Top Income Inequality and the Business Cycle[†]

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Abstract

This paper studies how the pass-through businesses of top income earners affect the aggregate fluctuations in the U.S. economy. I develop a heterogeneous-household real business cycle model with endogenous labor supply and occupational choice and calibrate the model to capture the observed top income inequality. Compared to the counterfactual economy with the factor-income-driven top income inequality, the economy in the baseline model features the aggregate fluctuations that outperform in explaining the recent changes in the business cycle: 1) lower volatility of aggregate output and 2) stronger negative correlation between labor hour and productivity. Heterogeneous labor demand sensitivities to TFP shocks between pass-through businesses and C-corporations build the core of the aggregate dynamics, and the aggregate employment dynamics display substantial nonlinearity due to this heterogeneity.

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1 Introduction

This paper studies how the changes in the income distribution affected the aggregate fluctuations in the U.S. economy. One of the most notable changes in the income distribution of the U.S. during the recent 30 years is the rising top income inequality. In 1984, the top 1% and 0.1% income group's income share was around 12% and 5%. In 2014, their income share marked around 19% and 9% of total income in the U.S, respectively.[1] Over the same period, the business cycle statistics in the U.S. have dramatically changed. Among the changes, lower aggregate output volatility and the negative correlation between hours and labor productivity are conspicuous.

The main link between the two macroeconomic changes is the rising business income. The rising pass-through businesses have substantially contributed to the rise in the top income inequality. In 1984, 28% of top income earners' income and 25% of top 0.1% income earners' income were business income. 30 years later, 34% of top 1% income earners' income and 37% of top 0.1% income earners' income is from the pass-through businesses. These rising pass-through businesses generate significant changes in aggregate fluctuations because pass-through businesses are more financially constrained than C-corporations. Pass-through businesses are mostly owned by a single owner or a closed group such as a family. Therefore, their equity financing channel is limited by the nature of the closed ownership. This makes the pass-through businesses rely more on debt financing. Then, they tend to display less sensitivity to an aggregate productivity shock in the data. Instead, they sensitively respond to an aggregate financial shock. Using the SOI Integrated Business Data, I document that pass-through businesses display the explained patterns over the business cycle compared to the C-corporations.

To quantify how the rising top income inequality driven by pass-through businesses affects the business cycle, I develop a heterogeneous-household business cycle model that can capture the endogenous pass-through business formation and labor supply decision.

[1] The numbers are from distributional national accounts (DINA) of Piketty et al. (2018).

In the model, the pass-through businesses face a financial constraint (maximal debt level), and the wealth of the owning household determines the constraint level. Then, I calibrate the model without an aggregate uncertainty separately for the 2010s and the early 1980s based on the empirical moments in the income distribution of the corresponding periods. Then, using the disciplined model, I study how the same exogenous fluctuations in aggregate productivity and aggregate financial condition affect the business cycles of the two different periods differently.

I additionally calibrate the model based on the same income distribution moments as in the 1980s, but I target the top income group share at the level of the 2010s. This counterfactual economy enables the quantification of two important channels through which the cross-sectional changes in the income affect the business cycle. The first channel is the top income inequality channel. By comparing the aggregate fluctuations in the 1980s with the counterfactual economy, I quantitatively analyze how the increased top income inequality affects the business cycle without changes in the income sources' composition. The second channel is through the composition of income sources of the top income earners. This channel is analyzed by the comparison between the economy in the 2010s and the counterfactual economy.

According to the calibrated model, top income inequality driven by the pass-through businesses dramatically changes the productivity-driven aggregate fluctuations. First, rising pass-through business dampens the output volatility by aroudn 50% compared to the economy of the 1980s and 24% compared to the counterfactual economy. Pass-through businesses are more financially constrained than C-corporations. Therefore, their binding allocations do not sensitively respond to the aggregate TFP fluctuations.[2] And the greater weight on pass-through businesses leads to a substantial dampening effect in the aggregate output. An increase in top income inequality also contributes to the output

[2]The insensitivity of pass-through businesses are conditional on their operation (intensive-margin). However, the exit and entry of pass-through (extensive-margin) is more volatile than those of C-corporations. This is true in the data and also captured in the model.

volatility change through the wealth effect in the saving behavior. However, this effect is only marginal compared to the channel of the composition of top income earners' income source.

Second, the rising pass-through businesses make the labor productivity and the labor hours more negatively correlated. This is because the pass-through businesses' low output volatility leads to a large invariant component in the aggregate output. This invariant part in the aggregate output generates an intercept effect in the relationship between aggregate output and the labor hours. Thus, the labor productivity and the labor hours become negatively correlated in the economy of the 2010s. I verify this effect through the data decomposition analysis. In the data, the negative correlation between the labor productivity and the labor hours becomes substantially flattened once the intercept effect from the pass-through businesses is removed from the aggregate output. On the other hand, in the economy of the 1980s and counterfactual economy, this effect is only negligible.

Related literature This paper is directly related to three strands of literature. The first is the literature that studies cross-sectional changes in the income and wealth distribution in the economy. Rios-Rull and Kuhn (2016) and Piketty et al. (2018) have documented that the top income inequality has sharply increased in the U.S. Cooper et al. (2016) and Smith et al. (2019) document that the rising top income inequality is dominantly driven by pass-through businesses.[3] Relatedly, Hubmer et al. (2020) argue the rising inequality in wealth has been substantially driven by wealth returns. This paper builds upon these facts investigated already in the literature. Given that the top income inequality has been strongly driven by pass-through businesses, I study how this trend has affected the aggregate fluctuations through a lens of a business cycle model with heterogeneous households. The stationary equilibrium of the model closely follows Quadrini (2000), Cagetti and De Nardi (2006), and Quadrini and Ros-Rull (2015). However, the model includes fluctuations in the aggregate TFP to explore the business cycle implications of the rising top income in-

[3]The literature has not reached a consensus on whether to categorize the business income as a labor income or capital income. Many papers treat the business income as capital income.

equality.

The second strand of related literature is about the recent changes in the business cycle. Stock and Watson (2002) documents that the output volatility has dramatically dampened since the mid-1980s. This change has been referred to as the Great Moderation. According to Gali and Gambetti (2009), the Great Moderation has been accompanied by multidimensional changes in the business cycle. Especially, they document the volatility of hours relative to output has increased, and the correlation between labor productivity and hours has become negative. In the perspective of the Real Business Cycle models, the low correlation between labor productivity and labor hours had been a puzzling observation even before the Great Moderation started. It is because the aggregate productivity fluctuations make these two allocations co-move in the same direction in the RBC models. This has been one of the main rationales for the claim that RBC models cannot capture the realistic business cycle. Regarding this, by considering the extensive-margin labor supply of heterogeneous households, Chang and Kim (2007) capture realistic co-movements of allocations, including labor hours and labor productivity from the aggregate TFP fluctuations. However, the recent negative correlation between these two allocations documented by Gali and Gambetti (2009) is substantially different from the low correlation that is close to zero in the existing models with aggregate TFP fluctuations. My paper introduces both endogenous labor supply and endogenous occupation choice in each households problem. Due to the financially constrained nature of pass-through businesses, realistic aggregate fluctuations happen in the model even when only aggregate TFP fluctuations are considered. On top of that, the quantitative analysis result shows that the entire economy becomes more sensitive to aggregate financial shocks. This gives a possible explanation of why the financial crisis has been more disastrous than the recessions before the crisis.

