Monetary Policy and Aggregate Investment: The Role of Entrepreneurs*

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Abstract

We study the role of entrepreneurs for the transmission of monetary policy to aggregate investment. To this end, we develop a HANK model with entrepreneurs who invest in private firms with risky returns. The model matches the distribution of private business returns over owners' net worth observed in the Survey of Consumer Finances. This is important because a lower return premium over the risk-free rate leads to stronger portfolio rebalancing towards the private business in response to expansionary monetary policy. Entrepreneurs are quantitatively important for the transmission of monetary policy. If they do not react to the change in the interest rate, the output response is more than 30% smaller. A shift of wealth from workers to entrepreneurs as observed in the US since the 1980s, strengthens the real effects of monetary policy.

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, account for approximately 7.5% of all US households, but they own about one third of total household wealth and their businesses employ nearly half of all workers.[1] Over the last 40 years, entrepreneurs have become wealthier relative to the rest of the population and the employment share of their businesses has increased, while the share of entrepreneur households has stayed constant. In this paper, we investigate the quantitative importance of entrepreneurs' private business investment and the consequences of the observed shift of wealth towards entrepreneurs for the transmission of monetary policy to aggregate investment, employment, and GDP.

We develop a Heterogeneous Agent New Keynesian (HANK) model in which we distinguish between workers and entrepreneurs. In contrast to workers, entrepreneurs can invest in private businesses with risky returns. The calibrated model yields two main findings. First, entrepreneurs are quantitatively important for the transmission of monetary policy to the real economy, despite constituting a relatively 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. The size of this effect crucially depends on the distribution of wealth among entrepreneurs.

In the model, both workers and entrepreneurs save in a liquid and an illiquid asset, but entrepreneurs have access to a third 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 features idiosyncratic risk that cannot be perfectly insured because of incomplete markets. Hence, private business investment is risky.

When monetary policy lowers the risk-free interest rate, all entrepreneurs rebalance their portfolios away from the risk-free liquid asset towards their private firms, but the extent of this reallocation depends on an entrepreneur's net worth: Wealthy entrepreneurs own large firms with a small marginal product of capital. They accept small risk and liquidity premia from private firm capital because they are well insured and can bear the risk associated with investment in the private firm. When the risk-free interest rate falls, the small excess returns of wealthy firm owners increase relatively strongly, and so their reallocation response is large. Hence, the interest rate elasticity of private firm investment is high for wealthy entrepreneurs.

In contrast, the elasticity is low for entrepreneurs with little wealth and small firms. For them, returns from their private business are large compared to the liquid asset, i.e., they earn large premia on private firm investment. An interest rate cut does not raise this excess return much in relative terms, and hence the portfolio reallocation response is small.

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

While the direct portfolio reallocation effect is small for poor entrepreneurs, in general equilibrium, the poorest entrepreneurs still react strongly to monetary policy. They own relatively small businesses and could earn large returns from investing in their firms, but borrowing constraints prevent them from expanding their businesses. Hence, their marginal propensity to invest in their business is large. Since poor entrepreneurs are leveraged, expansionary monetary policy reduces their interest burden and generates a positive income effect, which leads them to expand private business investment. In addition, expansionary monetary policy stimulates economic activity and raises business incomes. Given the high marginal propensity to invest, poor entrepreneurs respond strongly to this additional income and expand their firms. Taken together, the portfolio reallocation effect, the income effect of an interest rate change, and the general equilibrium effects of monetary policy result in a response of private firm investment following an interest rate cut that is u-shaped in net worth: Poor and wealthy entrepreneurs respond most strongly. For this reason, the distribution of wealth among entrepreneurs is important for the transmission of monetary policy.

We calibrate the model to the US economy. The calibration strategy targets 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. We also target the shares of hand-to-mouth workers and of hand-to-mouth entrepreneurs since these determine marginal propensities to consume which are crucial for the transmission of monetary policy to consumption.

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 declines with net worth. Our model matches the empirical distribution of returns from private businesses, both unconditionally and conditional on net worth, even though we do not target these statistics in the calibration. Second, we provide direct empirical evidence for the portfolio reallocation of entrepreneurs. Using identified monetary policy shocks, we document that, after a decrease in the federal funds rate, entrepreneurs increase the portfolio share of private firm capital. Our findings suggest that this response is heterogeneous across entrepreneurs. In line with our model, entrepreneurs with low and with high returns react most strongly, while the response is smaller for entrepreneurs with intermediate returns.

The calibrated model yields an important role for entrepreneurs in the transmission of monetary policy, even though they constitute only a small fraction of all households. The responses of output and aggregate investment are about 30% smaller when entrepreneurs ignore the reduction of the risk-free interest rate. This highlights the importance of the direct effects of monetary policy, specifically the portfolio reallocation effect.

To understand how wealth inequality affects the transmission of monetary policy, we assume that some entrepreneurs are born with a private business, in contrast to our baseline model in which all households begin their lives without any wealth. This leads to an increase in wealth inequality and can be interpreted as a reduction in estate taxation as observed in the US since the 1980s. We find that the output response to monetary policy is amplified by 2.4% to 7.3% for every percentage point increase in the top 10% wealth share, depending on the distribution of these bequests.

The remainder of this paper is structured as follows. First, we discuss the related literature. In Section 2 we document the importance of entrepreneurs for total household wealth and aggregate employment. In Section 3 we present a simple entrepreneurial portfolio choice problem that illustrates how entrepreneurs' net worth affects the portfolio reallocation following an interest rate change. We extend this model of entrepreneurs' portfolio choice and incorporate it into a general equilibrium HANK model à la Kaplan et al. (2018) in Section 4. We calibrate the model in Section 5 and analyze the transmission of monetary policy in Section 6. In Section 7 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 investigate the effects of higher wealth inequality for the transmission of monetary policy in Section 8. Section 9 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 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. (2022) 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. Second, Leahy and Thapar (2022) 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 rate of entrepreneurship in this age group which leads to strongly increasing entrepreneurial activity. Our paper is the first to analyze quantitatively the role of private business owners for the transmission of monetary policy in a structural model.

We develop a HANK model building on Kaplan et al. (2018) and use the solution methods from Achdou et al. (2022). The HANK literature has largely focused on the transmission of monetary policy to aggregate consumption. In contrast, our focus is on aggregate investment. We emphasize the role of entrepreneurs' net worth and private business risk for the transmission of monetary policy to aggregate investment through the portfolio reallocation channel.

We share the focus on the role of household heterogeneity for the response of aggregate investment to monetary policy with a few recent papers, and we 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) and argues that they are high for wealthy individuals. We focus on the portfolio reallocation of entrepreneurs following the interest rate change. In our model, as in Luetticke (2021), investment of richer workers in the illiquid asset is less responsive to the risk-free interest rate than illiquid investment of poorer workers. We find, that the response of entrepreneurs' private business investment is very different, it is u-shaped in net worth, such that wealthier entrepreneurs respond particularly strongly. 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 increasing consumption of households with high marginal propensities to consume (MPC). Our model features both, rich heterogeneity among entrepreneurs who crucially determine the direct investment response to monetary policy and high MPCs of workers driving the indirect effects on consumption.

Similar to us, Melcangi and Sterk (2020) study how the wealth distribution affects the transmission of monetary policy to aggregate investment. However, they focus on stock market participation and portfolio reallocation towards mutual funds as a transmission mechanism of monetary policy, whereas we emphasize the role of private firm investment.

We share with Kekre and Lenel (2022) the focus on households' willingness to take investment risks. Kekre and Lenel (2022) study the transmission of monetary policy when households differ in their level of risk aversion. They emphasize the redistribution of wealth towards households with higher marginal propensities to take risks in response to expansionary policy, which amplifies the response of investment in risky capital. Since all households have the same investment opportunities, they face the same risk premium and the partial equilibrium interest rate elasticity of capital investment is the same for all households. In our model, in contrast, entrepreneurs earn endogenously different excess returns on their private business investment, which leads to heterogeneous portfolio reallocation responses to monetary policy.

Heterogeneous returns to private equity that are falling in net worth at the very top of the wealth distribution are documented in recent empirical work (Boar et al. 2022; Halvorsen et al. 2023; Smith et al. 2021; Xavier 2021). Our model replicates this relationship and is the first to show that it is important for the transmission of monetary policy to aggregate investment.

Lastly, our paper is related to recent works by Ottonello and Winberry (2020), Jeenas (2019), and Cloyne et al. (2023) who study how firm heterogeneity matters for monetary transmission to aggregate investment in the presence of financial frictions. These authors concentrate on the role of monetary policy on access to credit, i.e., market funding.

Our focus is on privately owned businesses, and their access to funding from owners. In our model, the asset portfolio of private business owners determines the investment response of privately held businesses to monetary policy. As such, our paper connects the literature on the effects of firm heterogeneity for monetary transmission with the literature on household heterogeneity for the transmission to aggregate investment.

2 Entrepreneurs and Private Businesses in the US

In this section, we document the importance of entrepreneurs and their private businesses 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 an important advantage for our analysis compared to other publicly available data sources.

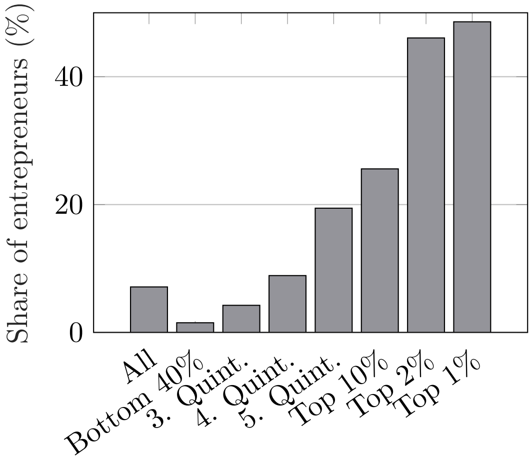
Following Cagetti and De Nardi (2006), we define a household as an entrepreneur if it meets the following three criteria: i) the household head is self-employed, ii) the household head owns, at least partly, a private business, and iii) the household head has an active management role in the business.

Only about 7.5% of all households are entrepreneurs according to this definition, and this share has been rather stable over time. However, this small group of households plays a disproportionate role for several aggregate statistics in the US, as we will document next.

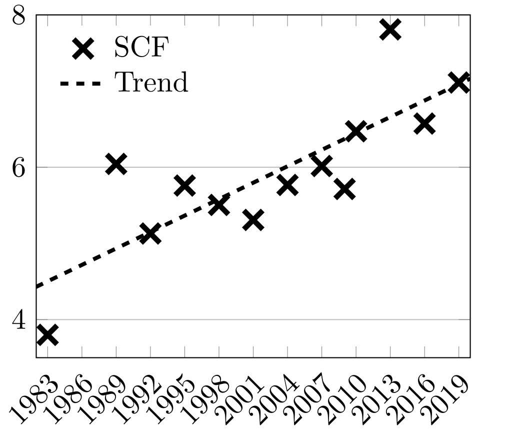
Net worth The average entrepreneur is wealthy. As has already been pointed out by Cagetti and De Nardi (2006), entrepreneurs hold about 33% of total household net wealth. Figure 1a shows the share of entrepreneurs in different parts of the US net worth distribution in 2019. In the bottom 40% of the net 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.

Figure 1b plots the ratio of the average wealth of an entrepreneur to the average wealth of a non-entrepreneurs over time. Historically, entrepreneurs have been four to eight times wealthier than non-entrepreneurs. This ratio has trended upward over time. While entrepreneurs have always been richer than workers on average, the wealth gap between the average entrepreneur and non-entrepreneur has widened since the 1980s. While the average wealth of an entrepreneur was four to six times as large as the average wealth of a non-entrepreneur in the 1980s and 1990s, this ratio has increased to six to eight in recent years. The time trend is statistically significantly different from zero with a p-value of 0.1%. Excluding the possible outlier in 1983, the trend is flatter but remains statistically significant with a p-value of 1.0%.

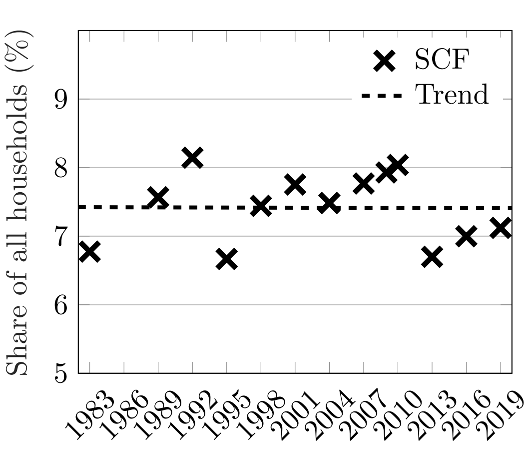
The fact that (relatively rich) entrepreneurs have become even richer compared to



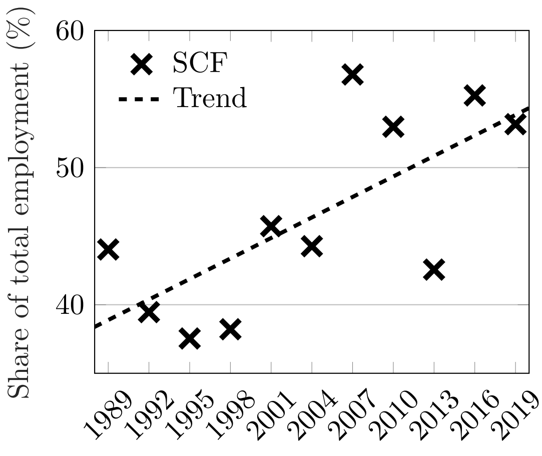
(a) Entrepreneurs by net worth percentile, 2019.



