1 (Micro)	39.3	4.7
2–9 (Micro)	50.2	20.0
10–49 (Small)	7.9	17.9
50–249 (Med.)	2.2	24.2
250 and more	0.4	33.2

Notes: Since we observe employment and ownership shares only in the first two businesses of a given entrepreneurial household, we assume that if an entrepreneur has more than two businesses employment in these additional businesses is as in the second business.

Table 12: Firm size distribution by gross sales (SCF 2019)

Sales	Share of firms (in %)	Share of sales (in %)
< 2 Mio \$ (Micro)	93.0	14.2
2–10 Mio \$ (Small)	5.1	11.8
10–50 Mio \$ (Med.)	1.4	14.7
50 Mio \$ and more	0.5	59.3

Notes: Since we observe gross sales and ownership shares only in the first two businesses of a given entrepreneurial household, we assume that if an entrepreneur has more than two businesses gross sales in these additional businesses is as in the second business.

Table 13: Firms by legal status (SCF 2019)

Legal status	Share (in %)	Share of net worth (in %)
Partnership	5.9	6.6
Sole Proprietorship	40.8	13.5
S Corp.	14.1	25.8
Other Corp. (incl. C Corp.)	7.1	9.8
Limited Partnership / LLP	32.1	44.3

Notes: Left column: Share of entrepreneurs who declare that their first business is of a given legal status. Right column: Net worth of entrepreneurs who declare that their first business is of a given legal status, relative to total entrepreneurial net worth.

Table 14: Firms by source of funding (SCF 2019)

Source of funding	Share (in %)	Share of net worth (in %)
Personal savings	26.3	14.6
Credit card	8.5	6.3
Personal loan	6.7	6.7
Business loan	10.7	16.2
Equity investors	1.1	2.0
Inherited	0.0	0.0
No external money	53.4	54.7
No answer	1.7	9.0

Notes: Multiple answers possible. Left column: Share of entrepreneurs who declare that they used a given source of funding for their first business. Right column: Net worth of entrepreneurs who declare that they used a given source of funding for their first business, relative to total entrepreneurial net worth.

Table 15: Firms by industry (SCF 1992, seven most important by share)

Industry	Share (in %)	Share of NW (in %)
Professional practice, incl. law, medicine, architecture; accounting; bookkeeping	16.8	19.7
Contracting; construction services; plastering; painting; plumbing	13.8	9.4
Other retail and/or wholesale business	9.9	10.7
Farm; nursery; train dogs; forest managem.; agricultural services; landscaping; fisheries	9.4	7.0
Real estate; insurance	7.3	15.8
Manufacturing, incl. printing/publishing	6.6	11.1
Personal services: hotel, dry cleaners, funeral home	6.3	2.9

Notes: Left column: Share of entrepreneurs who declare that their first business is in a given industry. Right column: Net worth of entrepreneurs who declare that their first business is in a given industry, relative to total entrepreneurial net worth.