This paper is also related to the literature that studies how the business cycle affects agents in the economy differently across various dimensions. Castaeda et al. (1998) study how each income-level groups' income share changes over the business cycle. They document that low-income groups' income share is highly pro-cyclical over the business cycle, and the top income groups' income share is acyclical over the business cycle. Kwark and Ma (2021) claims that the top income group's income share is acyclical over the business cycle due to the endogenous change in the number of entrepreneurs in the top income group. Instead of studying how the business cycle affects the cross-section of the households' income, my paper studies the relationship in a reverse direction. In this regard, the spirit of my paper follows Krueger et al. (2016), which studies how cross-sectional variations in the economy affect aggregate fluctuations. Especially, I argue that on top of the changes in the cross-section of the income distribution, the changes in the income source strongly affect the aggregate fluctuations in the economy.

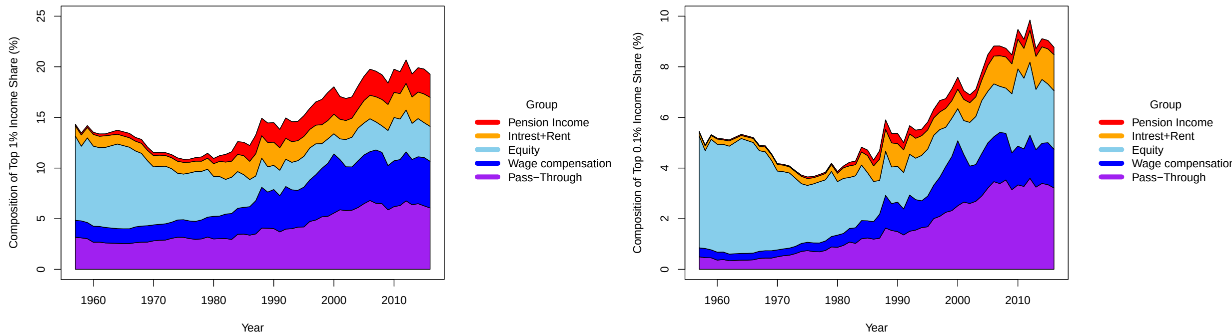
Roadmap Section 2 explores empirical facts. Section 3 develops a business cycle model with heterogeneous households where endogenous labor supply and occupation choice are allowed. In Section 4, I explain calibration used for this model. Using the model under the calibrated parameters, Section 5 quantitatively analyze how the top income earner's pass-through business affect the business cycle. Section 6 concludes. Proofs and other detailed figures and tables are included in the appendices.

2 Empirical facts

2.1 Rising top income inequality and the pass-through businesses

Figure 1 plots the time-series of the top income group's income share and the composition of the income source over the 60 years from 1957 to 2016. Panel (a) is for top 1% income group, and panel (b) is for top 0.1% income group. The data is pre-tax income from Piketty et al. (2018), which I refer to as PSZ hereafter. The top income share has shown fast growth over the last 30 years in the sample. In 1984, the top 1% and 0.1% income group's income share was around 12% and 5%. 30 years later, their income share has become around 19%

and 9% of total income in the U.S, respectively.



(a) Top 1%

(b) Top 0.1%

Figure 1: Rising top income share and business income (from PSZ data)

Table 1 summarizes the annual growth rate of the income share of top income groups for two periods: 1) from 1960 to 1984 and 2) from 1985 to 2016. As reported in the first column, income inequality among the top 10% group has shown a declining trend during the first periods. However, the income inequality among the top 10% group has risen sharply in the following periods, as can be seen from the second column. The growth rate displays a monotonously increasing pattern along with the ranking of the income group. Especially, the top 0.01% income group's growth rate of income share (2.53%) was substantially higher than the other groups.

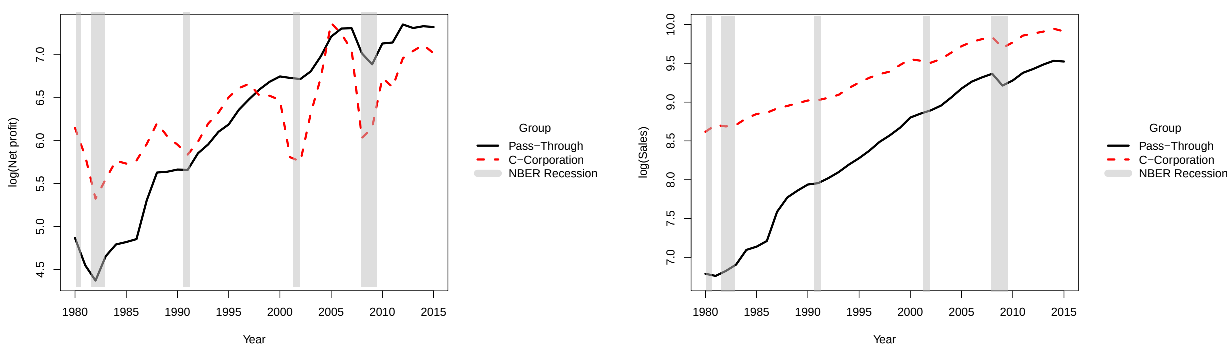
The earlier periods diminishing income inequality was largely contributed by the shrinking labor income inequality, as reported in the fifth column. Top 0.5% income groups' labor income share has declined faster than lower-ranked top income groups' labor income share. In the recent rising income inequality among top income groups, the pass-through business has played a dominant role (the fourth column). The pass-through business growth rate has been greater than any top income group's gross income share growth rate.

The entire pass-through businesses have shown steady growth since 1980. Figure 2 plots the time-series of profit (panel (a)) and sales (panel (b)) for pass-through businesses

	Total		Pass-Through		Labor Income	
	Pre84	Post85	Pre84	Post85	Pre84	Post85
Top 10%	0.02	0.76	1.22	0.94	-0.82	0.39
Top 5%	-0.21	0.95	1.69	1.32	-1.2	0.45
Top 1%	-0.48	1.32	1.6	1.83	-1.36	0.83
Top 0.5%	-0.57	1.49	2.1	1.88	-1.86	0.83
Top 0.1%	-0.45	1.87	2.61	2.37	-1.71	1.03
Top 0.01%	-0.32	2.53	2.74	3.81	-1.43	1.73

Table 1: Income share growth rate by top income group (from PSZ data)

(solid line) and C-corporations (dashed line).[4] In the early 1980s, the total profit of pass-through businesses were only 20% of the entire profit in the U.S. economy. Then, by the end of the 1990s, the pass-through business has earned more profit than the rest of businesses, including C-corporations. In sales, pass-through businesses still take less portion than C-corporations do. However, pass-through businesses' sales growth (6.8%, annual) was dominantly faster than C-corporations (2.4%, annual).



(a) Profit (b) Sales

Figure 2: Rising pass-through business profit and sales

2.2 Changes in the business cycle

In this section, I summarize the facts about the changes in the cyclical behaviors of the aggregate allocations in the U.S. economy. Table 2 reports the major changes in the busi-

[4]The data is from SOI Tax Stats - Integrated Business Data. The profits are "Net Income (less Deficit)" before tax, and the sales are "Business receipts."

ness cycle statistics. The data is the quarterly frequency and obtained from BEA.[5] The first reports the statistics in the period from 1947 Q1 to 1984 Q4.The second column reports the statistics for the period from 1985 Q1 until 2017 Q4. The third and fourth column is model-implied statistics from the standard RBC model and the heterogeneous-agent model with endogenous labor supply (Chang and Kim, 2007). All the variables are logged and HP-filtered with a smoothing parameter at 1600.

It has been vastly documented that the output volatility has been dramatically reduced since the mid-1980s. The first row reports that logged-output volatility has been reduced by almost half in the recent period. In the second row, the correlation between labor productivity and hours is reported. In the earlier period, the correlation is 0.18, which is much lower than standard RBC model's statistics (0.93, the third column). By including the extensive-margin labor supply decision, Chang and Kim (2007) capture the low correlation between labor productivity and hours.