(b) Ratio of average wealth of entrepreneurs to non-entrepreneurs.



(c) Entrepreneurs as a share of all households.



(d) Employment at private businesses of entrepreneurs.

Figure 1: Entrepreneurs: population share, wealth, and employment at their firms.

the rest of the population is not surprising, given that wealth inequality in the US has increased since the 1980s, as documented, for instance, by Saez and Zucman (2016) and Kuhn et al. (2020). In addition, wealth has also become more unequally distributed within the group of entrepreneurs: the wealthiest 10% of entrepreneurs owned about 60% of wealth of all entrepreneurs in 1989, and this share has increased to about 66% in 2019 (see Figure 13b in the Appendix). In sum, entrepreneurs command a disproportionate share of household assets, wealth has shifted from non-entrepreneurs to entrepreneurs over the recent decades, and especially the wealthiest entrepreneurs have become richer.

Employment The importance of entrepreneurs for the US economy is also reflected in the large number of workers who are employed by entrepreneurs' businesses. Starting in 1989, the SCF asks entrepreneurs how many people are employed by their businesses. We use this question to estimate employment in private firms owned by entrepreneurs as a share of total US employment. It is depicted in Figure 1d. The employment share is large, about 46% on average between 1989 and 2019, and displays an upward trend over time, similarly to the average wealth ratio. The p-value of the time trend is 1.5%. While entrepreneurs' firms accounted for roughly 40% of US employment in the late 1980s and early 90s, their 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 1b. The likely reason is that we obtain aggregate employment at entrepreneurs' firms by multiplying the average number of employees with the share of entrepreneurial households in the population (Figure 1c), and the latter series displays some volatility itself.[2] The average number of employees at an entrepreneur's firm is less volatile but also displays a clear upward trend (see Figure 12b in the Appendix).

The employment numbers likely constitute a lower bound on actual employment at entrepreneurial firms for two reasons. First, entrepreneurs are only asked about employees of the first two businesses they own. Hence, employment in any additional businesses is not taken into account.[3] Second, the data on employment in privately held businesses is top coded at 5,000 in the public-use SCF files.[4] Another data limitation is that there is no information about the intensive margin, i.e., hours worked are not observed. However, we do not expect the hours share of private businesses and to be much smaller than the employment share, as part-time work is more common in industries with small numbers of entrepreneurial businesses. We discuss this further in Appendix B.

2. 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 1c). We then multiply the result by total households and divide by employment level.

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

4. The data is top coded at 5,000 employees from 1995 to 2019, but at 2,500 in 1989 and at 25,000 in 1992.

Table 1: Firms by source of funding (SCF 2019)

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

Notes: Multiple answers possible. Left column: Population share of entrepreneurs who state they used a source of funding for their first business. Right column: Net worth share.

Investment The SCF does not contain reliable information about entrepreneurs' investment in their private firms. Asker et al. (2015) estimate that about 53% of aggregate US investment stems from private firms. The relatively restrictively defined group of entrepreneurs, however, includes 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 publicly listed firms (see for instance Gutiérrez and Philippon 2017), about 40% of aggregate investment is left unexplained and would hence be attributable to private firms.

Funding of entrepreneurs' businesses Table 1 shows the sources of funding for entrepreneurs' businesses. Importantly, less than 11.8% of entrepreneurs' businesses use business loans or equity investors as a source of funding. Instead, most of the entrepreneurs' businesses rely on their owners savings, personal loans, and credit cards, or do not use external funding at all. This suggests an important role for entrepreneurs' personal wealth, portfolio composition, and willingness to take risks for aggregate investment.

Firm heterogeneity The average numbers on employment mask significant heterogeneity among entrepreneurial firms, whose distribution is heavily skewed to the right. There exist many very small firms and few very large firms, both in terms of employment and in terms of sales. Appendix B reports more detailed statistics on the firm size distribution in our sample. It also shows the distribution of legal forms and industry for the entrepreneurial firms in our sample. Typical entrepreneurial firms include law firms, medical practices, architect's or accounting offices, and firms in construction services, retail and wholesale business.

To summarize, entrepreneurs are a small but wealthy group of US households. Their businesses are important for aggregate employment and rely largely on private funding from their owners. The importance of entrepreneurs for the US economy has increased over time, as the average wealth ratio and the employment share have trended upward since the 1980s.

3 An Entrepreneur's Investment Problem

In this section, we present a simple entrepreneurial investment problem. It contains the main mechanism through which the distribution of entrepreneurial net worth affects the interest rate elasticity of private business investment: High net worth entrepreneurs accept lower excess returns of private business investment over the risk-free interest rate which makes them more sensitive to changes in the interest rate.

Time t is continuous. Consider an infinitely-lived entrepreneur who owns a private business. The entrepreneur chooses consumption c_t, bond holdings b_t, and private business capital $k_{e,t}$, to maximize expected lifetime utility given by

$$\mathbb{E}\left[\int_0^\infty e^{-\rho t}\log c_t\,dt\right].$$

Bonds pay the risk-free interest rate r^b. Private business capital is used in the entrepreneur's private business to produce output y_t^e according to the decreasing returns to scale production function

$$y_t^e = (k_{e,t})^\nu ,$$

with $\nu \in (0,1)$. Note that the firm only uses the capital provided by its owner, it relies entirely on equity financing. This describes the situation of the vast majority of private businesses in the US as can be seen from Table 1. Private business capital is a risky investment because it depreciates stochastically. The entrepreneur's budget constraint is given by

$$\dot{b}_t = (k_{e,t})^\nu - \left(\delta k_{e,t} + \sigma_k k_{e,t}\dot{W}_t\right) + r^b b_t - c_t$$

where $\delta k_{e,t} + \sigma_k k_{e,t}\dot{W}_t$ is the total depreciation of private business capital. The mean depreciation rate is δ, σ_k is the volatility of the capital stock and $\dot{W}_t$ is a standard Wiener process. The entrepreneur faces the borrowing constraint $b_t \geq 0$ and firm capital has to be positive, $k_{e,t} \geq 0$.

The Hamilton-Jacobi-Bellman equation associated with the entrepreneur's problem is

$$\rho V(N) = \max_{c,k_e}\left\{\log c + V'(N)\left[(k_e)^\nu - \delta k_e + r^b(N-k_e) - c\right] + \frac{1}{2}\left(\sigma_k k_e\right)^2 V''(N)\right\},$$

where $N = b + k_e$ denotes the entrepreneurs total net worth. The first order condition for the optimal firm size equates the marginal benefit of increasing the firm size with its marginal cost,

$$\underbrace{\nu \cdot (k_e)^{\nu-1} - \delta}_{MB(k_e)} = \underbrace{r^b - k_e \sigma_k^2 \frac{V''(N)}{V'(N)}}_{MC(k_e;N,r^b)}.$$

The left-hand side is the marginal benefit of a larger firm coming from increased firm production net of depreciation. This is independent of the entrepreneur's net worth, it only depends on the firm size. The right-hand side is the marginal cost. It consists of the forgone interest income from investing in the bond (r^b) and the increase in income uncertainty captured by the risk premium $-k_e \sigma_k^2 \frac{V''(N)}{V'(N)}$. Note that, in general, the risk premium depends on the entrepreneur's net worth. The higher the entrepreneur's net worth, the better he or she is insured against the risk of the private business, and the smaller the marginal cost of investing in the private business.

Figure 2a shows the marginal benefit and marginal cost of investing in the private business as a function of the firm size.[5] The optimal firm size is the intersection of the MC and MB curves. The marginal benefit of private business investment is declining in firm size, because of decreasing returns to scale, but it is independent of the entrepreneur's net worth. The marginal costs of private business investment are increasing in firm size because of the riskiness of the business. Without risk, the marginal cost would be constant and equal to the risk-free interest rate. Figure 2a plots the marginal cost curve for entrepreneurs with low (N_1) and high net worth (N_2). The marginal cost curve is flatter for entrepreneurs with high net worth. As a result, they invest more in the private business than entrepreneurs with low net worth and earn a smaller return. Net worth also affects how an entrepreneur responds to changes in the interest rate r^b. An increase in the interest rate shifts up the marginal cost curve as depicted by the dashed lines in Figure 2a. This leads to a reduction in the optimal firm size. Since the marginal cost curve is flatter for entrepreneurs with high net worth, they reduce their firm's size more strongly in response to an increase in the interest rate.

With constant returns to scale, the marginal benefit is a horizontal line. In this case, simple trigonometry shows that the relative change in firm size is independent of the entrepreneur's net worth. This is the standard Merton problem with constant portfolio shares, independently of the entrepreneur's net worth. In contrast, with decreasing returns to scale, the marginal benefit curve is convex and entrepreneurs with high net worth are at a relatively flat section of the marginal benefit curve.

Without idiosyncratic firm risk, the marginal cost curve is a horizontal line at the risk-free interest rate, independent of the entrepreneur's net worth. In this case, the optimal firm size is the same for all entrepreneurs. Those with sufficient net worth attain this optimal firm size. Entrepreneurs for which the optimal firm size is not feasible, invest all

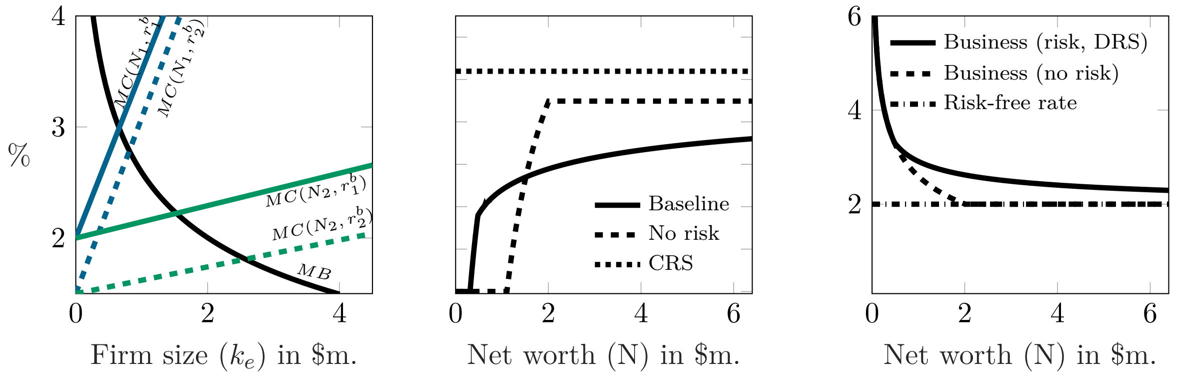
5. In line with the quantitative model below, we use $\rho = 0.024$, $\sigma_k = 0.12$, $\delta = 0.0175$, $\nu = 0.79$, and $r_b = 0.02$.

their wealth in the business. A reduction in the interest rate leads to the same firm size adjustment for all entrepreneurs who are at the optimal firm size, and to no adjustment at all for those who are not.

Figure 2b shows the semi-elasticity of firm capital with respect to the risk-free interest rate as a function of net worth. It confirms the intuition obtained from the previous discussion and Figure 2a. With decreasing returns to scale and idiosyncratic firm risk, the semi-elasticity of firm capital with respect to the risk-free interest rate is an increasing function of net worth.

An intuition for the positive relationship between net worth and the semi-elasticity of firm capital with respect to the risk-free interest rate can be obtained from Figure 2c, which shows the marginal returns from business investment as a function of net worth, given the entrepreneur's optimal investment decision. As net worth increases, the demanded risk premium decreases and the marginal return of private business investment approaches the risk-free rate. An increase of the risk-free rate therefore leads to a relatively large reduction in the excess return of private business investment for entrepreneurs with high net worth, whereas the excess return for entrepreneurs with low net worth is not affected much. Consequently, entrepreneurs with high net worth reduce their firm size more strongly in response to an increase in the interest rate than entrepreneurs with low net worth.

Hence, if there are more entrepreneurs with high net worth, the aggregate elasticity of private business investment with respect to the interest rate is higher. Next, we incorporate entrepreneurs facing an extended version of this simple investment problem alongside workers into a Heterogeneous Agent New Keynesian model along the lines of Kaplan et al. (2018) to study the quantitative importance of this mechanism in general equilibrium. We know from the simple model that two statistics will be important for the quantitative analysis, the extent of decreasing returns to scale and the riskiness of private business investment.