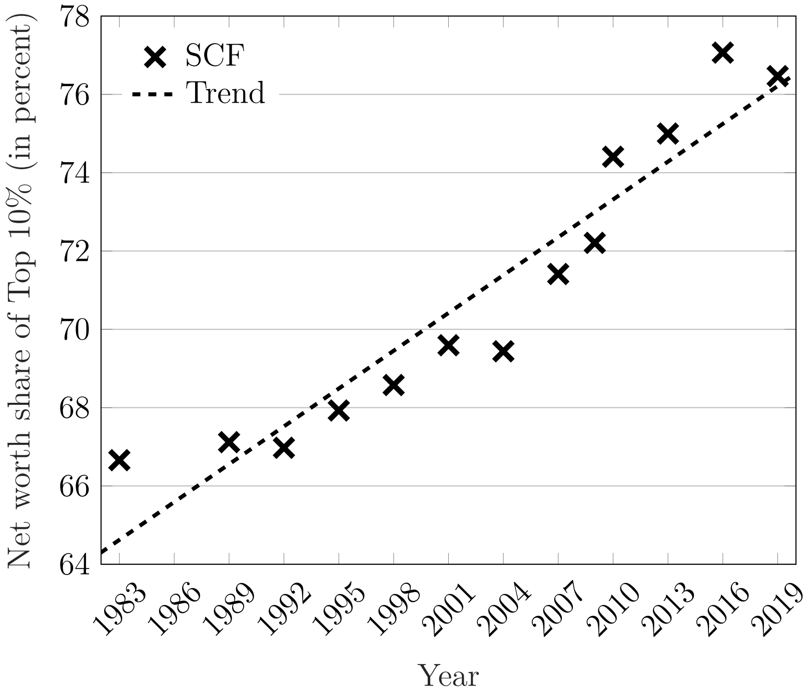

Figure 15: Share of total wealth held by the Top 10% wealthiest households.

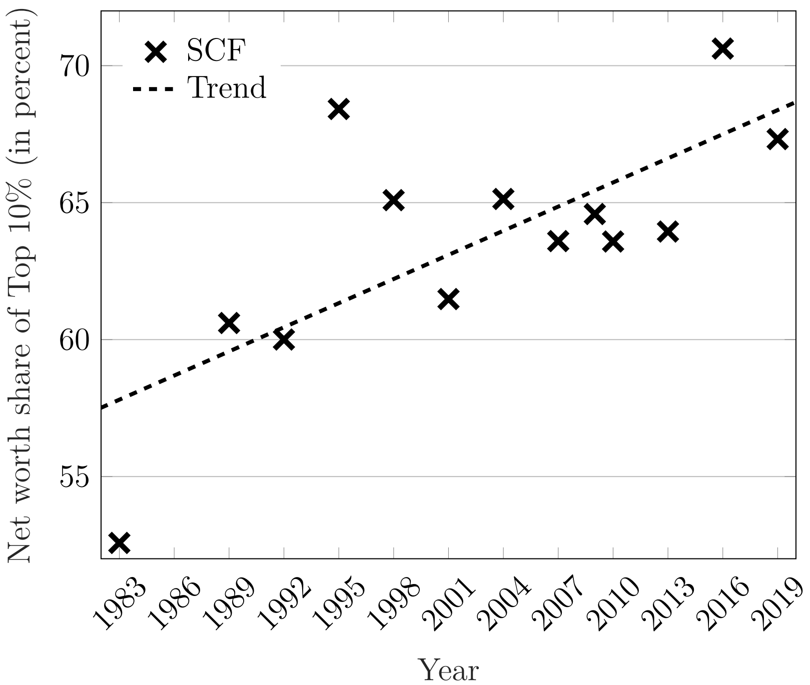

Figure 16: Share of total wealth held by the Top 10% wealthiest households, conditional on being an entrepreneur.

B Further Empirical Evidence on Business Returns

First, we estimate the relationship between net worth and business returns non-parametrically using kernel-weighted local polynomial smoothing with an Epanechnikov kernel. Figure 17 shows the results, which paint a very similar picture as Figure 7 in the main text. Households with net worth of \$100,000 make an average return of almost 100% while households with net worth around \$50,000,000 are estimated to earn an average return of about 35%. Note that we are considering average returns here which are larger than the median returns in Figure 7 as the distribution of returns is right-skewed.

Next, we estimate the relationship between net worth and business returns from the linear regression

$$r^e_{it} = \alpha + \beta \ln(\text{net worth}_{it}) + \gamma X_{it} + u_{it}. \tag{11}$$

Here, X is a vector of controls and u is an error term. The coefficient of interest is β which tells us by how many percentage points business returns change when the log of net worth increases by one percent.

Table 16 presents the estimates obtained when pooling all SCF waves. The first column shows the estimate for β we get without any additional controls. It is significantly smaller than zero and tells us that a 1% increase in net worth is associated with a decline in the return on business investment of 0.148 percentage points. In column three we control for household demographics such as age, education, marital status and the number of children. We also include fixed effects for the legal form of the business, the household's self-reported risk attitude and the survey year. With these controls, we get an estimate for β of -0.165.