	Pre-1984	Post-1985	RBC	Hetero. Labor supply
sd(Y)	2.59	1.23	1.60	1.28
Corr(Y/H,H)	0.18	-0.46	0.93	0.23
std(Y/H)/std(Y)	0.91	1.12	0.99	0.68
std(H)/std(Y)	0.79	1.20	0.44	0.76

Table 2: Changes in business cycle statistics

Gali and Gambetti (2009) have documented that the correlation between labor productivity and hours has become negative in recent years, as computed in the second column of the second row (-0.46). Also, as in the third and fourth rows in the table, the volatilities of productivity and hours relative to output volatility have significantly increased. These changes are hardly captured in the existing real business cycle models. Gali and Gambetti (2009) argue that the non-real aggregate shock accounts for these changes in the business cycle statistics.

This paper shows that these changes are well-explained by the changes in the productivity-

[5] The data on the labor hour is from Cociuba et al. (2018).

driven aggregate fluctuations induced from the cross-sectional changes in the economy.[6] Especially, the rising pass-through businesses play a key role in capturing the changes in the business cycle. The next section analyzes the cyclical characteristics of the pass-through businesses compared to the C-corporations.

2.3 Cyclical characteristics of pass-through businesses

In this section, I compare the differences in the characteristics between the pass-through businesses and the C-corporations. I use sector-level balance sheet data from SOI Integrated Business Data. The data is the annual frequency, and covers from 1995 until 2016. Table 3 reports the volatilities of logged balance sheet items for C-corporations and pass-through businesses. The volatilities of C-corporations' non-financial allocations and cash holdings are substantially greater than the pass-through businesses'. However, the debt-to-asset ratio of pass-through businesses is around three-times more volatile than the C-corporations' debt-to-asset ratio.

	C-Corp	Pass-Through
σ(log(Investment))	103.54	46.31
σ(log(Profit))	1.42	0.56
σ(log(Value-Added))	0.38	0.27
σ(log(Labor))	0.12	0.12
σ(Debt/Asset)	0.56	1.54
σ(Cash/Asset)	7.86	3.87

Table 3: Volatilities of C-corporations and pass-through businesses

Table 4 reports the correlation coefficients between logged balance sheet items and the logged aggregate output. The balance sheet items of C-corporations and pass-through businesses share similar cyclical patterns except for the debt-to-asset ratio. The debt-to-asset ratio is weakly pro-cyclical for C-corporations, while it is weakly counter-cyclical for pass-through businesses. For both production sectors, investment, profit, value-added,

[6] The exogenous aggregate productivity process is assumed to stay the same.

and labor are all pro-cyclical allocations, and the cash-to-asset ratio is the counter-cyclical allocation.

	C-Corp	Pass-Through
$corr$(log(Investment),log(Y))	0.64	0.80
$corr$(log(Profit),log(Y))	0.57	0.75
$corr$(log(Value-Added),log(Y))	0.68	0.81
$corr$(log(Labor),log(Y))	0.92	0.76
$corr$(Debt/Asset,log(Y))	0.13	-0.07
$corr$(Cash/Asset,log(Y))	-0.34	-0.40

Table 4: Cyclicality of C-corporations and pass-through businesses

Pass-through businesses and C-corporations display significantly different behavior during the recession. And the difference varies by the different recessions. There are two recessions in the sample periods: one is the dot-com bubble crash at 2001, and the other is the financial crisis in 2008. Table 5 reports the balance sheet items' deviation from the trend by production sector and by different recessions.[7] During the dot-com bubble crash, the impact of the recession on the investment and the value-added were much smaller in pass-through businesses than in C-corporations. However, the debt-to-asset ratio responded more strongly in pass-through businesses than C-corporations. However, during the financial crisis, the recession impacted the pass-through businesses' investment stronger than it did the C-corporations' investment. The value-added has responded at a similar rate between the two sectors. The debt-to-asset ratio of pass-through businesses increased by a substantially greater rate than C-corporations' ratio during the financial crisis.

Figure 3 plots the time-series of each sector's balance sheet items. The dashed line represents C-corporations, and the solid line represents pass-through businesses. As reported in Table 3, C-corporations' real allocations such as investment, profit, value-added, and labor expenditure and cash-to-asset ratio are more volatile than pass-through businesses'

[7]The deviation from the trend is normalized by the level of the trend. The trend is obtained from the HP-filter.

	C-Corp (2001)	Pass-Through (2001)	C-Corp (2008)	Pass-Through (2008)
Δlog(Investment)	-377.43	-59.93	-124.08	-150.80
Δlog(Value-Added)	-0.60	-0.37	-0.69	-0.63
Δ(Debt/Asset)	0.46	1.05	1.30	4.18

Table 5: Different responses to two recessions: Dot-com bubble crash vs. Financial crisis

allocations. However, the debt-to-asset ratio is more volatile in pass-through businesses than in C-corporations.

The investment rate (panel (a)) of C-corporations significantly dropped during the dot-com bubble crash. During the same period, the pass-through businesses barely display any decrease in the rate. Profit, value-added, and labor expenditure show similar pro-cyclical patterns over the business cycle, and C-corporations' profit features substantially greater volatility than pass-through businesses. In contrast, the debt-to-asset ratio is more volatile and counter-cyclical in pass-through businesses than in C-corporation.

2.4 Discussion: Financially constrained pass-through businesses

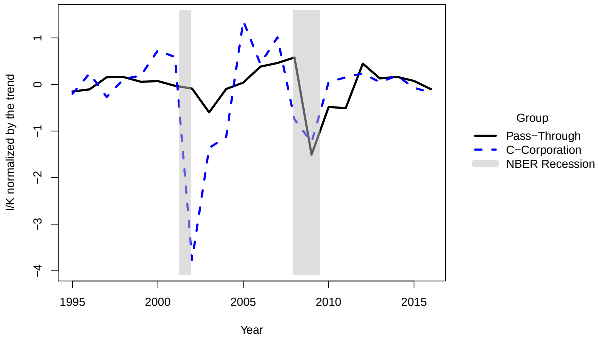
In this section, I summarize the cyclical characteristics of pass-through businesses and discuss the reason for their specific behaviors over the business cycle.

To summarize the empirical facts about the cyclical characteristics of pass-through businesses:

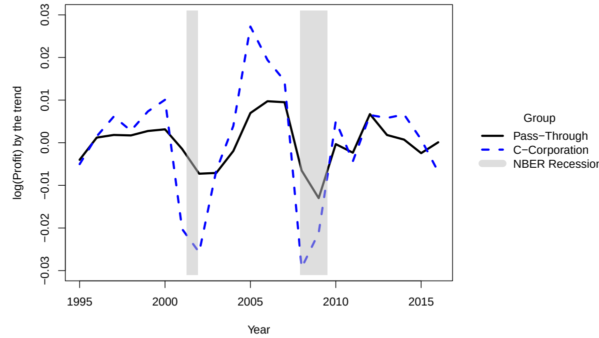
1. Pass-through businesses feature low volatility in real allocations while their debt-to-asset ratio is highly volatile.

2. During the dot-com bubble crash, which is more associated with a negative productivity shock than the financial crisis, pass-through businesses' allocations are not strongly affected.

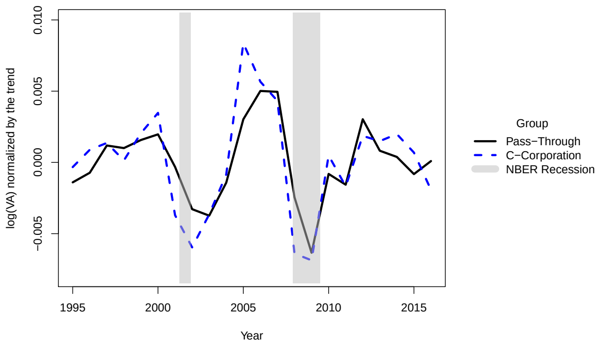
3. During the financial crisis, all the real allocations showed a significant drop in the level, while the debt-to-asset ratio has dramatically increased.