(a) Optimal choice of firm size.

(b) Semi-elasticity of firm capital with respect to the risk-free rate, $-\frac{\Delta k_e}{\Delta r^b}\frac{1}{k_e}$.

(c) Marginal returns of different investment opportunities across the net worth distribution.

Figure 2: Net worth, portfolio choice, and interest rate elasticity of firm capital.

4 A Quantitative HANK Model with Entrepreneurs

In this section we describe the quantitative model, which adds entrepreneurs facing a problem similar to the one described in the previous section to the general equilibrium HANK model of Kaplan et al. (2018). In contrast to the simple model of Section 3, entrepreneurs' businesses employ labor in addition to capital and there are capital adjustment costs. Besides entrepreneurs' private firms, there is a representative firm which also employs capital and labor to produce output using a constant returns to scale technology. We refer to this representative firm as the corporate sector. It stands for all publicly listed companies in the economy. Private firms and the corporate sector produce the same homogeneous intermediate good and constitute the first stage of production of an otherwise standard New Keynesian supply side. Firms facing monopolistic competition and price adjustment costs differentiate the intermediate good. They sell the differentiated goods to a final goods producing firm which bundles them into a final output good that is consumed and used for investment.

On the household side, there is a second type of households besides entrepreneurs, workers. The occupational choice is exogenous and household types are fixed over the lifetime. Workers are subject to uninsurable labor income risk and work either for private firms or the corporate sector. We model workers as in Kaplan et al. (2018). In particular, workers can save in a liquid and illiquid asset, which generates a high share of wealthy hand-to-mouth households, a realistic aggregate MPC, and ensures a realistic transmission of monetary policy to aggregate consumption. Entrepreneurs, on the other hand, will be important for the transmission to aggregate investment, the focus of our study. Besides their private firm, entrepreneurs can invest in the same liquid and illiquid assets as workers.

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 is of idiosyncratic nature, there is no aggregate risk. The monetary policy shock we consider later on is a one-time, unexpected ("MIT") shock.

4.1 Households

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 with the same occupation (worker or entrepreneur). Entrepreneurs are born with a draw from the stationary distribution of entrepreneurial talent, workers with a draw from the stationary distribution of labor productivity. In our baseline specification, all households begin their lives with zero assets as in Kaplan et al. (2018). In Section 8 we compare the effects of monetary policy shocks in this baseline specification to one in which entrepreneurs are born with positive assets, which leads to higher wealth inequality.

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

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

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 $\lim_{c \to 0} u_c(c, \ell) = \infty$.

All households can invest in a liquid asset b_t and an illiquid asset a_t. 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, households face a portfolio adjustment cost $\chi^a(d_t, a_t)$. We denote by r_t^a the risk-free 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 $r_t^a > r_t^b$.

Entrepreneurs In addition to liquid and illiquid assets, entrepreneurs can invest in the capital of their own private firm $k_{e,t} \geq 0$, whose shares cannot be traded. We denote investment in the private firm by f_t. Entrepreneurs disinvest if $f_t < 0$. If an entrepreneur wants to grow or shrink her firm she has to pay capital adjustment costs $\chi^e(f_t, k_{e,t})$. Hence, private business capital constitutes a second illiquid asset in the economy. What distinguishes private firm capital k_e from the illiquid asset a is the associated risk and the fact that k_e cannot be traded. 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 ℓ_{et} from workers, whom they pay the real wage w_t. The amount of invested capital $k_{e,t}$ together with the entrepreneur's talent y and hired labor then determines production of the entrepreneur according to the decreasing returns to scale production function

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

with $\nu \in (0, 1)$. The parameter $Z_e > 0$ governs the productivity of the entrepreneurial sector relative to the corporate sector, which has productivity normalized to one and which we describe in more detail below.

Decreasing returns to scale are common in the literature on entrepreneurship (Cagetti and De Nardi 2006; Tan 2021). They are of key importance for the portfolio re-allocation mechanism that we emphasize in this paper. 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.[6] Decreasing returns to scale have the consequence that wealthier entrepreneurs earn lower returns from their firm. This implication is in line with recent findings in Boar et al. (2022) and Xavier (2021), and we provide additional evidence in Section 5.3.

There are two sources of idiosyncratic investment risk. The first is a capital quality shock that affects the capital employed in the firm $k_{e,t}$, just as in Section 3. Firm capital evolves over time according to the following process:

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

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

6. 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 (Cooley and Quadrini 2001; Asker et al. 2014).

δ denotes the depreciation rate. The second source of risk is productivity risk. Current productivity of an entrepreneur y_t evolves stochastically according to some process

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

Entrepreneurs work a fixed number of hours, $\bar{\ell}$, on tasks regarding the management of the firm. Their labor input does not enter the production function.[7] Entrepreneurs are not paid wages, compensation for their work 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

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

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

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

Taken together, entrepreneurs maximize utility solving the problem

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

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 $\tau_e \cdot \delta \cdot k_{e,t}$.

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 deceased households are distributed to the living households in proportion to their current assets, i.e., there are perfect annuity markets.

Firm dynamics As occupational choice is exogenous, there is no endogenous entry and exit of firms. However, households die with probability ζ and are then replaced by

7. 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.

households of the same type with zero assets. Hence, exogenous entry and exit exists in our model, and we observe both very large and very small firms in equilibrium.

Workers Like 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 are indifferent between working for the corporate firm or a private firm, as they receive the same wage in both cases. Wage payments are subject to a proportional labor tax τ_l. 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

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

given initial conditions.

In Appendix A we provide the Hamilton-Jacobi-Bellman equations that characterize the solutions to the household problems recursively.

4.2 Production

The economy features a standard New Keynesian supply side with one adjustment: The first layer of production does not only consist of a representative firm which uses capital and labor to produce. Rather, all entrepreneurs as well as a representative corporate sector firm produce input goods that are perfectly substitutable (see Figure 3). Monopolistically competitive intermediate goods producers differentiate the input goods. These intermediate goods producers are subject to price adjustment costs. Lastly, the differentiated 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 corporate firm employs labor L_{ct} and capital K_{ct} to produce output Y_{ct} which it sells at price p_t. This is the same price at which entrepreneurs sell their production because both produce an identical good. The corporate sector firm operates a Cobb-Douglas production function

$$Y_{ct} = L_{ct}^{1-\alpha} K_{ct}^{\alpha}.$$

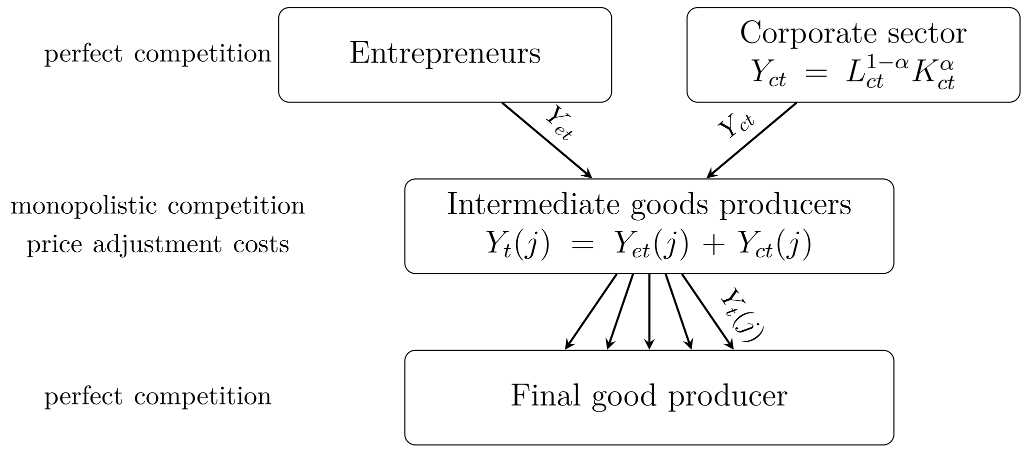


Figure 3: Production flow.

Profit maximization requires that factor prices equal marginal products

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

There is a continuum of mass one of monopolistically competitive intermediate goods producers. Intermediate good producer j buys the amount $Y_{et}(j)$ of the general input good from entrepreneurs and the amount $Y_{ct}(j)$ from the representative corporate sector firm at price p_t, and produces a differentiated variety $Y_t(j)$ using the linear technology

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

Intermediate good producer j sets a nominal price $P_t(j)$ for its intermediate good variety to maximize the present value of real profits. When setting the price, the intermediate good producer takes into account the demand schedule

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

derived from the profit maximization problem of the final goods producer, where P_t denotes the aggregate price level and $\epsilon > 0$ is the demand elasticity for intermediate goods. Intermediate goods producers face price adjustment costs are of the quadratic form as in Rotemberg (1982) and discount the future at rate r_t^a, 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

$$\max_{\{P_t(j)\}_{t\geq 0}} \int_{t=0}^{\infty} e^{-\int_0^t r_s^a \mathrm{d}s} \left[\left(\frac{P_t(j)}{P_t} - p_t\right) \cdot \left(\frac{P_t(j)}{P_t}\right)^{-\epsilon} \cdot Y_t - \frac{\theta}{2} \cdot \left(\frac{\dot{P}_t(j)}{P_t(j)}\right)^2 \cdot Y_t\right] \mathrm{d}t, \qquad (4)$$

where Y_t denotes final output and the parameter θ determines the level of price adjustment costs. Observe that the price of the input goods p_t is the real marginal cost of the intermediate goods producers, $mc_t \equiv p_t$. The profit maximization problem of the intermediate goods producer yields the New Keynesian Phillips curve

$$\left(r_t^a - \frac{\dot{Y}_t}{Y_t}\right)\pi_t = \frac{\epsilon}{\theta}\left[mc_t - \frac{\epsilon - 1}{\epsilon}\right] + \dot{\pi}_t, \tag{5}$$

where $\pi_t = \frac{\dot{P}_t}{P_t}$ denotes the inflation rate (see Appendix A for the derivation). Per-period profits net of price adjustment costs are

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

4.3 Mutual fund and profits from intermediate goods producers

Households' holdings of the illiquid asset a_t are managed by a mutual fund. The fund owns corporate sector capital K_{ct} which it rents out at rate r_t^k, and it invests in shares of the intermediate goods producers, which trade at price q_t.

Intermediate goods producers pay out a fraction $\omega \cdot \frac{Y_{ct}}{Y_t}$ of their profits as dividends, 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.[8] These payments can be interpreted as bonuses. The remaining share $\omega \cdot \left(1 - \frac{Y_{ct}}{Y_t}\right) = \omega \cdot \frac{Y_{et}}{Y_t}$ of profits are paid into the liquid account of the entrepreneurs in proportion to the output of their firm. Hence, entrepreneurs share in the profits of their customers. Splitting up profits Π_t in this fashion ensures that the movement of profits following a monetary policy shock similarly affects investment into the private and into the representative firm.

We normalize the total number of shares to one. Optimality of the fund's portfolio allocation requires that the returns on both investments are the same,

$$\frac{\omega \cdot \frac{Y_{ct}}{Y_t} \cdot \Pi_t + \dot{q}_t}{q_t} = r_t^k - \delta = r_t^a. \tag{6}$$

4.4 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 denoted by B^S, which assumes a positive value when the government has debt. It pays out transfers to the households and spends an amount

8. This is analogous to the treatment of profits in Kaplan et al. (2018).

G on government expenditures. The government budget constraint is

$$G + r_t^b B^S + T_t = \tau_l (w_t L_t + (1-\omega)\Pi_t) + \text{Rev}_{et}, \tag{7}$$

where N_t denotes aggregate labor supply, and Rev_{et} denotes revenues from taxing entrepreneurial profits (see Appendix A.1).

The monetary authority sets the nominal interest rate $i_t = r_t^b + \pi_t$ following a Taylor rule

$$i_t = \bar{r} + \phi \pi_t + \varepsilon_t, \tag{8}$$

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 $\eta = 0.5$

$$\varepsilon_t = \exp(-\eta t) \cdot \varepsilon_0.$$

This completes the description of the model. We relegate the formal equilibrium definition to Appendix A.1.

5 Calibration

Most model parameters are calibrated externally and wherever possible, our strategy closely follows Kaplan et al. (2018). We use the same income process for workers and the same values for the externally calibrated parameters presented in Table 2. We describe these briefly in the next subsection before we discuss the externally calibrated parameters of the entrepreneurial sector in more detail.

Our strategy for the calibration of the remaining parameters, especially those governing the behavior of entrepreneurs, is described in Section 5.2.

5.1 Externally calibrated parameters

Preferences and demographics The felicity function is

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

where we set γ equal to 1 and φ to 2.2. These choices imply an intertemporal elasticity of substitution of one, 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.

Table 2: Externally calibrated parameters.