As entrepreneurs can potentially hold multiple private businesses at the same time—something that we have abstracted from in our model—we additionally control for the number of businesses the entrepreneur operates in columns three and four. We find a negative effect on the return of total business capital, which appears intuitive. By running multiple businesses entrepreneurs are able to diversify their portfolio so that the idiosyncratic risk associated with their total business investment becomes smaller. Hence, they are willing to accept a lower risk premium so that average returns on total private business investment are lower for them.

The reader might be worried because firm value affects our measure of business returns negatively as it enters the denominator. Therefore, other things equal, households that overstate the value of their business exhibit smaller business returns as well as higher net worth. As a result, measurement error in business value could mechanically lead to a negative relationship between returns and net worth.

To account for this, we replace net worth with non-business wealth in the regression equation (11). The estimates are shown in columns two (without controls) and four (with controls). We again find a statistically significant negative relationship, as would also be implied by our quantitative model. Households whose non-business wealth is one percent

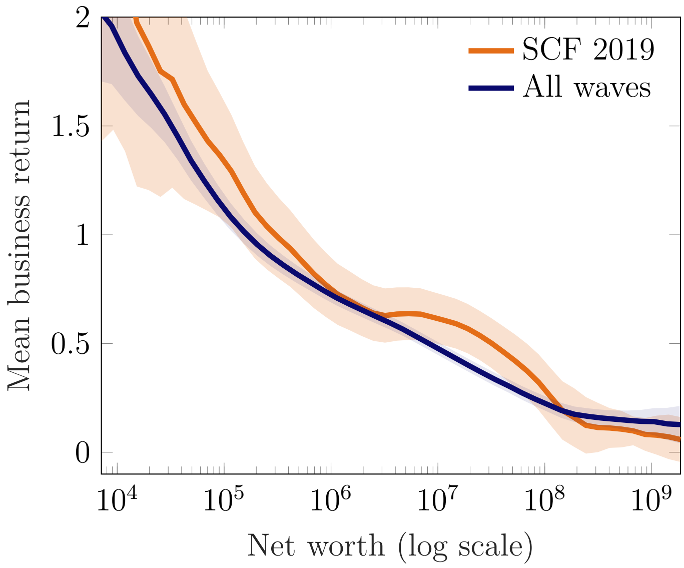

Figure 17: Non-parametrically estimated relationship between business returns and net worth.

Notes: We use kernel-weighted local polynomial smoothing with an Epanechnikov kernel, confidence intervals are at the 95% level.

Table 16: Regressions of business returns on net worth and non-business wealth using SCF since 1989.

	(1)	(2)	(3)	(4)
Log net worth	-0.148***		-0.165***	
	(0.00455)		(0.00635)	
Log non-business wealth		-0.0795***		-0.0500***
		(0.00504)		(0.00643)
Number businesses owned			-0.0236***	-0.0463***
			(0.00327)	(0.00389)
Demographics	No	No	Yes	Yes
Legal form FE	No	No	Yes	Yes
Risk attitude	No	No	Yes	Yes
Year FE	No	No	Yes	Yes
Observations	7288	7132	7288	7132

Notes: Demographics include age, dummies for education level, number of kids, marital status, whether the entrepreneur founded the business, and the years that have passed since the start/acquisition of the business. Risk attitude is captured by a categorical variable with four categories constructed from the respondent's answer to the question: "On a scale from zero to ten, where zero is not at all willing to take risks and ten is very willing to take risks, what number would you be on the scale?"

larger, earn a return on their business that is on average 0.05 percentage points lower.

The effect is somewhat smaller than the one we obtain for net worth. One reason is the possible effect of measurement error in business value mentioned above, which could bias the estimates in columns one and three. However, in an environment with decreasing returns, there is also an economic reason. If a household's net worth increases by 1%, she invests into her firm but at the same time increases the portfolio share of non-business assets because of the diminished return. Therefore, a 1% increase in net worth is associated with an increase in non-business wealth of more than 1%.