(a) I/K

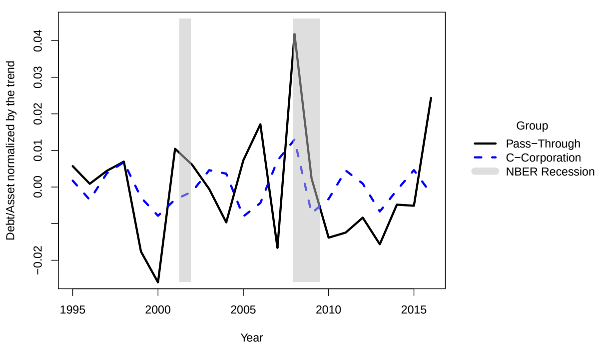


(b) log(Profit)

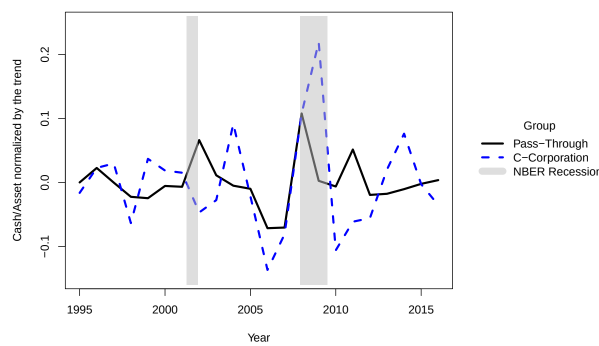


(c) log(Value-Add)

(d) log(Labor Expenditure)



(e) Debt/Asset



(f) Cash/Asset

Figure 3: Time-series of balance sheet items of pass-through businesses and C-corporations

A hypothesis that can coherently explain all the facts above is that pass-through businesses are financially constrained firms. Financially constrained firms cannot flexibly adjust their allocations against the real shocks as their original allocations were at the constrained level. Therefore, their allocations feature less volatility over the aggregate productivity fluctuations. However, the financially-constrained firms' allocations strongly respond to the fluctuations in the financing conditions. Figure 4 plots the deb-to-capital ratio of pass-through businesses and C-corporations.[8] As shown in Figure 3, the debt-to-asset ratio has increased during the recessions, but debt-to-capital has dramatically decreased during the recessions. Given the capital is a collateralizable asset, deterioration in the financing condition would decrease the debt-to-capital ratio. And the rise in the debt-to-asset ratio is driven by a shrink in the non-debt assets in the balance sheet.

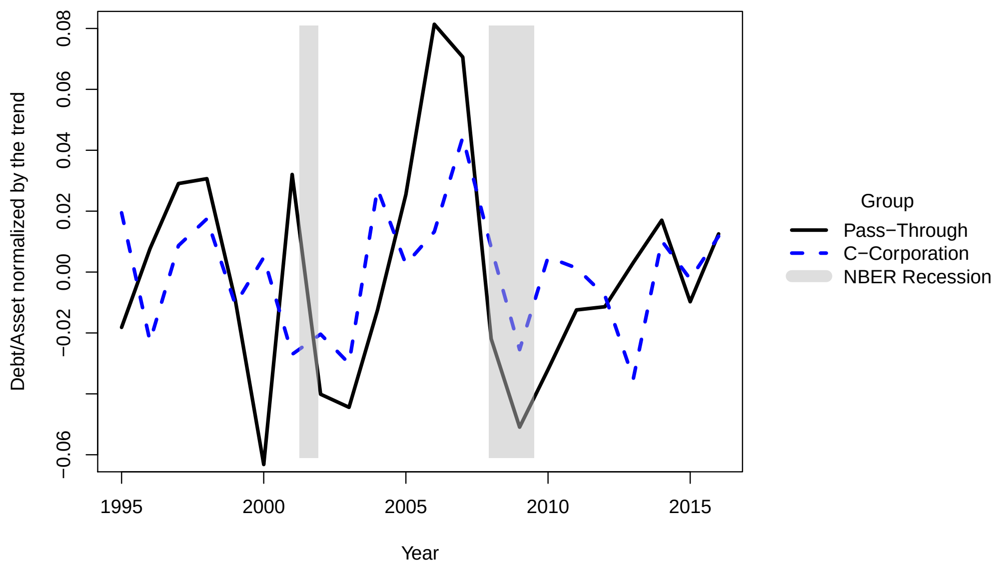


Figure 4: Debt/Capital

Therefore, the hypothesis of financially constrained pass-through businesses is well supported by the observed cyclical patterns in the balance sheet items. Consistent with the evidence, pass-through businesses are severely constrained by the equity financing channel by the nature of closed ownership structure. These firms are extensively owned by a family or a small group of owners, so they cannot easily liquidate their ownerships to external investors. Therefore, their financing naturally tends to rely more on debt financing rather than equity financing. This makes pass-through businesses become debt constrained.

In this paper, I study a business cycle model where heterogeneous households decide labor supply and occupation. In the model, there are two production sectors: pass-through

[8] The capital is depreciable assets reported in the balance sheet. I interpret this capital as a tangible capital that can be collateralized.

businesses and C-corporations. The critical difference between these two sectors is the pass-through businesses are financially constrained. Through the lens of the model, I study how the cross-sectional changes in the economy affect the aggregate fluctuations given the exogenous aggregate shocks fixed.

3 Model

3.1 Household

A measure one of a continuum of ex-ante homogenous households is considered. Time is discrete, and households live forever. Each household consumes, supplies labor, and saves wealth which could be flexibly used for production in the C-corporation sector or in the pass-through business. Household's temporal utility takes the following form:

$$log(c_t) - h_t \xi \quad (h_t \in \{0, \overline{h}\}, \quad \xi \sim_{iid} Unif([0, \overline{\xi}]))$$

where $\overline{h} = 1/3$ is the full-time working hours and ξ is the labor disutility drawn from $U([0, \overline{\xi}])$.

At the beginning of each period, households are given the wealth level a_t, managerial ability z_t, and labor efficiency x_t. Managerial ability and labor efficiency x_t follow Markov processes specified as follows:

$$ln(ln(z_{t+1})) = \rho_z ln(ln(z_t)) + \sigma_z \epsilon_{t+1}, \quad \epsilon_{t+1} \sim \tilde{N}(0,1)$$
$$ln(ln(x_{t+1})) = \rho_x ln(ln(x_t)) + \sigma_x \epsilon_{t+1}, \quad \epsilon_{t+1} \sim \tilde{N}(0,1)$$

where $\tilde{N}(0,1)$ represents a folded standard normal distribution.[9] In the computation, I discretize each process using seven grid points based on the Tauchen Method. In the discretization, the double-logged grid points $\{ln(ln(\zeta_t))\}_{i=1}^{7}$, for $\zeta \in \{x, z\}$ are equally

[9] For a random variable X, the following equivalence holds: $X \sim \tilde{N}(0,1) \iff |X| \sim N(0,1)$.

spaced in the interval of $([0, 5\sigma_\zeta/(1-\rho_\zeta^2)^{1/2}])$.

Given labor efficiency x_t and wage w_t, a household earns labor income $x_t w_t \bar{h}$ if it becomes a worker. If they do not work, they make zero labor income. Lastly, if they choose to become an entrepreneur, they earn a pass-through business profit, which will be specified in the next section.

Owning a pass-through business is assumed to incur the same labor disutility as the full-time worker's labor disutility. Households are subject to borrowing constraint $a_{t+1} \geq 0$ as in the standard incomplete market models (Aiyagari, 1994).