Parameter		Value	Description	Source or Target
Demographics	s_e	7.5%	share entrepreneurs	SCF
	ζ	0.0056	death rate	avg. lifetime 45 years
Preferences	φ	2.2	labor disutility	avg. working time 8h/day
	γ	1.0	Frisch elasticity	KMV
Technology	$\underline{b}$	1	borrowing limit	avg. qarterly labor inc.
	α	0.33	capital share	KMV
	ω	0.33	dividend ratio	equal to capital share α
	ϵ	10	demand elast. intermediates	mark-up 11%
	θ	100	price adjustment cost	slope of Phillips curve 0.1
	δ	0.018	depreciation rate	7% p.a.
	ν	0.79	returns to scale	Tan (2021)
Policy	ϕ	1.25	inflation response	KMV
	τ_l	0.3	tax rate on labor income	KMV
	τ_e	0.3	tax rate on business income	same as on labor
	T_t	$0.06 \cdot Y_t$	lump-sum transfers	KMV
	$\bar{r}$	0.0050	steady state interest rate	2% p.a.

Notes: KMV stands for Kaplan et al. (2018).

Portfolio adjustment costs 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.

Workers For worker i, log productivity z_{it} consists of two additive parts, a transitory component $z_{1,it}$ and a more persistent component $z_{2,it}$,

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

Each of the two components follows a jump-drift process, with jumps arriving at rate λ_{zj} for $j = 1, 2$. 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 9. This is the same income process as in Kaplan et al. (2018), 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 by Guvenen et al. (2021).

Entrepreneurs 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 (2021), who estimates a value of 0.79. Since most of the entrepreneurial businesses in the SCF are sole proprietorships, partnerships or S corporations (see Table 15 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.

The entrepreneurial capital adjustment cost function is of a 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.

Productivity y of entrepreneurs can take on two values. We interpret the low productivity state, y_l, as a low-talent or subsistence entrepreneur (Poschke 2013). The other state, y_h, captures highly talented entrepreneurs or opportunity entrepreneurs. Since overall productivity of the entrepreneurial sector, Z_e and $\mathbb{E}[y]$ are not separately identified, we normalize $\mathbb{E}[y] = 1$.

Transitions between the two states occur stochastically, at Poisson rate $\lambda_{y,lh}$ from low to high, and at rate $\lambda_{y,hl}$ from high to low state. We interpret switches between the two states as "career shocks", similarly to the persistent component z_2 of workers' labor productivity in Kaplan et al. (2018). Accordingly, we calibrate the transition intensities between the two states to occur on average every 38 years. We further assume that 12.3% of entrepreneurs are of the low (subsistence) type, a number we take from Poschke (2013). This pins down the transition intensities, $\lambda_{y,lh} = 0.04$ and $\lambda_{y,hl} = 0.006$.

We calibrate the process for capital depreciation internally as described in the next subsection. The productivity process and the depreciation process together determine a process for entrepreneurial business income. At the end of Section 5 we verify that the resulting process of business income is comparable to its data analogue estimated in DeBacker et al. (2023).

Corporate sector The output elasticity of capital, α, assumes a value of 0.33 and capital depreciates at 7% annually. The parameter governing the fraction of profits that is reinvested into the illiquid account, ω, is set equal to α. This sterilizes the effect of cyclical profits on investment (see Kaplan et al. 2018). The demand elasticity faced by the intermediate goods producers, ϵ, is set to 10. A value of $\theta = 100$ for the price adjustment costs then ensures that the slope of the Phillips curve is 0.1.

Government 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%.

5.2 Internally calibrated parameters

Eight parameters remain to be calibrated internally. Following Kaplan et al. (2018), 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%) to pin down the discount rate ρ, the borrowing wedge κ, and the portfolio adjustment cost function parameters χ_1^a and χ_2^a.[9]

The remaining four parameters are specific to the entrepreneurial sector. These are the parameters governing the productivity of the entrepreneurial sector, Z_e, the 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 entrepreneurs' businesses of 46% to pin down productivity in the entrepreneurial sector. We also want to match the average portfolio composition of entrepreneurs, as their portfolios and the portfolio reallocation following a monetary policy shock are the focus of our analysis. To this end, we target the share of liquid assets (b) in the US economy held by entrepreneurs, on average 22% across all SCF waves, the share of illiquid assets (a, i.e., without private firms) held by entrepreneurs (also 22%), and the share of entrepreneurs that are hand-to-mouth (16%).[10]

While the identification of any single parameter cannot be traced back to one single target, there exist tight connections between our targets and the calibrated parameters. Capital quality shocks occur frequently in our model, so that entrepreneurs accumulate liquid assets to insure against them. Hence, the share of liquid assets held by entrepreneurs informs σ_k. In contrast, talent shocks occur very infrequently, such that 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 the productivity of opportunity entrepreneurs relative to subsistence entrepreneurs y_h/y_l. Lastly, when capital

9. Kaplan et al. (2018) calibrate an additional third parameter for the intercept of the portfolio adjustment cost function. We follow Alves et al. (2020) and set it to zero to economize on the number of parameters.

10. We construct hand-to-mouth shares in the SCF following the procedure in Kaplan et al. (2014).

Table 3: Internally calibrated parameters.

Parameter	Value	Description	Target
ρ	0.018	discount rate	liquid assets to GDP
κ	0.015	borrowing wedge	illiquid assets to GDP
χ_1^a	0.84	portfolio adjustment costs	share wealthy HtM
χ_2^a	1.45		share poor HtM
$\bar{y}$	2.01	mean entrepreneur talent	employment in private firms
y_h/y_l	1.86	spread entrepreneur talent	share illiquid assets held by entrep.
σ_k	0.12	capital quality shock	share liquid assets held by entrep.
χ_1^e	1.00	adjustment costs firm	share HtM entrepreneurs

Table 4: Targeted moments.

	$\frac{K}{Y}$	$\frac{B}{Y}$	Phtm	Whtm	Lab. at e.	Liq. e.	Illiq. e.	Htm e.
Model	2.63	0.26	0.10	0.20	0.40	0.19	0.23	0.16
Data	2.92	0.26	0.10	0.20	0.46	0.22	0.22	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 poor and wealthy hand-to-mouth households, *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, *Htm e.* is the share of hand-to-mouth entrepreneurs.

adjustment costs are high, entrepreneurs grow their firm relatively slowly and relatively few are at the borrowing constraint $\underline{b}$.[11] If adjusting capital is cheap, growing the firm quickly, at a binding borrowing constraint, becomes more attractive. Therefore, the share of hand-to-mouth entrepreneurs informs the capital adjustment cost parameter χ_1^e.

Table 3 lists the calibrated parameters. The first four are very close to the values in Kaplan et al. (2018). In terms of parameters of 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.[12] Table 4 documents that for these calibrated parameters the model matches the eight targets relatively well.

5.3 Untargeted moments

The analysis of the entrepreneurial investment problem in Section 3 showed that the elasticity of private business investment with respect to the risk-free interest rate crucially

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

12. 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 5: Share of entrepreneurs by net worth percentiles in %.

	All	1.+2. Q.	3. Q.	4. Q.	5. Q.	Top 10%	Top 2%	Top 1%
Model	7.5	1.0	2.1	5.0	28.3	42.7	58.3	64.4
SCF 2019	7.1	1.5	4.2	8.9	19.4	25.6	46.1	48.6

Notes: Q. stands for quintile.

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

	Bottom 50%	Top 20%	Top 10%	Top 1%
Model	0.3	92.4	81.1	36.0
SCF 2019	0.1	87.4	76.5	37.2

depends on i) the distribution of entrepreneurs' wealth, ii) the degree of private business risk, and iii) the extent of decreasing returns in production. In this subsection we show that the calibrated model matches the data on these three dimensions relatively well, even though they are not targeted explicitly.

Distribution of entrepreneurs' wealth In Table 5 we compare the stationary joint distribution of occupation and wealth with the SCF data. The table shows the probability that a randomly selected household from a specific percentile of the wealth distribution is an entrepreneur. The numbers from the SCF correspond to those shown in Figure 1a. The model matches the data relatively well, although it overstates the likelihood of entrepreneurs appearing at the very top of the wealth distribution. In terms of overall wealth inequality the model performs relatively well, as can be seen in Table 6.

Entrepreneurs' income risk We calibrate the parameters governing the risk associated with private business investment, 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 match aggregate targets. However, the resulting income process also matches recent direct estimates of business income risk by DeBacker et al. (2023) relatively well, as shown in Table 10 in the appendix.

Distribution of business returns The last untargeted moment we compare to the data are the returns from private business investment. The distribution of returns over net worth determines the aggregate elasticity of private business investment with respect to the risk-free interest rate, as discussed in section 3. Given business risk, the relationship between net worth and returns is determined by the degree of decreasing returns in production. The span-of-control parameter ν we took from the direct estimates in Tan (2021) yields a relationship between net worth and returns that is very similar to the one

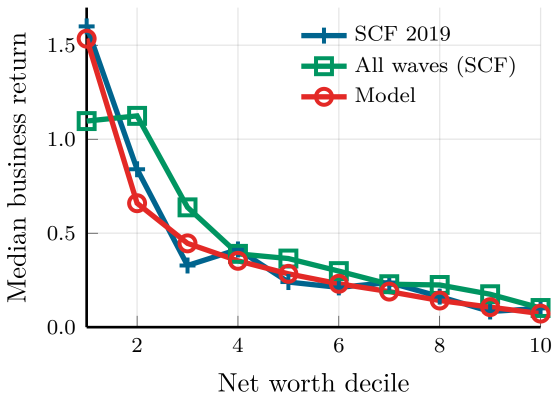


Figure 4: Median business returns by decile of the net worth distribution of entrepreneurs. *Notes:* Depicted are returns from SCF data only for 2019 (blue), over all waves (green), and steady state returns from the model (red).

in the data, as can be seen from Figure 4.

The figure 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 and in the model. We follow De Nardi et al. (2007) and measure the return on business investment using the inverse price to earnings ratio

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

where, i denotes the household and t the year. 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.[13] 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.

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 very high. 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. 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 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 tell apart. Lastly, all returns shown here correspond to business income before taxes,

13. By our definition of entrepreneurs, the head's main job is at the privately owned and managed business.

and hence returns after taxes would be smaller.

The implied median returns from the model fit the data very well, both in terms of levels and in terms of the evolution over net worth ($k_e + a + b$). We view this as a success of our model, as our calibration directly targets neither the overall level of returns nor the returns conditional on net worth deciles.

The negative relationship between wealth and returns to entrepreneurship is also in line with recent empirical evidence provided in other studies. Xavier (2021) also uses SCF data, 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 in the 90th to 97th percentile of the population-wide net worth distribution.[14] 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 tends to raise our measure of profits especially for smaller firms. In addition, Smith et al. (2021) document falling returns to private business capital among the highest percentiles of the wealth distribution using administrative income tax data. Halvorsen et al. (2023) find the same pattern in administrative Norwegian data.

Boar et al. (2022) use balance sheet data on privately owned Spanish firms to document that private firm equity and returns are negatively correlated.[15] Given that firm equity and owner's net worth are highly positively correlated, we view this as further evidence in support of a negative relationship between entrepreneurs' net worth and business returns.

The results so far indicate a negative unconditional correlation between net worth and business returns. In Appendix E 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 many observable household characteristics. In both cases, a robust negative relationship between net worth and returns emerges. We also discuss potential shortcomings of our analysis and investigate the relationship between business wealth and returns as well as that of business wealth and portfolio composition.

6 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.

14. 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 4.

15. See in particular Figure 1 in Boar et al. (2022).

The left panel in Figure 5 shows the response of aggregate output and its components to an expansionary monetary policy shock, an unexpected one time innovation of –100 basis points annually to the Taylor rule, which leads to a drop in the liquid rate r^b on impact of about 41 basis points (see Figure 6). Output, investment, and consumption all rise in response to a cut in the interest rate before they return to their steady state values after about 8 quarters, only consumption remains elevated a bit longer. Output increases by about 1.2% 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).

Consumption accounts for about 28% of the increase in output, investment in private businesses for 24%, and investment in the corporate sector for 35%. Table 7 shows the contributions of entrepreneurs and workers to these aggregate responses on impact. While entrepreneurs do not contribute significantly to the increase in consumption demand directly, they are responsible for about 54% of the total increase in investment. More than 73% of their additional investment is directed towards their private businesses, but entrepreneurs also account for about a quarter of the additional investment in the mutual fund and thus in capital of the corporate sector.