Portfolio shares Another testable implication of our model is that for owners of small firms, firm capital makes up a larger share of their portfolio. In other words, exposure to business wealth declines in net worth. We do not find robust evidence supporting this in the SCF data. When regressing portfolio shares (i.e. the empirical analogue of $k_e/(k_e + a + b)$) on the log of net worth $(k_e + a + b)$, typical OLS estimates we find are close to zero, not smaller than zero as our model implies. There are two main explanations for this.

First, as mentioned above, there could be measurement error in k_e, which would tend to bias simple OLS estimates, as k_e appears on both sides of the equation. When we regress the ratio $k_e/(a+b)$ on the log of non-business wealth $(a+b)$, trying to alleviate this problem, we do find significant negative coefficients. This would imply that when non-business wealth increases, the portion of firm wealth in the household's portfolio decreases, i.e. falling exposures to firm capital, as suggested by our model. However, the issue of simultaneity clearly also affects this regression.

Second, small firm owners might want to hold other assets than their firm for objectives that we abstracted from in our model. For instance, households might want to hold some liquid assets for transactional purposes, which we do not model. Also, if we endogenized the occupational choice, households would save up assets before actually starting their firm, as in Cagetti and De Nardi (2006). In this case, at the start of their entrepreneurial career they would not be holding a portfolio that is almost completely made up of their firm, as is the case in our model.

C Model Details and Derivations

C.1 Equilibrium

An equilibrium is defined as paths for household decisions $\{a_t, k_{et}, b_t, c_t, d_t, \ell_t, f_t, n_{et}\}_{t\geq 0}$, input prices $\{r_t^k, w_t\}_{t\geq 0}$, returns on liquid and illiquid assets $\{r_t^b, r_t^a\}_{t\geq 0}$, the share price $\{q_t\}_{t\geq 0}$, the intermediate good price $\{p_t\}_{t\geq 0}$, the inflation rate $\{\pi_t\}_{t\geq 0}$, government transfers $\{T_t\}_{t\geq 0}$, distributions $\{\mu_{wt}, \mu_{et}\}_{t\geq 0}$, and aggregate quantities such that, at every t:

1. Given prices and aggregate quantities implied by the distributions $\{\mu_{wt}$ and $\mu_{et}\}_{t\geq 0}$,

and the stochastic processes for individual states, policy functions c_w^*, b_w^*, a_w^*, and ℓ^* for workers, and c_e^*, b_e^*, a_e^*, k_e^*, and n_e^* for entrepreneurs solve the problems (2) and (3).

2. All firms optimize, given input prices.

3. The sequence of distributions satisfies aggregate consistency conditions

4. The bond market and the capital market clear, the labor market clears, and all goods markets clear.

5. Monetary policy follows the Taylor rule (7), the government budget is balanced (6).

Bond market clearing Households demand liquid bonds

$$B_t^D = (1 - s_e) \int b_w^*(i)\ \mu_{wt}(i)\ \mathrm{d}i + s_e \int b_e^*(i)\ \mu_{et}(i)\ \mathrm{d}i$$

and hence the bond market clears if $B^S = B_t^D$.

Capital market clearing The representative firm optimally demands K_{pt}. Total supply of the illiquid asset by the households is given by

$$A_t^S = (1 - s_e) \int a_w^*(i)\ \mu_{wt}(i)\ \mathrm{d}i + s_e \int a_e^*(i)\ \mu_{et}(i)\ \mathrm{d}i$$

and hence the capital market clears if $K_{pt} = A_t^S - q_t$.

Labor market clearing Aggregate labor supply is given by

$$N_t^S = (1 - s_e) \int \exp(z) \cdot \ell^*(i)\ \mu_{wt}(i)\ \mathrm{d}i\ .$$

Labor demand is the sum of demand by public firms and demand by entrepreneurial firms

$$N_t^D = N_{pt} + N_{et} = N_{pt} + s_e \int {n_{et}}^*(i)\ \mu_{et}(i)\ \mathrm{d}i\ .$$

and hence the labor market clears if $N_t^D = N_t^S$.