3.1.1 Pass-through business

Household earns a pass-through business profit when it operates a business by combining own managerial ability, capital, and labor. Specifically, the production function takes the following Cobb-Douglas form:

$$z_t A_t \left(k_t^\alpha l_{d,t}^{1-\alpha} \right)^\gamma$$

where z_t is the given managerial ability; A_t is an aggregate TFP; k_t is capital stock; $l_{d,t}$ is labor demand; γ is the parameter that governs the span of control. The span-of-control parameter plays a crucial role in determining the thickness of the tail in the entrepreneurs' income distribution. Aggregate productivity shock A_t follows following AR(1) stochastic process:

$$ln(A_{t+1}) = \rho_A ln(A_t) + \sigma_A \epsilon_{t+1}, \quad \epsilon_{t+1} \sim N(0,1)$$

The stochastic process $\{A_t\}_t^\infty$ is discretized into three states using the Tauchen method. In the discretization, the logged aggregate productivity grid points $\{ln(A)\}_{i=1}^3$ are equally spaced in the interval of $([-\sigma_A/(1-\rho_A^2)^{1/2}, \sigma_A/(1-\rho_A^2)^{1/2}])$.

Following the literature that studies occupation choice of entrepreneurs (Buera and Shin, 2013; Cagetti and De Nardi, 2006; Quadrini, 1999, 2000; Evans and Jovanovic, 1989), I assume entrepreneurs are subject to a financing constraint that limits the size of capital borrowing to a fraction of given wealth a_t. Specifically, I assume $k_t \leq a_t/\lambda$, where $\lambda > 0$ is the parameter that determines the level of financial constraint. Thus, $\lambda \to 0$ implies there is no financial constraint.

Entrepreneur maximizes profit using the production function explained above. Given rental rate r_t and wage w_t, business profit π_t of an entrepreneur with wealth a_t and managerial ability z_t is

$$\pi_t := \pi(a_t, z_t) = \max_{k_t \leq a_t/\lambda, l_{t,d}} z_t A_t \left(k_t^{\alpha} l_{d,t}^{1-\alpha}\right)^{\gamma} - w_t l_{t,d} - (r_t + \delta) k_t$$

3.1.2 Tax function

Following the literature studying progressivity of income taxation (Benabou, 2002; Heathcote et al., 2017; Holter et al., 2019; Luduvice, 2020), I assume the following parametric tax function:

$$\tau(y) = (y - \theta_0 y^{1-\theta_1})/y$$

where $\tau(y)$ is the tax rate for a household with income level y. In the literature, capital income and labor income tax functions are often differently treated to capture the actual tax policy. However, as this paper focuses on the U.S., where the interest income and the labor income are taxed at the same rate, I do not distinguish capital income tax and labor income tax.

Tax revenue at time t is spent out as a uniform lump-sum subsidy T_t.

$$\int \tau(y_t(a, z, x, j)) y_t(a, z, x, j) d\Phi_t(a, z, x, j) = T_t$$

where a is a wealth level; z is an idiosyncratic managerial ability; x is an idiosyncratic labor efficiency; j is an occupation type; Φ_t is the distribution of (a, z, j) at time t.

3.2 C-corporation sector

The C-corporation sector is separately introduced on top of the pass-through business sector. The main difference between the C-corporation and the pass-through business is in the taxation of the profit. A pass-through business is a type of legal entity where the flow of income is regarded as the owner's individual income. From this definition, my model assumes the owner has the claim for the whole operating profit.[10]

In contrast, there are non-pass-through entities, where each of the shareholders holds a claim for only a part of the whole profit. C-corporation takes the dominant portion of this class of business. I model this sector as perfectly competitive and assume all the revenues are expensed out to factor costs. Specifically, the C-corporation sector's production function takes the following Cobb-Douglas form:

$$F(A_t, K_t, L_t) = A_t K_t^{\alpha} L_t^{1-\alpha}$$

where A_t is aggregate TFP as defined above; K_t is capital stock used in the C-corporation sector; L_t is aggregate hours to be spent on the C-corporation sector.

Given Aggregate productivity A_t, wage w_t, and rental rate r_t, the C-corporation sector's problem is described as follows:

$$\max_{K_t, L_t} \; A_t K_t^{\alpha} L_t^{1-\alpha} - w_t L_t - r_t K_t$$

Input factors in the C-corporation sector and input factors in the pass-through business sector are assumed to be perfectly substitutable. Thus, in general equilibrium, the price of input factors is determined at the level where each factor's supply meets the combined factor demand of C-corporation and private businesses.

In the literature, several different assumptions have been imposed on the competitive

[10] Among pass-through businesses, some entities such as partnerships also split the operating profits due to the multiple ownerships. For this, I regard each partner as operating a separate business even though they share the same business.

input market. Quadrini (2000) modeled the intermediation sector, which charges extra cost for households' borrowing.[11] Thus, the public production sector's financing cost is lower than households' financing cost in the model. In Cagetti and De Nardi (2006), all the labor demand is from the non-entrepreneurial production sector. This paper's input market is closely following Kwark and Ma (2021). In the dynamic stochastic general equilibrium, the interplay between C-corporations and pass-through sectors through the factor price channel builds the core dynamics of aggregate allocations and the entry of businesses.

3.3 Occupation choice

Given managerial ability z_t, labor efficiency x_t, wealth a_t, aggregate productivity A_t, wage w_t and rental rate r_t, a household willing to supply labor, decides on the occupation between entrepreneur and labor worker. As both occupations share the same disutility of labor, the occupation choice between two is determined from the income level one can earn using his/her wealth and ability. Therefore, the decision problem could be expressed in the following static form:[12]

$$\max\{\pi_t, w_t x_t \bar{h}\} = \max\{\Big(\max_{k_t \le a_t/\lambda, l_{t,d}} z_t A_t \left(k_t^{\alpha} l_{t,d}^{1-\alpha}\right)^{\gamma} - w_t l_{t,d} - (r_t + \delta) k_t\Big), w_t x_t \bar{h})\}$$

A household becomes an entrepreneur if pass-through business income exceeds the factor income he would get from working and capital rent. I formally state the condition when the household decides to become an entrepreneur.

Proposition 1. *(Occupation choice threshold)*

Given $(z_t, x_t, A_t, w_t, r_t)$, there exists $\bar{a}_t \in [0, \infty]$ such that a household decides to become an en-

[11]In Buera and Shin (2013), the input market is also competitive, but there is no separate public production sector.

[12]The occupation choice is a static problem. However, persistent idiosyncratic ability processes and smooth changes in wealth warrant infrequent occupation change in the model. The theoretical predictions are consistent with the model assuming pre-commitment to the occupation before the contemporaneous idiosyncratic abilities are realized (Bohacek, 2006).

trepreneur if

$$a_t \geq \bar{a}_t = \bar{a}(z_t, x_t; A_t, w_t, r_t)$$

Proof. See Appendix A.1. ■

Proposition 1 states that if a household holds a wealth level beyond a certain threshold, it becomes an entrepreneur. In the proof of the proposition, the key step is to find $\bar{z}_t = \bar{z}(z_t, x_t, A_t, w_t, r_t)$ such that only if $z_t > \bar{z}_t$, the wealth level $\bar{a}$ exists, where the household indifferent between two occupations. Thus, the following equation holds:

$$x_t w_t \bar{h} = (\bar{z}_t A_t)^{\frac{1}{1-\gamma(1-\alpha)}} (1 - \gamma(1-\alpha)) \left(\frac{\gamma(1-\alpha)}{w_t} \right)^{\frac{\gamma(1-\alpha)}{1-\gamma(1-\alpha)}} \left(\frac{\bar{a}}{\lambda} \right)^{\frac{\alpha\gamma}{1-\gamma(1-\alpha)}} - (r_t + \delta) \left(\frac{\bar{a}}{\lambda} \right)$$

This $\bar{z}_t$ has an important implication for entrepreneurship choice because $z_t < \bar{z}_t$ implies the household cannot become an entrepreneur regardless of the wealth level. In other words, there exists a minimum requirement of managerial ability for entrepreneurship that cannot be complemented by large wealth. This is formally stated in the following Corollary 1.