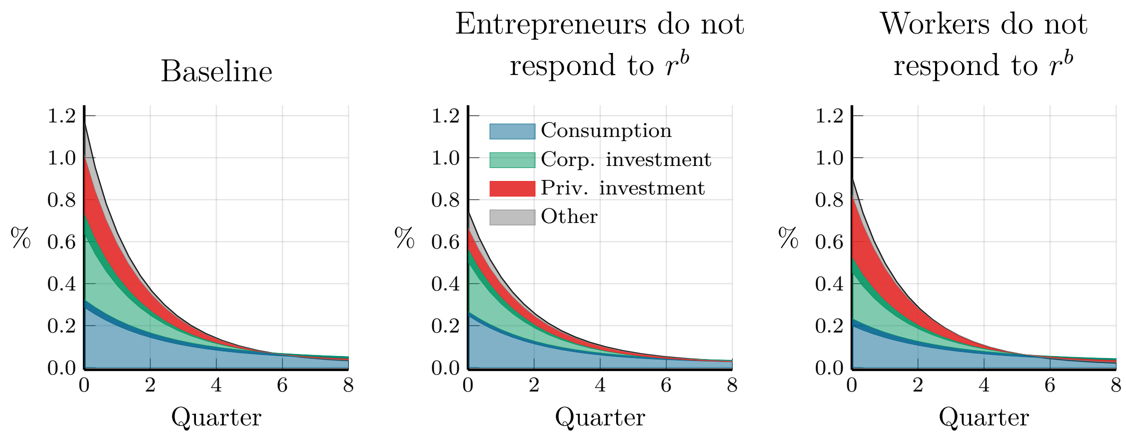


Figure 5: Output response to an expansionary monetary policy shock.

Notes: The figure shows the response of output to an expansionary monetary policy shock of -100 basis points annually. Left: baseline; middle: entrepreneurs (but not workers) ignore change in liquid rate r^b; right: workers (but not entrepreneurs) ignore change in the liquid rate r^b. Darker areas indicate the contribution of entrepreneurs, lighter areas the contribution of workers.

Table 7: Decomposition of output change (on impact, in %).

	Cons.	Inv. (total)	Inv. (priv.)	Inv. (corp.)
Total	27.7	59.0	23.6	35.3
Workers	24.5	27.1	–	27.1
Entrepreneurs	3.1	31.9	23.6	8.2

To better understand the role of entrepreneurs and of workers for the aggregate

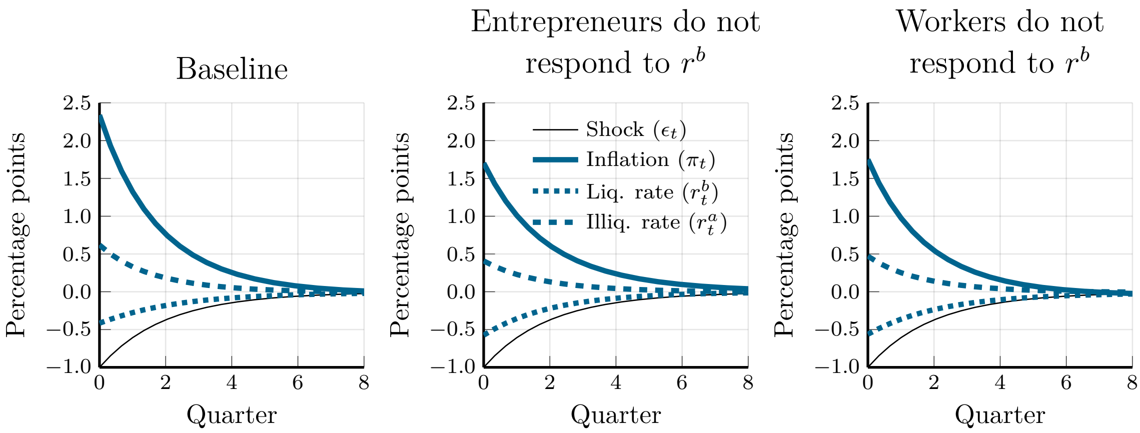


Figure 6: Response of interest rates and inflation to an expansionary monetary policy shock.

Notes: The figure shows the response of inflation and interest rates to an expansionary monetary policy shock of -100 basis points annually. Left: baseline; middle: entrepreneurs (but not workers) ignore change in liquid rate r^b; right: workers (but not entrepreneurs) ignore change in the liquid rate r^b.

response, we next consider two counterfactual scenarios. First, we assume that entrepreneurs ignore changes in the liquid interest rate in response to the monetary policy shock. They believe that the liquid rate is constant at its steady state value at all times and make their consumption and investment decisions accordingly. Entrepreneurs still face income changes due to the monetary policy shock and all factor markets clear at all times. This experiment allows us to assess the importance of the direct effect of monetary policy on entrepreneurs for the economy's response. In the second scenario, we assume that workers ignore the change in the liquid interest rate, while entrepreneurs take it into account.

The responses of aggregate output in these two scenarios are shown in the middle and right panel of Figure 5. When entrepreneurs ignore the change in the liquid rate, the output response is more than 30% smaller than in the baseline scenario. Not surprisingly, most of the difference is due to a smaller response of investment into private businesses, but consumption and corporate sector investment also respond less. In particular, the muted response of entrepreneurs' private business investment also dampens the response of wages and hence consumption of workers, albeit only to a small extent. When workers ignore the change in the liquid rate, the response of output is smaller than in the baseline scenario, but still larger than when entrepreneurs ignore the change in the liquid rate. In this scenario, the smaller output response relative to the baseline is due to a smaller response of consumption and corporate investment.

We conclude, that entrepreneurs' direct response is important for the transmission of monetary policy, even though entrepreneurs only make up a small fraction of households.

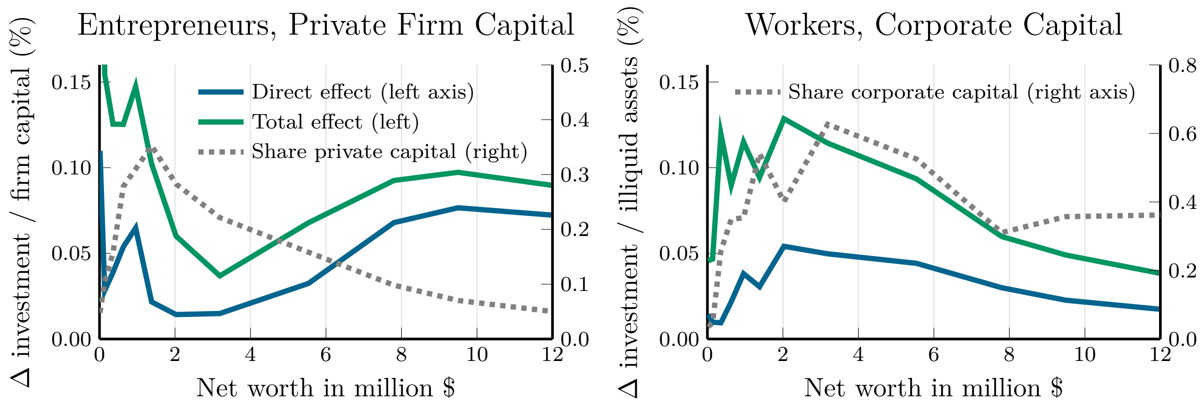


Figure 7: Heterogeneous private firm investment response after monetary policy shock.
Notes: Left panel: entrepreneur's private firm investment response. Right panel: worker's corporate sector investment response. Green line: Total change in investment relative to capital in response to monetary policy shock on impact. Blue line: Change in investment relative to capital caused by liquid rate change, other prices held fix. Gray dotted line: Share of private business capital (left panel) and share of corporate sector capital (right panel). All lines show averages in bins of net worth.

Dependence of the investment response on net worth. Entrepreneurs as a group are important for the evolution of aggregate investment in response to the shock, but, depending on their net worth, entrepreneurs respond to the interest rate change very differently.

The on-impact change in entrepreneurs' private firm investment relative to the stock of business capital across the net worth distribution is illustrated by the solid green line in the left panel of Figure 7. 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.

We decompose the total response of private firm investment into a direct effect, that is due to the change in the interest rate itself and an indirect effect, that comes from changes of other prices and incomes in general equilibrium.

The blue line in Figure 7 depicts the direct effect.[16] The response is increasing in net worth: wealthier entrepreneurs earn lower excess returns over the risk-free rate, and hence rebalance their portfolio more strongly towards the private business when the risk-free rate falls.[17]

Entrepreneurs with net worth below 2 million also exhibit a strong direct effect. Low net worth entrepreneurs have taken 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 they invest the additional

16. This corresponds to the partial equilibrium effect analyzed in the simple model of Section 3.
17. In contrast to the simple model in Section 3, the excess return here consists not only of a risk premium, but also of a liquidity premium.

income in their firm. In the simple model of section 3, this effect was absent because borrowing was ruled out. In terms of aggregate investment, however, these low net worth entrepreneurs are of minor importance, as they hold a small share of the overall capital stock. This is illustrated by the gray dotted line, which plots the share of business capital held at respective points of the net worth distribution.[18] A large number indicates that entrepreneurs at this level of net worth hold a large share of total private business capital.

Next, we turn to the indirect effect on entrepreneurial investment coming from changes in prices other than the liquid interest rate. The indirect effect is the difference between the green line (total effect) and the blue line (direct effect) in Figure 7. For most entrepreneurs, the indirect effect is smaller than the direct effect. In particular, this is the case for wealthy entrepreneurs for which 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.[19]

The response of entrepreneurs' private business investment over the net worth distribution is qualitatively different from the response of workers' investment into the corporate sector. The latter is displayed in the right panel of Figure 7 and shows the pattern emphasized in Luetticke (2021). For most levels of net worth, the response is declining in net worth: richer workers respond less strongly. This is because the interest rate cut constitutes a negative wealth effect, which is particularly strong for richer workers.

We summarize our results as follows. First, the investment decision of entrepreneurs significantly affects the aggregate output response. 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. Decreasing returns to scale, idiosyncratic firm risk, and illiquidity of business capital 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. Third, poor entrepreneurs also respond strongly to monetary policy because of large indirect effects. However, they only hold a small fraction of the total capital stock, which mutes their importance for aggregate investment.

18. The line integrates to 100% of business capital. To obtain it, we average the private firm capital share within small bins of net worth.

19. This can be seen from Figure 11 in the Appendix, which plots the marginal propensity to invest in private business capital as a function of net worth.

7 Direct Evidence on Portfolio Response

The u-shaped response of entrepreneurs' investment over net worth is also reflected in the data, as we show next.

To empirically estimate 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 a pseudo-panel approach similar to Luetticke (2021).

Let $\gamma_{p,t}$ denote the log portfolio share of firm capital for the p-th percentile of the business return distribution in year t. We estimate these portfolio shares non-parametrically using local linear regressions, effectively using information about the portfolio shares in percentile p and in those percentiles that lie close to p. Appendix F 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 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

$$\gamma_{p,t+h} = \alpha + \beta_{p,h} \cdot FF_t + \delta^{Y}_{p,h} \cdot \ln(Y_{t-1}) + \delta^{FF}_{p,h} \cdot FF_{t-1} + u_{t+h}, \tag{9}$$

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 $\beta_{p,h}$, which captures the effect of a 100 basis point increase in the interest rate on the log portfolio share in percentile p of the return distribution h years ahead.

Since the federal funds rate is endogenous, we instrument it with a series of identified monetary policy shock. We use the narratively identified series of shocks from Romer and Romer (2004) extended until 2007 by Ramey (2016). Since the series is monthly, we aggregate it to annual frequency (see Appendix F for the details.).

The left panel of Figure 8 depicts our baseline estimates of $\hat{\beta}_{p,h}$ for $h = 0, 1, 2$. Consider the red 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. We order percentiles in decreasing order on the x-axis, such that entrepreneurs with low returns who are typically wealthy are on the right.

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

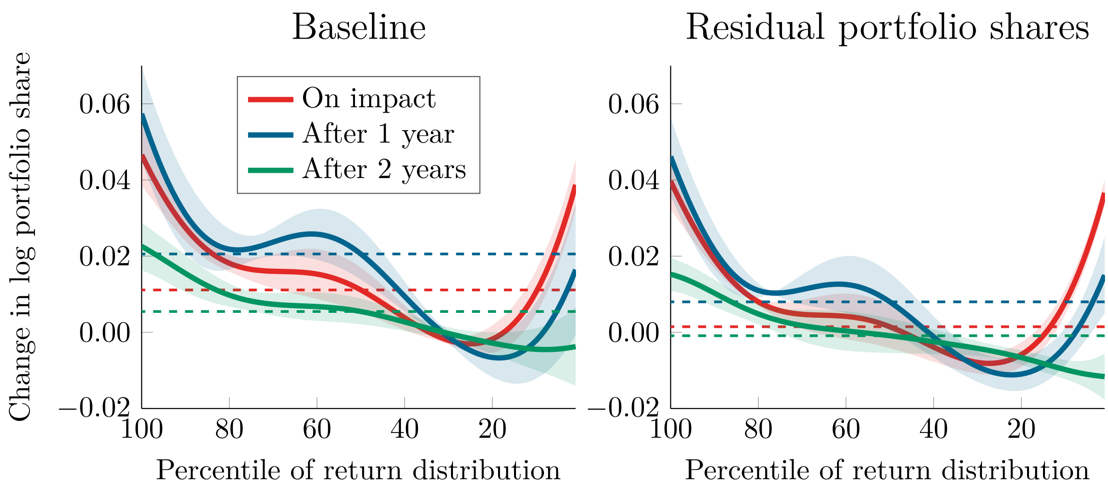


Figure 8: Impulse responses of portfolio shares to monetary policy shock.
Notes: Change in the logarithm of portfolio shares following a 25 basis points expansionary monetary policy shock by business return percentile. The dashed lines depict the responses at the median of the return distribution. Confidence bands are at the 66% level.