Input goods market clearing We have that

$$\int_0^1 Y_t(j)\mathrm{d}j = Y_{pt} + s_e \int y_e(i)\mu_{et}(i)\ \mathrm{d}i$$

Intermediate goods market clearing We have that

$$Y_t = \int_0^1 Y_t(j)\mathrm{d}j$$

and by symmetry of all intermediate goods firms,

$$Y_t(j) = Y_t \quad \forall j$$

Once the markets for the inputs and the intermediate goods clear, market clearing for the final good is implied by Walras' law.

Entrepreneurial taxes Revenues from taxing entrepreneurs that show up in (6) are defined as

$$\text{Rev}_t = s_e \tau_e \int (\Pi_e(i) - \delta k_{et}\ \mu_{et}(i))\, \mathrm{d}i$$

C.2 Hamilton-Jacobi-Bellman equation

If labor productivity and entrepreneurial talent follow the jump-drift processes described in Section 4, the solution to the entrepreneurs' problem can be characterized recursively by the following Hamilton-Jacobi-Bellman equation for low-productivity types (y_l)

$$\begin{aligned}(\rho + \zeta)\, V(b, a, k_e, y_l) = {} & \max_{c,d,f} u(c, \bar{\ell}) \\ & + V_b(b, a, k_e, y_l)\Big[(1 - \tau_e)\Pi_e(k_e, y_l) + r^b(b)b + T - d - \chi^a(d, a) \\ & \qquad - f - \chi^e(f, k_e) + \tau_e \delta k_e - c\Big] \\ & + V_a(b, a, k_e, y_l)(r^a a + d) + V_k(b, a, k_e, y_l)(f - \delta k_e) \\ & + \frac{1}{2} k_e \sigma_k^2 V_{kk}(b, a, k_e, y_l) \\ & + \lambda_{y,lh}(V(b, a, k_e, y_h) - V(b, a, k_e, y_l))\end{aligned} \tag{12}$$

and analogously for $V(b, a, k_e, y_h)$, i.e. high productivity types.

The solution to the workers' problem is characterized by

$$\begin{aligned}(\rho + \zeta)\, V(b, a, z) = {} & \max_{c,\ell,d} u(c, \ell) + V_b(b, a, z)\left[(1 - \tau)w \exp(z)\ell + r^b(b)b + T - d - \chi^a(d, a) - c\right] \\ & + V_a(b, a, z)(r^a a + d) \\ & + \sum_{j \in \{1,2\}} V_{z_j}(b, a, z)(-\beta_j z_j) + \lambda_j \int_{-\infty}^{\infty} (V(b, a, x) - V(b, a, z_j))\phi_j(x)\mathrm{d}x\end{aligned} \tag{13}$$

where $\phi_j(x)$ denotes the pdf of a normal distribution with standard deviation σ_{zj}.

C.3 Derivation of Phillips Curve

Here we derive the New Keynesian Phillips curve following Appendix B.2 of KMV. In recursive form, the profit maximization problem of an intermediate goods producer can be written as

$$r^a_t J(t, P_t(j)) = \max_{\pi_{jt}} \left(\frac{P_t(j)}{P_t}\right)^{1-\epsilon} Y_t - mc_t \left(\frac{P_t(j)}{P_t}\right)^{-\epsilon} Y_t - \frac{\theta}{2}\pi^2_{jt} Y_t \qquad (14)$$
$$+ J_t(t, P_t(j)) + P_t(j)\pi_{jt} J_p(t, P_t(j)),$$

where π_{jt} is the firm-specific inflation rate $\pi_{jt} = \frac{\dot{P}_t(j)}{P_t(j)}$. The first order condition for the maximization problem in (14) is

$$J_p(t, P_t(j)) = \frac{\theta \pi_{jt} Y_t}{P_t(j)}, \qquad (15)$$

the envelope condition is

$$(r^a_t - \pi_{jt}) J_p(t, P_t(j)) = \frac{Y_t}{P_t}(1-\epsilon)\left(\frac{P_t(j)}{P_t}\right)^{-\epsilon} + \frac{Y_t}{P_t}\epsilon \cdot mc_t \left(\frac{P_t(j)}{P_t}\right)^{-\epsilon-1}$$
$$+ J_{tp}(t, P_t(j)) + \pi_{jt} P_t(j) J_{pp}(t, P_t(j)) \ .$$