Corollary 1. *(Minimum requirement for managerial ability)*
Given (x_t, A_t, w_t, r_t), there exists $\bar{z}_t = \bar{z}(x_t; A_t, w_t, r_t)$ such that a household with $z_t < \bar{z}_t$ cannot become an entrepreneur at any wealth $a_t > 0$.

Proof. See Appendix A.2. ■

If managerial ability z_t is highly persistent, there exists a diverging saving motivation between households with $z_t < \bar{z}$ and households with $z_t > \bar{z}$. For low z_t households, cumulated wealth can be used for own business only in the far future. Therefore, large-scale saving is not as appealing as it is to high z_t households. From the comparative statics around the stationary equilibrium, I numerically check that higher persistence in z_t intensifies income and wealth inequality in the equilibrium. In other words, persistence in labor efficiency intensifies wealth inequality induced from a different saving motivation based on the heterogeneous wealth return, as in Fagereng et al. (2020).

Also, for $z_t > \overline{z}_t$, $\overline{a}_t$ decreases in z_t. Thus, households with better managerial ability can become an entrepreneur with relatively lower wealth. This theoretical prediction is consistent with the well-known results in the literature (Quadrini, 2009; Bohacek, 2006). Corollary 2 formally states this as follows:

Corollary 2. *(Monotonicity of threshold)*
Given $(z_t, x_t, A_t, w_t, r_t)$, for $z_t > \overline{z}_t$,

$$\tilde{z}_t > z_t \implies \overline{a}(\tilde{z}_t, x_t, A_t, w_t, r_t) < \overline{a}(z_t, x_t, A_t, w_t, r_t)$$

Proof. See Appendix A.3. ∎

3.4 Recursive formulation

I define the following set of value functions:

$$\{V, V_E, V_W, V_N\}$$

where V is an interim value function; V_E is a value function of an entrepreneur; V_W is a value function of a worker; V_N is a value function of a non-worker.[13]

$$V_j(a,z,x;A,\Phi) = \max_{c,a'} \quad log(c) + \beta \mathbb{E} V(a',z',x';A,\Phi')$$

s.t.

$$c + a' = T(A,\Phi) + a + \Big(\pi(a,z;A,\Phi)\mathbb{I}\{j=E\} + w(A,\Phi)x\overline{h}\mathbb{I}\{j=W\} + ar(A,\Phi)\Big)(1-\tau(a,z,x;A,\Phi))$$

$$a' \geq 0, \quad j \in \{E,W,N\}, \quad \Phi' = G_\Phi(\Phi,A),$$

$$log(A') = \rho_A log(A) + \sigma_A \epsilon, \quad log(z') = \rho_z log(z) + \sigma_z \epsilon, \quad x' \sim \pi(x'|x), x' \in [x_0,x_1,x_2]$$

A is the aggregate TFP following AR(1) process; Φ is the distribution of households' individual states. When a household is an entrepreneur $(j = E)$, it earns business profit π; when a household is a worker $(j = W)$, it earns labor income $w(A,\Phi)z\overline{h}$.

The interim value function V is defined as follows:

$$V(a,z;A,\Phi) := \int_0^{\overline{\overline{\xi}}} \max\{\max\{V_E(a,z;A,\Phi), V_W(a,z;A,\Phi)\} - \overline{h}\xi, V_N(a,z;A,\Phi)\} \left(\frac{1}{\overline{\overline{\xi}}}\right) d\xi$$

The occupation choice between entrepreneur and worker has a closed-form characterization, explained in the previous section. For the labor supply decision, choice-specific labor disutility shock smoothens the value function around the indifference point. Thus, V can be interpolated smoothly without concern about the kink point.

3.5 Equilibrium

I assume factor markets are competitive. Thus, both pass-through businesses and C-corporations can use a unit of labor and capital stock at the same prices for each input.

[13]Labor disutility is considered when the interim value function V is defined.

The clearing condition for the capital market is as follows:

$$\underbrace{\int k(a,z;A,\Phi)\mathbb{I}\{a \geq \overline{a}(a,z;A,\Phi)\}d\Phi(a,z,h)}_{\text{Capital demand from pass-through}} + \underbrace{K(A,\Phi)}_{\text{Capital demand from C-corporation}} = \underbrace{\int ad\Phi(a,z,h)}_{\text{Capital supply}}$$

The clearing condition for labor market is as follows:

$$\underbrace{\int l_d(a,z;A,\Phi)\mathbb{I}\{a \geq \overline{a}(a,z;A,\Phi)\}d\Phi(a,z,h)}_{\text{Labor demand from pass-through}} + \underbrace{L(A,\Phi)}_{\text{Labor demand from C-corporation}} = \underbrace{\int z\overline{h}\mathbb{I}\{h=\overline{h}\}\mathbb{I}\{a < \overline{a}(a,z;A,\Phi)\}d\Phi(a,z,h)}_{\text{Labor supply}}$$

Based on the market clearing conditions above, I formally define recursive competitive equilibrium as follows:

Definition 1. *(Recursive Competitive Equilibrium)*

$(g_c, g_a, g_{Occ}, V, V_E, V_W, V_N, \widehat{K}, \widehat{L}, w, r, G_\Phi)$ are recursive competitive equilibrium if

1. $g_c, g_a, g_k, g_l, V, V_E, V_W, V_N : (\mathbb{R}\times\mathbb{R}\times\mathbb{R})\times(\mathbb{R}\times\mathbb{R}^\infty) \to \mathbb{R}$, solve the household's problem. Note that $\mathbb{R}^\infty$ is a set of all distributions of individual state variables (a,z,x).

2. $\widehat{K}, \widehat{L} : \mathbb{R}\times\mathbb{R}^\infty \to \mathbb{R}$ solves C-corporation's problem.

3. Market clearing: $w, r : (\mathbb{R}\times\mathbb{R}^\infty) \to \mathbb{R}$ are set to satisfy

$$\int k(a,z,x;A,\Phi)\mathbb{I}\{a \geq \overline{a}(a,z,x;A,\Phi)\}d\Phi + \widehat{K}(A,\Phi) = \int ad\Phi$$
$$\int l_d(a,z,x;A,\Phi)\mathbb{I}\{a \geq \overline{a}(a,z,x;A,\Phi)\}d\Phi + \widehat{L}(A,\Phi) = \int x\overline{h}\mathbb{I}\{h=\overline{h}\}\mathbb{I}\{a < \overline{a}(a,z,x;A,\Phi)\}d\Phi$$

4. Lump-sum subsidy:

$$\int \Big(\pi(a,z,x;A,\Phi)\mathbb{I}\{j=E\} + w(A,\Phi)x\bar{h}\mathbb{I}\{j=W\} + ar(A,\Phi)\Big)\tau(a,z,x;A,\Phi)d\Phi = T(A,\Phi)$$

5. Consistency condition: the law of motion of Φ is consistent with the household's inter-temporal saving policy g_a

Due to the non-trivial market-clearing condition and a lump-sum subsidy, the standard Krusell and Smith (1998) algorithm is not easily applicable to the recursive competitive equilibrium computation. Also, due to heterogeneous labor demand sensitivity between path-through business and C-corporation, aggregate labor dynamics become highly nonlinear. For this problem, I use the repeated transition method, which I concurrently developed in Lee (2020). In this method, aggregate allocations' expected dynamics, including market-clearing prices, are directly calculated on the simulated path during the iterative computation. Also, the method does not rely on a parametric assumption on the law of motions of aggregate states. Thus, the recursive competitive equilibrium can be computed accurately despite the non-trivial market-clearing conditions and nonlinear dynamics.