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 green line indicates that after two years the response is a bit smaller.

Turning to heterogeneity, entrepreneurs at both extremes of the return distribution react relatively strongly on impact and one year after the shock. Through the lens of our model, and in accordance with Figure 7, this could be interpreted as strong direct effects for entrepreneurs with large firms and small returns, and large responses of entrepreneurs with small firms and hence large returns. The 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 (green line), we would indeed expect the strongest reallocation towards firm capital right after the shock materializes, i.e., on impact and one year after the shock.

We obtain very similar results, when we consider residual portfolio shares after controlling for household characteristics, as shown in the right panel of Figure 8. In Appendix F, we describe this approach in greater detail and provide additional results. There, we also use the Gertler and Karadi (2015) shocks from high-frequency identification as an alternative instrument.

8 Shift of Wealth From Workers to Entrepreneurs

We now use the model to study how a shift of wealth from workers to entrepreneurs affects the transmission of monetary policy. To this end, we compare the effects of a monetary policy shock at the baseline steady state to one at a steady state in which entrepreneurs command a larger share of wealth and wealth inequality is higher.

Table 8: Responses to a monetary policy shock for different bequest regimes.

Regime	(1) Share with bequest (%)	(2) Bequest size ($1,000)	(3) Top 10% wealth share	(4) Capital at private firms	(5) Output response	(6) Investment response
Baseline	0	0	81.1%	37%	1.18%	4.35%
1	100	500	+0.6pp.	+7pp.	+4.41%	+3.91%
2	25	2,000	+1.2pp.	+5pp.	+3.07%	+2.16%
3	5	10,000	+1.3pp.	+2pp.	+3.15%	+2.77%

Notes: The first row represents the initial steady state, the second to last rows different bequests regimes. Column (1) shows the fraction of entrepreneurs who receive bequests. Column (2) shows the bequeathed amount per bequest in $ million. Column (3) shows the difference in the top 10% wealth share compared to the baseline. Column (4) indicates the difference in the share of capital employed in private firms in steady state. Column (5) and (6) are the relative change in the output and investment response compared to the baseline (impact response of shock of -100 basis points annually).

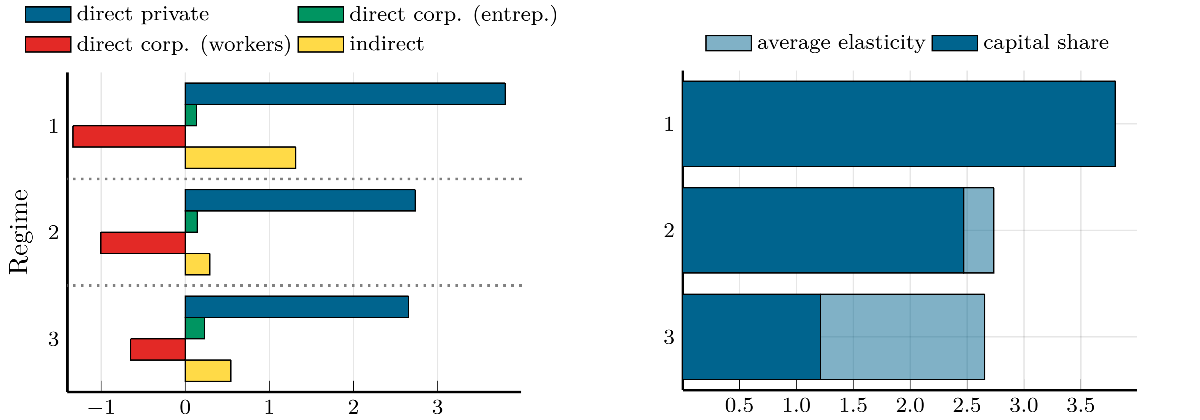
In the model, the stationary distribution of wealth is endogenous. To obtain a steady state in which entrepreneurs are richer, we therefore need to take a stance on the force that alters the stationary wealth distribution. We choose to vary the endowment of newborn households, and assume that some entrepreneurs are born with a positive amount of wealth. For the baseline steady state, in contrast, we assumed that all households were born without any wealth. A different initial wealth endowment of newborn households can be interpreted as a change in estate taxation. Indeed, federal estate taxation has become less broad-based since the 1980s and this has contributed to an increase in wealth inequality (Hubmer et al. 2021). Besides its empirical relevance, varying the initial wealth endowment also has the appealing property that it does not affect household policies for given prices. This allows us to attribute the differential responses under the new specification to changes in the distribution of wealth most clearly.

We assume that some entrepreneurs are born with a positive amount of wealth, whereas all workers are born without any asset holdings. The wealth endowment is composed entirely of private firm capital, but we found the asset composition to be inconsequential for the main results.

In the baseline model, assets of deceased households are distributed to living households in proportion to their assets, which effectively increases the return on assets. Now, only the assets of deceased households net of the wealth endowment of newborn households (bequests) are distributed to asset holders. This means the aggregate resource constraint continues to hold, since wealth of deceased households finances the initial endowments. Household preferences do not change: As before, households do not derive utility from leaving wealth to their offspring, so all bequests are accidental.

As a starting point, all newborn entrepreneurs receive $500,000 in bequests. We then consider the same monetary policy shock as before.

Table 8 gives an overview of the consequences for the distribution of capital and the



(a) Decomposition of change in investment response.

(b) Decomposition of change in direct response to private business investment.

Figure 9: Change in investment response to the interest rate change under different bequest regimes relative to the baseline and its components

transmission of monetary policy. The first row corresponds to the initial (low-inequality) steady state of our model. Here, entrepreneurs do not receive bequests and the share of capital employed in entrepreneurs' private firms is 37%. The second row corresponds to the high inequality steady state, in which all newborn entrepreneurs receive bequests of $500,000. This implies an increase in the stationary top 10% wealth share by 0.6 percentage points. The share of capital employed in private firms is 7 percentage points higher than in the baseline. The initial output response to the monetary policy shock gets amplified by 4.4% and the investment response by 3.9% of the respective responses without bequests. In the last two rows of Table 8, we consider more concentrated distributions of bequests: we keep the total amount of bequests constant but assume that only 25% or 5% of entrepreneurs receive bequests. More concentrated bequests lead to more wealth inequality, a smaller increase in the capital share of private businesses and a smaller increase of the output and investment responses compared to the baseline.

Figure 9a decomposes the change in the investment response in the different bequest regimes into the direct effects of the interest rate change due to private business investment, investment of entrepreneurs in the corporate sector, investment of workers in the corporate sector, and the indirect investment response.[20] It shows that a large part of the increase in the investment response under high inequality is due to the direct effect of the interest rate change on private firm investment. This is in line with our earlier finding that private business investment is important for the transmission of monetary policy in our model.

When bequests are more concentrated, the direct effect on private firm investment is slightly smaller, just as the overall investment response. This finding may appear at

20. Note that neither workers nor entrepreneurs invest in the corporate sector directly, we show their respective contributions to the increase in corporate investment through their investment in the mutual fund.

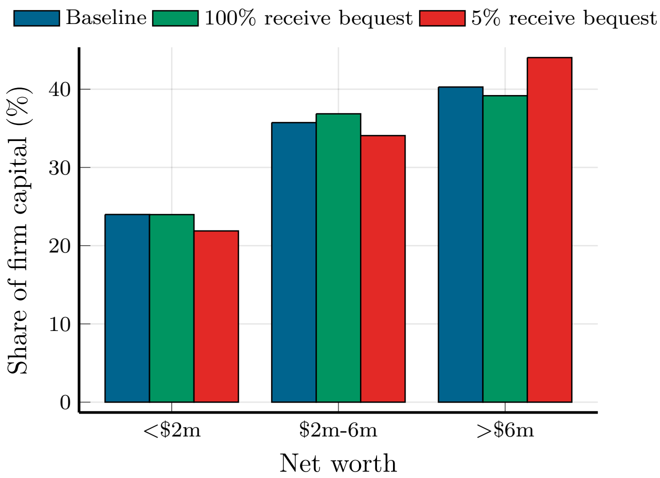


Figure 10: Share of firm capital held by entrepreneurs in different net worth groups.

odds with the results in section 3, where we found that the interest rate elasticity of private firm investment is larger for richer entrepreneurs. The reason is that there is a second effect at play besides this *elasticity effect*: The distribution of bequests alters the relative size of the private business sector (*size effect*) which also affects the response of total investment. Figure 9b decomposes the direct effect of the interest rate change on private firm investment into the part that is due to changes in the average elasticity (*elasticity effect*) and the part that is due to changes in the capital share of the private business sector (*size effect*). We see that a more concentrated distribution of bequests increases the average elasticity of private firm investment, as we would expect from the results in section 3. However, more concentrated bequests also decrease the capital share of the private business sector, which reduces the absolute response of private business investment. The sum of these two effects is similar across the different bequest regimes, but the *elasticity effect* is much more important when bequests are more concentrated. In this case, there are more rich entrepreneurs with small excess returns and high elasticities.

This can be seen from Figure 10, which plots the share of firm capital held by entrepreneurs in different net worth groups. When all newborn entrepreneurs receive bequests, a greater share of private business capital is held by entrepreneurs with net worth between $2 and 6 million. These entrepreneurs exhibit a relatively small direct investment response to interest rate changes (see Figure 7). In contrast, when only 5% of entrepreneurs receive bequests, the right tail of the net worth distribution becomes fatter and a larger share of private business capital is held by entrepreneurs with net worth exceeding $6 million and high interest rate elasticities of private business investment.

Overall, for the cases considered, the effect of a shift of wealth from workers to entrepreneurs on monetary transmission amounts to an amplification of the output response between 2.4% and 7.3% for every percentage point increase in the top 10% wealth share.

9 Conclusion

Entrepreneurs constitute a small fraction of all households, but they hold a large share of total wealth, and their firms employ almost half of the workforce. In addition, the gap between average wealth held by entrepreneurs and by workers has increased over the recent decades. We documented 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. We find that entrepreneurs are quantitatively important for the impact of monetary policy on the real economy. An increase in wealth inequality due to richer entrepreneurs strengthens the effects of monetary policy on aggregate output. The size of this effect crucially depends on the distribution of wealth among entrepreneurs. Thus, our findings suggest that central banks should pay particular attention to asset holdings of private business owners and to their portfolio composition.

Our model is a first step towards understanding the role of entrepreneurs for the transmission of monetary policy. It focuses on the intensive margin of entrepreneurial investment and on financing through the entrepreneur's own funds. Entry and exit from entrepreneurship as well as outside financing are interesting aspects for future work.

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A Model Details and Derivations

A.1 Equilibrium Definition

An equilibrium consists of paths for individual decisions of workers and entrepreneurs $\{a_t, k_{et}, b_t, c_t, d_t, \ell_t, f_t, n_{et}\}_{t\geq 0}$, 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 $\{\pi_t\}_{t\geq 0}$, fiscal variables $\{T_t\}_{t\geq 0}$, τ_l, τ_e, G, B^S, distributions $\{\mu_{wt}, \mu_{et}\}_{t\geq 0}$, and aggregate quantities such that, at every t:

1. Given equilibrium prices, taxes, and transfers, household decisions of workers and entrepreneurs solve the problems (2) and (3).

2. Firms maximize profits.

3. The path of distributions satisfies aggregate consistency conditions.

4. The bond market and the capital market clear, the labor market clears, and all goods markets clear (see below).

5. Monetary policy follows the Taylor rule (8), the government budget is balanced (7).

Bond market clearing

$$B^S = (1 - s_e) \int b_t \, \mathrm{d}\mu_{wt} + s_e \int b_t \, \mathrm{d}\mu_{et}$$

Capital market clearing

$$K_{pt} + q_t = (1 - s_e) \int a_t \, \mathrm{d}\mu_{wt} + s_e \int a_t \, \mathrm{d}\mu_{et}$$

Labor market clearing

$$(1 - s_e) \int \exp(z) \cdot \ell_t \, \mathrm{d}\mu_{wt} = L_{pt} + L_{et} = L_{pt} + s_e \int n_{et} \, \mathrm{d}\mu_{et}.$$

Input goods market clearing

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

Intermediate goods market clearing

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

Once the markets for the inputs and the intermediate goods clear, market clearing for the final good follows from Walras' law.