Since firms are symmetric, $P_t(j) = P_t$ and $\pi_{jt} = \pi_t$, and we have

$$(r^a_t - \pi_t) J_p(t, P_t) = (1-\epsilon)\frac{Y_t}{P_t} + \epsilon \cdot mc_t \frac{Y_t}{P_t} + J_{tp}(t, P_t) + \pi_t P_t J_{pp}(t, P_t). \qquad (16)$$

Taking the derivative of (15) with respect to time gives

$$J_{pp}(t, P_t(j))\dot{P}_t(j) + J_{tp}(t, P_t(j)) = \frac{\theta \dot{\pi}_t Y_t}{P_t(j)} + \frac{\theta \pi_t \dot{Y}_t}{P_t(j)} - \frac{\theta \pi_t Y_t}{P_t(j)} \frac{\dot{P}_t(j)}{P_t(j)}.$$

Recall that $\pi_t P_t = \dot{P}_t$ and substitute the above expression into (16). This gives the New Keynesian Phillips curve (4)

$$\left(r^a_t - \frac{\dot{Y}_t}{Y_t}\right)\pi_t = \frac{\epsilon}{\theta}\left[mc_t - \frac{\epsilon - 1}{\epsilon}\right] + \dot{\pi}_t.$$

D Monetary Policy Shocks and Portfolio Shares

D.1 Portfolio shares

This section details how we arrive at our estimates for the (log of the) portfolio shares at different percentiles p of the business return distribution. We closely follow Luetticke (2021) in arriving at these estimates.

We first sort entrepreneurial households in a given year t by their business return r^e.

Next, we calculate the percentile of each household in the return distribution as

$$prctl_i = \frac{\sum_{j:r_j^e<r_i^e} w_j}{\sum_j w_j}$$

where w_j denote the sample weights provided by the SCF. For each percentile, we then regress the log of the portfolio share on the appropriately adjusted percentile measures. Specifically, to estimate the portfolio share at the p'th percentile, we perform a weighted regression

$$\ln(\text{portf. share}_i)\,\omega_i = \alpha\,\omega_i + \beta(prctl_i - p)\,\omega_i + u_i$$

where u is an error term and the weight we use for observation i is

$$\omega_i = \sqrt{w_i \phi\left(\frac{prctl_i - p}{0.1}\right)}\,,$$

where $\phi(\cdot)$ corresponds to the probability density function of a standard normal distribution. The estimate of the intercept α is our estimate of the log of the portfolio share at percentile p for the year t.

D.2 From monthly to annual shock series

To convert the monthly monetary policy shock series provided by Ramey (2016) into an annual series, we follow the approach proposed by Meier and Reinelt (2020) and Ottonello and Winberry (2020). In particular, we attribute a monthly shock fully to our yearly shock only if it takes place in January. If it takes place later in the year, we partly attribute the shock to the current year and partly to the next year. More specifically, we use the monthly series of shocks ϵ_t^m from Ramey (2016) to construct annual shocks ϵ_t^y according to

$$\epsilon_t^y = \sum_{\tau\in\mathcal{M}(t)} \phi(\tau,t)\cdot\epsilon_\tau^m + \sum_{\tau\in\mathcal{M}(t-1)} (1-\phi(\tau,t-1))\cdot\epsilon_\tau^m\,,$$

where $\mathcal{M}(t)$ is the set of months in year t and

$$\phi(\tau,t) = \frac{\text{remaining number of months in year } t \text{ after announcement in month } \tau}{12}\,.$$