4 Calibration

The model is calibrated to match key moments in the data. For basic parameters such as a discount factor β and a depreciation rate δ, I fixed them following the standard level in the literature. Those parameters are reported in Table C.3.

The model has been calibrated separately for the early 1980s and the 2010s periods. Additionally, the model is calibrated for a counterfactual economy where the top income shares are identical to the 2010's economy, while factor incomes drives the top income inequality.[14]

[14]Specifically, the shares of business income out of top income groups' total income are fixed at the level of the 1980s.

I calibrate the model parameters in two steps. The first step is calibrating model parameters to match cross-sectional moments of the stationary equilibrium with the data counterparts. The target moments and corresponding parameters for the 2010s are summarized in Table 6. The other period calibration results are summarized in Table B.1 and Table B.2. The second step is to calibrate the parameters that govern the aggregate TFP process based on the stochastic dynamic general equilibrium outcomes. The TFP process is calibrated using the cross-sectional parameters fitted to the 2010s.

The employment-to-population ratio is targeted at 58.9%, and this moment identifies the labor disutility parameter ξ. The target moment is from the U.S. Bureau of Labor Statistics. The debt-to-asset ratio of pass-through business is from the IRS SOI Integrated Business Data. This moment identifies the parameter of the financial constraint, λ. At the stationary equilibrium, almost all pass-through businesses are financially constrained. However, over the business cycle, this constraint binds occasionally. The target level of the value-add ratio between pass-through businesses and C-corporations is also from IRS SOI Integrated Business Data. This moment identifies the pass-through specific productivity level A.

Parameters	Target Moments	Data	Model	Level
ξ	Employment/Population	58.9	57.5	1.25
λ	Debt/Asset of path-through businesses	45.6	45.6	0.544
A	Value-Add ratio between path-through and C-corp.	75.3	66.5	0.352
γ	Top 10% income share	46.3	62.1	0.945
ρ_z	Top 1% income share	19.0	21.8	0.688
σ_z	Top 0.1% income share	8.9	7.8	0.173
ρ_x	Top 10% business income share	20.9	31	0.902
σ_x	Top 1% business income share	33.2	33.4	0.17
	Top 0.1% business income share	37.1	35.9	

Table 6: Target moments of the economy of the 2010s

The next moments are related to the top income inequality in the economy. Top income 0.1%, 1%, and 10% earners' income shares of total income is targeted at 8.9%, 19.0%, and 46.3% based on the PSZ distributional national accounts (DINA). Also, the business income share is matched for each top income group. The span-of-control parameter γ and the parameters of idiosyncratic labor shock process ρ and σ are jointly identified by matching the target moments. Especially, the span-of-control parameter governs the business income distribution's thickness of the right tail. In the calibrated results, this parameter γ has been dramatically changed between the 1980s and 2010s. This is consistent with the fact that the rising top income inequality has been driven by the thickened tail of business income distribution. However, the counterfactual economy's span-of-control parameter stays the same as in the 1980s.

Then, I calibrate the aggregate TFP process. I first compute the Solow residual of the production sector and then fit the time series into the AR(1) process. As the aggregate production side of the economy is composed of two sectors, Solow residual follows a different process than the model TFP shock process. I calibrate this AR(1) process to have the auto-correlation of 0.95 and the standard deviation of 0.007 following Kydland and Prescott (1982).

The calibrated aggregate TFP process is as follows:

$$TFP_{t+1} = 0.87 * TFP_t + 0.003 * \epsilon_{t+1} \quad \epsilon_{t+1} \sim N(0,1)$$

Under the TFP process above, the Solow residual's autocorrelation becomes 0.949 and the shock volatility is 0.008.

5 Quantitative analysis

In this section, I quantitatively analyze how the model economy behaves over the business cycle.

5.1 Business cycle analysis

Table 7 reports the correlations of aggregate allocations that display significant differences across different cross-sectional calibrations. The first column is baseline outcome; the second is based on the early 1980's calibration; the third is based on the counterfactual calibration; the fourth and the fifth columns are about pre-1984 and post-1985 periods, respectively.

Correlation	Baseline	1980	CF	Pre84	Post85
$Corr(log(Y_{t-1}), log(Y_t))$	0.960	0.986	0.972	0.841	0.886
$Corr(log(Y_t/H_t), log(H_t))$	-0.526	0.224	-0.073	-0.218	-0.526
$Corr(log(1+r_t), log(Y_t))$	0.357	-0.690	-0.247	-0.058	0.164

Table 7: Time-series correlations

Under the same calibrated productivity fluctuations, the aggregate output displays lower autocorrelation than in the early 1980s and in the counterfactual economy. This is consistent with the changes observed in the data. The relationship between the labor hours and labor productivity is well captured. As the business income drives the top income inequality (a change from the early 1980s to the baseline), the correlation between the labor hours and labor productivity becomes substantially negative. However, if the factor income drives the top income inequality (CF), the correlation does not drop as starkly as in the baseline case. The correlation between real gross interest rate and the output increases in recent years, and this is the consistent change with the observed patterns in the data.

Standard Deviations	Baseline	1980	CF	Pre84	Post85
$\sigma(log(Y_t))$	0.010	0.020	0.013	0.020	0.011
$\sigma(log(Y_t/H_t)/\sigma(log(Y_t))$	1.068	0.952	0.998	0.612	0.654

Table 8: Time-series volatilities

Table 8 reports the volatility of allocations that display substantial differences across different cross-sectional calibrations. Each column indicates the same model as Table 7.

Even if the same aggregate productivity process is assumed, the output volatility drops by 50% in the baseline compared to the one in the early 1980s. Also, the counterfactual economy displays a large drop in output volatility. The relative volatility of the labor productivity has increased in the 2010s compared to the 1980s, and this change is well-captured by the cross-sectional variations in the model. However, the level of the relative volatility of labor hours is dramatically different from the observed level. This is possibly due to a lack of non-technological shocks in the model, which might be prevalent in reality.

5.2 Intercept effect and empirical evidence

According to the computation results, the aggregate TFP fluctuation leads to the co-movement of labor hours and labor productivity in the opposite direction. In this section, I analyze why the correlation becomes negative in the economy with top income inequality driven by pass-through businesses.

The aggregate output (GDP), Y^A, can be decomposed into pass-through businesses' output (y) and C-corporations' output (Y). Then, the following equations are immediate from the first order condition of the C-corporation sector:

$$\begin{aligned} Y^A &= y + Y \\ &= y + \frac{w(A, \Phi)}{(1-\alpha)} L \\ &= y + \frac{w(A, \Phi)}{(1-\alpha)} (L^A - l_d) \\ &= \left(y - \frac{w(A, \Phi)}{(1-\alpha)} l_d \right) + \frac{w(A, \Phi)}{(1-\alpha)} L^A \end{aligned}$$

where l_d denotes the labor demand of pass-through businesses and L denotes the labor demand of C-corporations. In the model, labor hour is an affine function of labor demand.

$$h_d = \overline{h} * l_d, \quad H^A = \overline{h} * L^A$$

This leads to the following decomposition:

$$Y^A = \underbrace{\left(y - \frac{w(A,\Phi)}{\bar{h}(1-\alpha)}h_d\right)}_{\text{Intercept effect}} + \underbrace{\frac{w(A,\Phi)}{\bar{h}(1-\alpha)}}_{Slope} H^A$$

Then, the pass-through businesses' output and labor hours generate the intercept effect in the relationship between aggregate output and hours. This generates a negative correlation between labor productivity and hours:

$$\text{Productivity} = \frac{\overbrace{\left(y - \frac{w(A,\Phi)}{\bar{h}(1-\alpha)}h_d\right)}^{\text{Intercept effect}} + \overbrace{\frac{w(A,\Phi)}{\bar{h}(1-\alpha)}}^{\text{Conventional productivity}} H^A}{H^A}$$

The negative relationship is illustrated in Figure 6. If an hour increases, the slope of the ray that passes the origin and the coordinate of hours and output decreases due to the presence of intercept in the graph. And the intercept moves only marginally over the business cycle as the pass-through businesses are financially constrained.