Revenues from taxing entrepreneurs that show up in the government budget constraint (7) are defined as

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

A.2 Hamilton-Jacobi-Bellman equation

If labor productivity and entrepreneurial talent follow the jump-drift processes described in Section 5, the solution to the entrepreneurs' problem can be characterized recursively by the following Hamilton-Jacobi-Bellman equation for low-productivity types (y_l)

$$\begin{aligned}\tilde{\rho} V^l(b,a,k_e) = \max_{c,d,f} u(c,\bar{\ell}) + V_b^l(b,a,k_e)\Big[(1-\tau_e)\Pi_e(k_e,y_l) + r^b(b)b + T - d - \chi^a(d,a) - f \\ - \chi^e(f,k_e) + \tau_e \delta k_e - c\Big] + V_a^l(b,a,k_e)(r^a a + d) + V_k^l(b,a,k_e)(f - \delta k_e) \\ + \frac{1}{2} k_e^2 \sigma_k^2 V_{kk}^l(b,a,k_e) + \lambda_{y,lh}(V^h(b,a,k_e) - V^l(b,a,k_e)),\end{aligned} \tag{10}$$

where $\tilde{\rho} = \rho + \zeta$. The value function for high productivity types, $V^h(b,a,k_e)$, is defined analogously.

The solution to the workers' problem is characterized by

$$\begin{aligned}\tilde{\rho} V^w(b,a,z) = \max_{c,\ell,d} u(c,\ell) + V_b^w(b,a,z)\Big[(1-\tau) w \exp(z)\ell + r^b(b)b + T - d \\ - \chi^a(d,a) - c\Big] + V_a^w(b,a,z)(r^a a + d) \\ + \sum_{j\in\{1,2\}} V_{z_j}^w(b,a,z)(-\beta_j z_j) + \lambda_j \int_{-\infty}^{\infty} (V^w(b,a,x) - V^w(b,a,z_j))\phi_j(x)\mathrm{d}x\end{aligned} \tag{11}$$

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

A.3 Derivation of Phillips Curve

Here we derive the New Keynesian Phillips curve following Appendix B.2 of Kaplan et al. (2018). Equivalently to 4, we can formulate the profit maximization problem as a choice over firm level inflation π_{jt},

$$\begin{aligned}&\max_{\{\pi_{jt}\}_{t\geq 0}} \int_{t=0}^{\infty} e^{-\int_0^t r_s^a \mathrm{d}s} \left[\left(\frac{P_t(j)}{P_t} - mc_t\right) \cdot Y^d \left(\frac{P_t(j)}{P_t}\right) - \Theta\left(\pi_{jt}\right)\right] \mathrm{d}t \\ &\text{s.t.} \quad \dot{P}_t(j) = \pi_{jt} P_t(j)\end{aligned}$$

A necessary condition for optimality is the associated HJB equation

$$r_t^a J(t, P_t(j)) = \max_{\pi_{jt}} \left(\frac{P_t(j)}{P_t}\right)^{1-\epsilon} Y_t - mc_t \left(\frac{P_t(j)}{P_t}\right)^{-\epsilon} Y_t - \frac{\theta}{2}\pi_{jt}^2 Y_t \\ + J_t(t, P_t(j)) + P_t(j)\pi_{jt} J_p(t, P_t(j)), \tag{12}$$

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 (12) is

$$J_p(t, P_t(j)) = \frac{\theta \pi_{jt} Y_t}{P_t(j)}, \tag{13}$$

the envelope condition is

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

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

$$(r_t^a - \pi_t) J_p(t, P_t) = (1-\epsilon)\frac{Y_t}{P_t} + \epsilon \cdot mc_t \frac{Y_t}{P_t} + J_{tp}(t, P_t) + \pi_t P_t J_{pp}(t, P_t). \tag{14}$$

Taking the derivative of (13) 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 (14). This gives the New Keynesian Phillips curve (5)

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

A.4 Calibration Details

Table 9: 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

DeBacker et al. (2023) use a large confidential panel of US income tax returns to scrutinize 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. In contrast to our definition of entrepreneurs, they also consider business income of households who do not actively manage a business. DeBacker et al. (2023) report how likely it is for households to move from a given decile of the business income distribution to another decile in the following year. Table 10 shows these numbers, as well as the analogous statistics from the model simulation. For better readability we reduce the dimension of the transition matrix from ten deciles to five quintiles. The matrix in DeBacker et al. (2023) contains transition probabilities to and from a separate state with "no business income" alongside the ten deciles of the business income distribution. Since the probability of zero business income is zero in our model, we delete the zero income state and re-weight the original transition matrix in DeBacker et al. (2023).[21] This way, we can compare transition probabilities between quintiles of the business income distribution in the model and the data conditional on non-zero business income.

Overall, the income process in the model is similar to that in the data, though it features somewhat more volatility. Also in the data, 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.

Table 10: Annual transition matrix of business income (Model/Data), in %.

From \ To	1. Quintile	2. Quintile	3. Quintile	4. Quintile	5. Quintile
1. Quintile	39 / 63	24 / 19	14 / 8	13 / 5	10 / 5
2. Quintile	20 / 18	37 / 49	24 / 21	13 / 8	7 / 4
3. Quintile	13 / 7	18 / 20	37 / 47	20 / 22	11 / 4
4. Quintile	13 / 5	14 / 7	18 / 18	33 / 53	22 / 16
5. Quintile	16 / 5	6 / 3	8 / 4	20 / 14	50 / 75

Notes: The table reports the probability of moving from the row quintile of business income to the column quintile within one year. The data (right values) are from DeBacker et al. (2023). 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 the 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.

21. In Table 11 we lump exits and transitions into the first quintile.

Table 11: Annual transition matrix of business income (Model/Data), in %.

From \ To	1. Quintile or exit	2. Quintile	3. Quintile	4. Quintile	5. Quintile
1. Quintile	39 / 68	24 / 16	14 / 7	13 / 5	10 / 5
2. Quintile	20 / 34	37 / 40	24 / 17	13 / 6	7 / 3
3. Quintile	13 / 19	18 / 17	37 / 41	20 / 19	11 / 4
4. Quintile	13 / 10	14 / 6	18 / 17	33 / 50	22 / 15
5. Quintile	16 / 7	6 / 2	8 / 3	20 / 13	50 / 73

Notes: The table reports the probability of moving from the row quintile of business income to the column quintile within one year. The data (right values) are from DeBacker et al. (2023). We use the values from their Table 1. We sum their first and second column and delete their first row (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.

A.5 Marginal propensities to invest

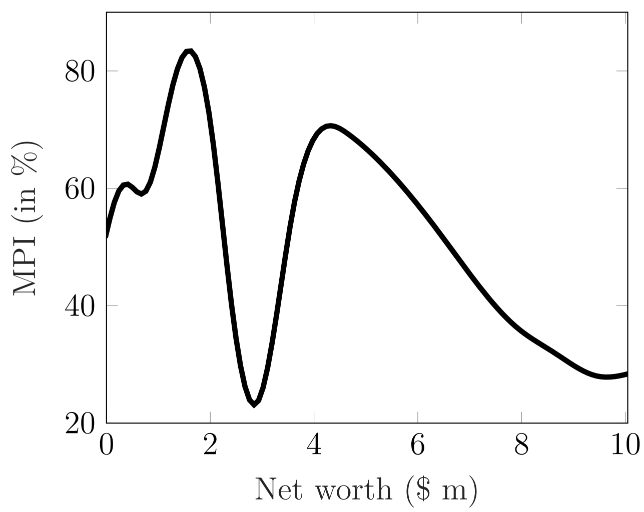
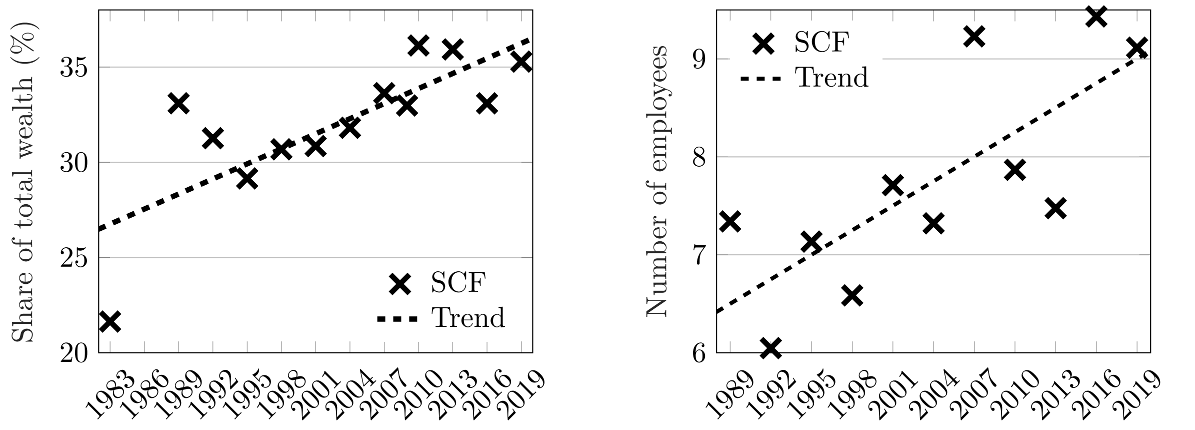


Figure 11: Marginal propensity to invest (MPI) in the private business out of a transfer of $500 into the liquid account over one quarter.

B Data on Entrepreneurs and Wealth Inequality

Figure 12b plots average employment per entrepreneurial firm. Figure 12a displays the share of total household wealth held by entrepreneurs. It shows that over the recent decades, entrepreneurs hold on average a third of wealth in the economy. Furthermore, the same upward time trend that was visible in the plots of the main text is visible here as well. One might be worried that this result is driven exclusively by the data point in 1983 with a very low entrepreneurial wealth share. However, even without the observation in



(a) Share of total US household wealth held by entrepreneurs, 1983–2019.

(b) Average number of employees in firms owned by entrepreneurs, 1989–2019.

Figure 12: Wealth and employment of entrepreneurs over time.

1983, the time trend is positive and statistically significant with a p-value of 1.5%.

Employment share Since we lack information on the intensive margin of labor supplied in the entrepreneurial firms, one might be worried the share of hours worked (intensive margin) at entrepreneurs' firms is lower than the employment share (extensive margin). To address this concern to some extent, we compare the distribution of private businesses over industries with a lot of part-time work. There is little indication that private firms are overrepresented in industries with many part-time employees. According to the Bureau of Labor Statistics (BLS), in January 2019, about 17% of all US workers worked part-time, the large majority of them (13%) for non-economic reasons. More than 50% of the wage and salary workers working part-time for non-economic reasons worked in retail trade, food services and drinking places, and private educational services.[22] While data on industries of entrepreneurs' firms in the more recent waves of the SCF is too coarse to be informative, data on industries before 1992 can provide some insight. In 1992, the four industries entrepreneurs mentioned most often as the industry of their first firm were (see also Table 12)

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

22. See Dunn (2018).

Table 12: 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.

Table 13: 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 are as in the second business.

Hence the overlap between those industries with many private businesses and those with a lot of part-time work is small.

Firm size distribution Table 13 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 important for the overall employment of entrepreneurial sector. More than three quarters of all employment in private businesses is due to firms that employ ten or more workers. A similar pattern can be seen in Table 14, which reports the firm size distribution in terms of gross sales. Lastly, Tables 15 and 12 show the distribution of entrepreneurial firms across different legal statuses and industry, respectively.

Table 14: Firm size distribution by gross sales (SCF 2019)

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

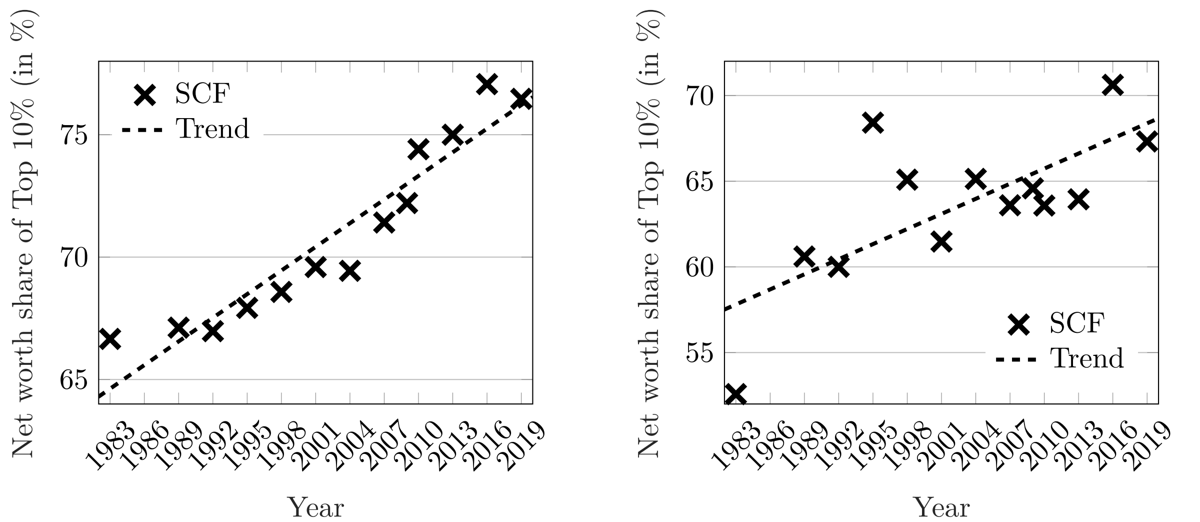
Notes: Since we observe gross sales and ownership shares only in the first two businesses of a given entrepreneurial household, we assume that if an entrepreneur has more than two businesses gross sales in these additional businesses are as in the second business.