Putting more weight on shocks early in the current year and late in the previous year allows us to more reliably inspect the response of portfolio shares "on impact", i.e. for horizon $h = 0$. However, as some of the respondents answered the survey in the early months of a given year and therefore potentially before some of the monthly shocks of that year materialized, the estimates of $\beta_{p,0}$ have to be interpreted with some caution even when using this particular weighting of monthly shocks.[38]

[38] We also performed our analysis using simply the sum of all shocks occurring in a given year. The results

D.3 Discussion and robustness

Given that the SCF is a repeated cross-section and not a panel, the identifying assumption that we make is that the characteristics of entrepreneurial households within a given percentile of the business return distribution stay unchanged over time. This assumption appears reasonable for entrepreneurs with firms in the middle of the firm size distribution and hence with close to median returns. Their business values and net worth by construction assume relatively common values, and therefore the households themselves are not likely to be unusual in terms of observed and unobserved characteristics. Also, the non-parametric estimation of portfolio shares ensures that for the percentiles in the middle of the return distribution we include information on portfolio shares from many neighboring percentiles. This makes the estimates for the middle percentiles less sensitive to individual observations in percentile p at year t. Therefore, we are confident that the portfolio reaction at the median of the return distribution is well identified.

Both for very small and very large firm owners, the identifying assumption might be less credible. On the one hand, there could be considerable turnover due to entry and exit of firms among the small firm owners, confounding our results at the upper end of the return distribution. Very wealthy entrepreneurs, on the other hand, with businesses producing returns at the low end of the return distribution, might possess some peculiar characteristics that are not shared by entrepreneurs at the same extreme position in the return distribution in a different year. For both of these groups, at the high and low end of the return distribution, by definition there are few neighboring percentiles either to the right or to the left of the given percentile p, and hence individual observations can influence the estimate of the portfolio share relatively strongly.

To address this issue, we first run regressions of the observed portfolio shares on various observable characteristics of the households. The controls are the same as in columns three and four of Table 16 in Appendix B. We then subtract the predicted portfolio shares from the actual shares, and then estimate the portfolio shares $\gamma_{p,t}$ for each year and percentile of the return distribution as described above, but this time using the residual portfolio shares. Last, we run (8) using the new estimates of the portfolio shares $\gamma_{p,t}$. The results are displayed in the right panel of Figure 8 in the main text. They are very similar to the ones in our baseline specification, though the portfolio responses at the median are more muted. The general shape, however, and therefore the results regarding heterogeneity of responses highlighted above, are not affected by using residual portfolio shares instead of the actual ones.

D.4 Gertler and Karadi (2015) shocks

In our baseline specification we used the Romer & Romer shock series as instruments for the federal funds rate. Here, we instead employ the shock series derived by Gertler and

are very similar.