Table 15: 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.

Wealth inequality As pointed out in the main text, several studies have found that wealth inequality has risen in the US since the 1980s (Kuhn et al. 2020; Saez and Zucman 2016; Hubmer et al. 2021). Figure 13a shows this using the share of wealth held by the richest 10% of the population as a measure of wealth inequality. Moreover, wealth inequality has also increased within the group of entrepreneurs, as Figure 13b shows.



(a) Share of total wealth held by the wealthiest 10% of households.

(b) Wealth of wealthiest 10% of entrepreneurs relative to wealth of all entrepreneurs.

Figure 13: Wealth inequality over time.

C Additional Model Results

C.1 Phillips Curve

We investigate how the changes in the wealth distribution affect the trade-off between inflation and activity (the Phillips curve). Figure 14 plots the Phillips curve for the baseline economy (blue) and for the economy where 5% of entrepreneurs receive a bequest of 10 million USD (red). It shows output gap and inflation on impact for differently sized monetary policy shocks between -200 and +200 basis points. The figure confirms our findings that a given shock has larger effects on output when wealth inequality is higher: the red points are shifted outwards compared to the blue points. The slope of the Phillips curve is virtually the same in both cases, however. This means that the trade-off between inflation and activity is not affected by the distribution of endowments. Marginal costs of output depend on the wealth of entrepreneurs and its distribution, which determines how strongly they expand their firms and in responds to price changes. As can be seen from the bottom left panel of Figure 14, relationship between output gap and marginal costs is virtually the same in both economies. Changes in the distribution of wealth of the size considered here do not alter the relationship between output and marginal costs and therefore leave the slope of the Phillips curve unchanged.

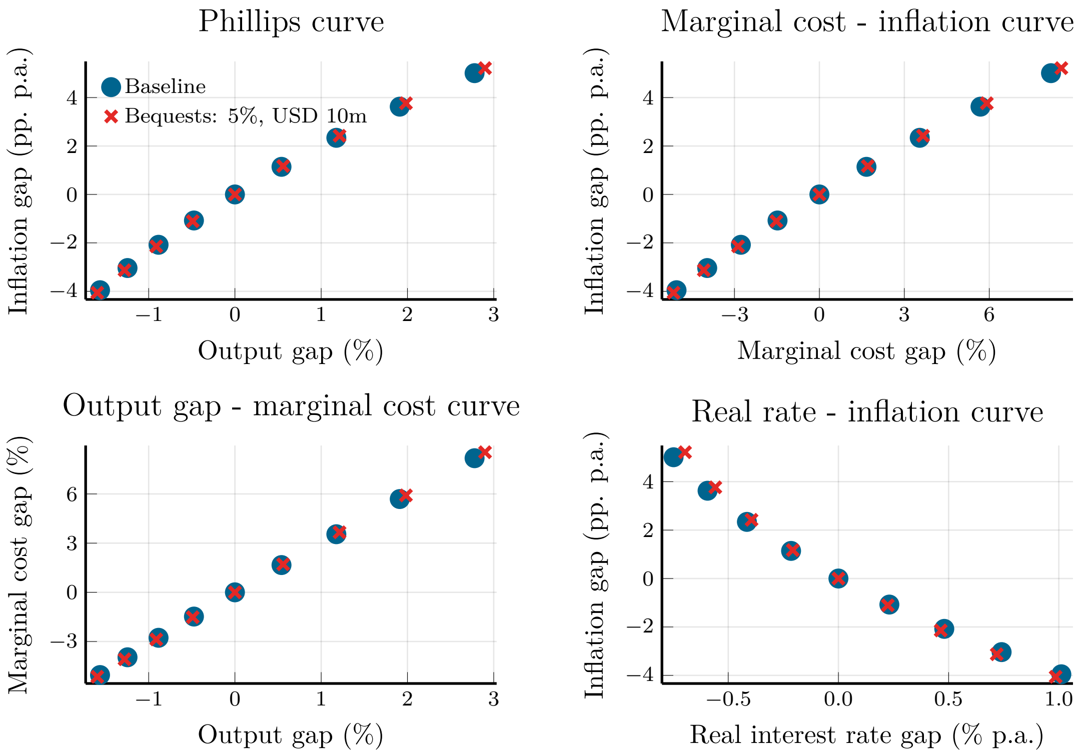


Figure 14: Phillips curve.

D Computational Details

D.1 Solving the Kolmogorov Forward Equation with stochastic death and many states

One computational challenge is to solve the Kolmogorov Forward Equation (KFE) to obtain the equilibrium asset distribution. This task is particularly demanding in our model, since when households die, they are replaced by newborns with zero assets. This feature adds discrete jumps into the transition matrix which break the sparsity pattern of the transition matrix. To fix ideas, consider the case of entrepreneurs with state vector (b, a, k_e, y). Let N_b, N_a, N_{k_e} and N_y denote the number of grid points for the respective state variable. Let A denote the transition matrix obtained from the solution to the HJB equation. This matrix captures the movement of agents in the state space and is very sparse. However, the need to take into account death of agents and birth of new agents with zero assets requires an adjustment of A when solving for the stationary distribution. In particular,

$$A_{adj} = A - \zeta I + \zeta C$$

where ζ is the dying probability and $C = \text{diag}\{\underbrace{c, \dots, c}_{N_y}\}$ where

$$c = \begin{pmatrix} 0 & 0 & \dots & 0 & 1 & 0 & 0 & \dots & 0 \\ 0 & 0 & \dots & 0 & 1 & 0 & 0 & \dots & 0 \\ & & \vdots & & & & & & \\ 0 & 0 & \dots & 0 & 1 & 0 & 0 & \dots & 0 \end{pmatrix}$$

is a $(N_b N_a N_{k_e}) \times (N_b N_a N_{k_e})$ matrix capturing the birth of a mass ζ of new households with zero asset holding and an initial draw of entrepreneurial talent, y, from its stationary distribution. The matrix c is zero everywhere except for column corresponding to zero assets, which is a vector of ones.[23] Denote the number of this column by N_0.[24] The stationary distribution μ is the solution to

$$A_{adj}^T \mu = 0.$$

The difficulty here is that while $(A - \zeta I)^T$ is very sparse and fast to invert as described in Achdou et al. (2022), A_{adj}^T is not. However, we can exploit its special structure. Observe that

$$\begin{aligned} A_{adj}^T \mu &= 0 \\ \Leftrightarrow (A - \zeta I + \zeta C)^T \cdot \mu &= 0 \\ \Leftrightarrow \mu &= \underbrace{-\left[(A - \zeta I)^T\right]^{-1} \zeta}_{\equiv B} \cdot C^T \cdot \mu. \end{aligned} \tag{15}$$

Due to the special structure of C^T, we have that

$$\mu = B \cdot \begin{pmatrix} 0 \\ \vdots \\ 0 \\ \sum_{i=1}^{N_{bak_e}} \mu_i \\ 0 \\ \vdots \\ 0 \\ \sum_{i=N_{bak_e}+1}^{2N_{bak_e}} \mu_i \\ 0 \\ \vdots \end{pmatrix}$$

23. Note, that we assume here that the y-dimension is ordered last in the transition matrix.
24. If the first point of all grids is zero, $N_0 = 1$. If the first point on the a- and k_e-grid are zero, but only the k-th point on the b-grid is zero, $N_0 = k$, and so on.

and so

$$\mu = \begin{pmatrix} b_{1,N_0} \\ b_{2,N_0} \\ \vdots \\ b_{N,N_0} \end{pmatrix} \sum_{i=1}^{N_{bake}} \mu_i + \begin{pmatrix} b_{1,N_0+N_{bake}} \\ b_{2,N_0+N_{bake}} \\ \vdots \\ b_{N,N_{bake}} \end{pmatrix} \sum_{i=N_{bake}+1}^{2N_{bake}} \mu_i + \dots$$

Note that the sums on the right-hand side are known. They are the mass of households with entrepreneurial talent y_1, y_2 and so on and can be computed from the exogenous process for entrepreneurial talent. For this reason, we can compute $C^T\mu$ once and for all and then compute the stationary distribution μ by solving (15), which only requires inversion of $(A - \zeta I)^T$. We can apply the same logic to the KFE for the transition case, given that the economy starts from the stationary talent distribution.

E Further Evidence on Business Returns

First, we estimate the relationship between net worth and average business returns non-parametrically using kernel-weighted local polynomial smoothing with an Epanechnikov kernel. Figure 15 shows the results, which paint a very similar picture as Figure 4 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 4 in the main text as the distribution of returns is right-skewed.

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

$$r^e_{it} = \alpha + \beta \ln(\text{net worth}_{it}) + \gamma X_{it} + u_{it}. \tag{16}$$

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 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

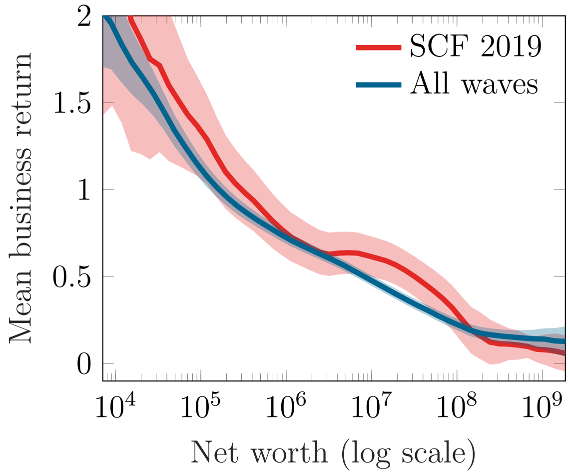


Figure 15: Non-parametrically estimated relationship between business returns and net worth.

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?"

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	0.00	1861.5
Business wealth	17.0	0.3	1.3	8.4	62.9	0.00	1300.6
Observations	7288						

Notes: Net worth and business wealth are measured in millions of 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 7 in the main text). In all other analyses we conduct in this paper, we use the sampling weights provided by the SCF.

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 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.

A potential concern with these results is the following. Because firm value affects our measure of business returns negatively as it enters the denominator, other things equal, households who 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 (16). 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 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%.

F Monetary Policy Shocks and Portfolio Shares

F.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).

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.

F.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 Ottonello and Winberry (2020) and Meier and Reinelt (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. 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 respondents answered the survey in the early months of a given year and therefore potentially before some of that year's shocks materialized, the estimates of $\beta_{p,0}$ have to be interpreted with some caution even when using this particular weighting of monthly shocks.[25]

F.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, 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 E. We then subtract the predicted

25. We also performed our analysis using simply the sum of all shocks occurring in a given year. The results are very similar.

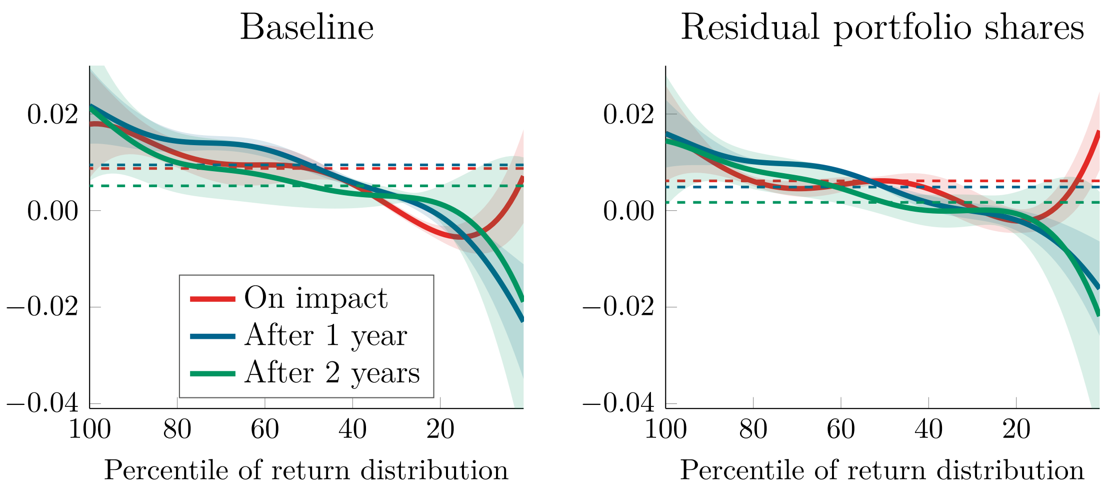


Figure 16: Impulse responses of portfolio shares to Gertler and Karadi (2015) monetary policy shock.
Notes: Change in the logarithm of portfolio shares following a 25 basis points expansionary monetary policy shock by business return percentile. The dashed lines depict the responses at the median of the return distribution. Confidence bands are at the 66% level.

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 (9) in the main text 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.

F.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 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 16 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 covered by the Gertler and Karadi (2015) shocks (and 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.

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