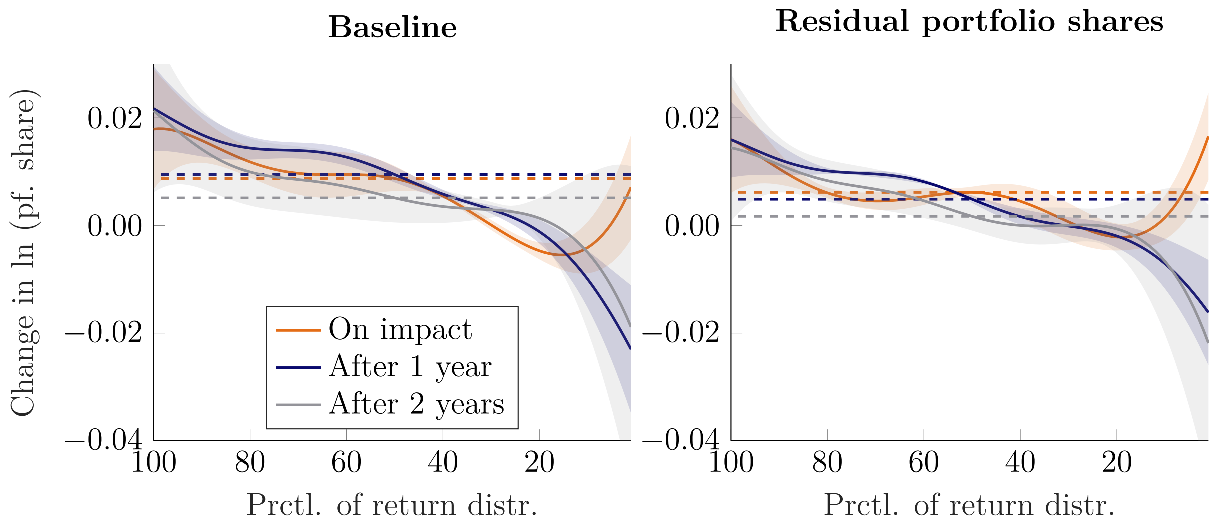

Figure 18: Impulse responses of portfolio shares to Gertler and Karadi (2015) monetary policy shock.
Notes: Change in the logarithm of portfolio shares following a 25 basis points expansionary monetary policy shock by business return percentile. The dashed lines depict the responses at the median of the return distribution. Confidence bands are at the 66% level.

Karadi (2015) who use high-frequency data to identify monetary policy surprises. We follow Ramey (2016) in focusing on the series that uses the 3-month ahead fed funds futures as instruments. Figure 18 shows the results.

The median responses are very similar to those found when using the Romer & Romer shocks series. We find the robustness of the results in this regard encouraging, given that the time window that is covered by the Gertler and Karadi (2015) shocks (and hence the SCF waves that we use to estimate portfolio shares) has only a small overlap with that of the Romer & Romer shocks. Regarding the heterogeneity of responses, the u-shape that we find when using the Romer & Romer shocks only appears in the impact response to the shock, and most clearly when using the residual portfolio shares.

E Additional Graphs and Tables

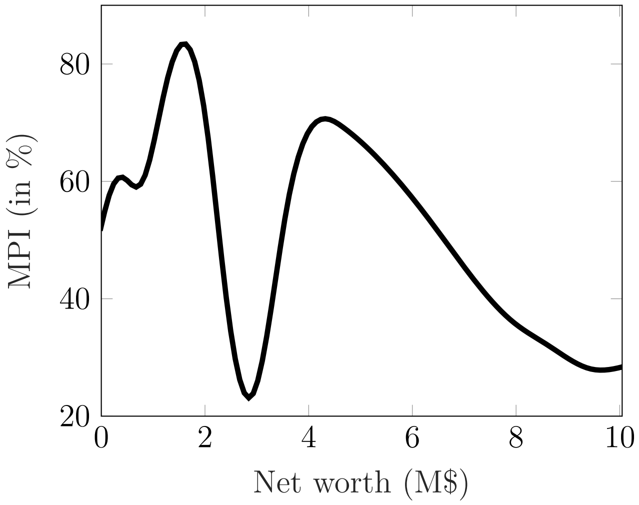

Figure 19: MPI into the private business out of a transfer of $ 500 into the liquid account over one quarter.

Table 17: Summary statistics SCF since 1989

	mean	p25	p50	p75	sd	min	max
Business return	0.60	0.05	0.19	0.60	1.04	-0.89	6.73
Net worth	30.0	0.9	4.3	20.2	90.4	0.0	1861.6
Bus. wealth	17.0	0.3	1.3	8.4	62.9	0.0	1300.6
Observations	7288						

Notes: Net worth and business wealth are measured in million US dollars, all deflated to 2019. Sample selection is as explained in main text. The displayed summary statistics do not make use of the sampling weights. Therefore, as the SCF oversamples rich individuals, the means and percentiles of net worth and business wealth appear large in comparison to equivalent statistics generated from the model (see for a comparison Figure 6). In all other analyses we conduct in this paper, we use the sampling weights provided by the SCF.