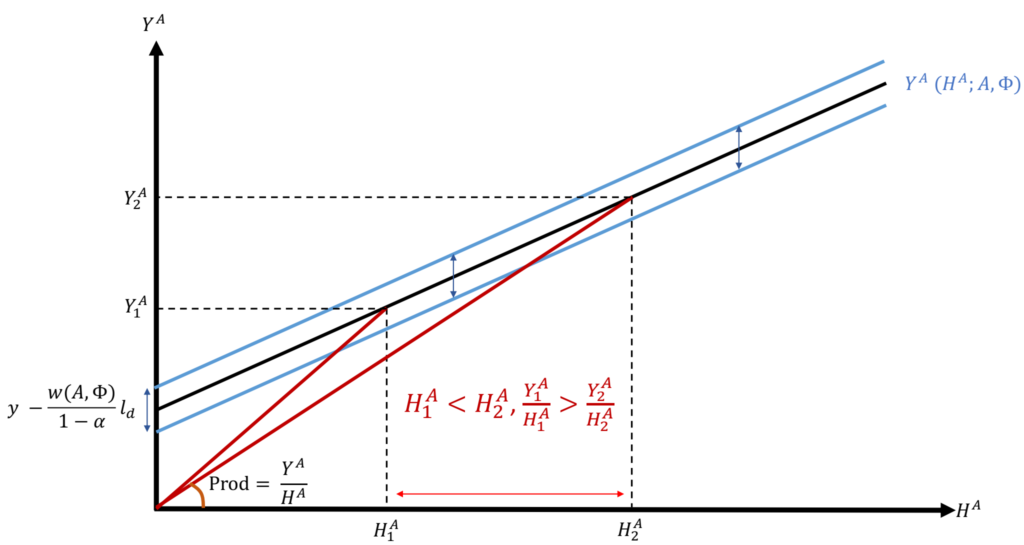
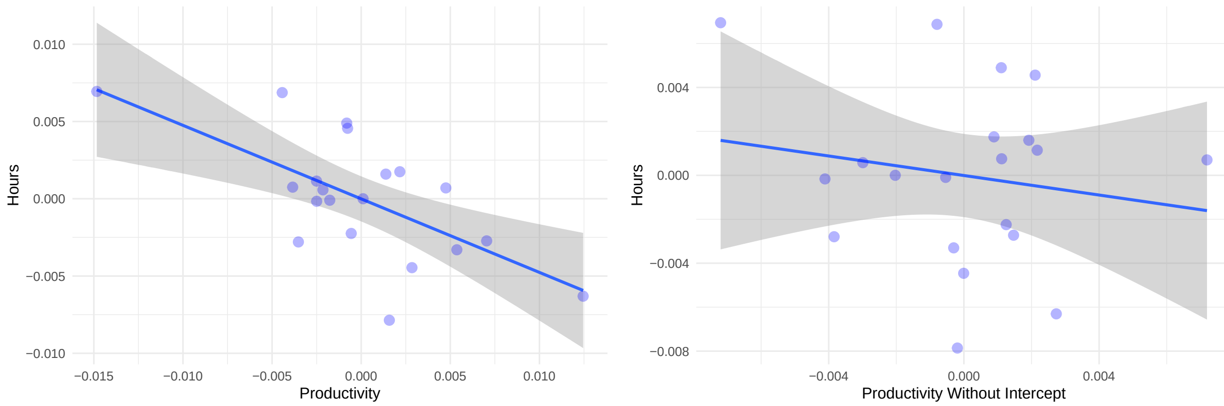


Figure 5: Intercept effect in the relationship between output and hours

The passes-through business allocations y_d and h_d are observable together with the aggregate allocations and the wage. Using the data, I decompose the labor productivity as in the equation above.[15] Figure 6 shows the scatter plot of labor productivity and labor hours with the intercept term (panel (a)) and without the intercept term (panel (b)). With the intercept term, labor hours and productivity display negative correlation over the business cycle. However, when the intercept term is removed, the relationship between labor hours and productivity becomes flat, consistent with the near-zero correlation between the two allocations in the 1980s before the pass-through businesses has risen. This result verifies the presence of the intercept effect from the pass-through businesses.



(a) With Intercept (b) Without intercept

Figure 6: Mitigated negative relationship between productivity and hours after removing the intercept

6 Conclusion

In this paper, I study how top income inequality driven by pass-through business affects the business cycle through a lens of a heterogeneous-household business model with endogenous labor supply and occupation choice.

[15] y_d is computed by the value-add of pass-through businesses, and $w(A, \Phi)h_d$ is directly from the labor expenditure in the balance sheet. Sector-level allocations of pass-through businesses and C-corporations do not exactly add up to the aggregate-level allocations. Therefore, I decomposed aggregate allocations based on the weight between passes-through businesses and C-corporations.

According to the quantitative analysis based on the calibrated model, the top income inequality driven by pass-through business affects the productivity-driven aggregate fluctuations in two ways. First, the output volatility is reduced due to the rising importance of financially constrained pass-through businesses. Second, pass-through businesses generate an intercept effect in the aggregate output and labor hours relationship, leading to a negative correlation between labor productivity and labor hours. Also, when the pass-through businesses drive the top income inequality, the economy becomes more sensitive to a financial shock.

The paper's quantitative theory provides a useful tool to understand how the changes in the cross-section of the households' income sources affect the business cycle. At the same time, it gives an analytical framework to analyze how a fiscal policy affects the business cycle through the changes in the cross-sectional income distribution. For example, fiscal policies that support small businesses, such as the Tax Reform Act of 1986, have boosted pass-through businesses' entry. This change affects aggregate fluctuations due to the financially constrained nature of pass-through businesses. I leave the quantitative analysis on how the fiscal policy changes have affected the business cycle through the cross-sectional changes to future research.

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A Appendix: Proofs for the theoretical results

A.1 Proof for Proposition 1

Proposition 1. *(Occupation choice threshold)*

Given $(z_t, x_t, A_t, w_t, r_t)$, there exists $\bar{a}_t \in [0, \infty]$ such that a household decides to become an entrepreneur if

$$a_t \geq \bar{a}_t = \bar{a}(z_t, x_t; A_t, w_t, r_t)$$

Proof.

As the problem is static, I omit the time subscript for simplicity in the notation.

Suppose the financial constraint is not binding. Then, from the first-order conditions,

$$\begin{aligned}
l^*(z, A, w, r) &= (zA\gamma)^{\frac{1}{1-\gamma}} \left(\frac{\alpha}{r+\delta}\right)^{\frac{\alpha\gamma}{1-\gamma}} \left(\frac{1-\alpha}{w}\right)^{\frac{1-\alpha\gamma}{1-\gamma}} \\
k^*(z, A, w, r) &= (zA\gamma)^{\frac{1}{1-\gamma}} \left(\frac{\alpha}{r+\delta}\right)^{\frac{1-\gamma+\alpha\gamma}{1-\gamma}} \left(\frac{1-\alpha}{w}\right)^{\frac{(1-\alpha)\gamma}{1-\gamma}} \\
\pi^*(z, A, w, r) &= (zA)^{\frac{1}{1-\gamma}} (1-\gamma)\gamma^{\frac{\gamma}{1-\gamma}} \left(\frac{\alpha}{r+\delta}\right)^{\frac{\alpha\gamma}{1-\gamma}} \left(\frac{1-\alpha}{w}\right)^{\frac{(1-\alpha)\gamma}{1-\gamma}}
\end{aligned}$$

There exists $\bar{z} = \bar{z}(x, A, w, r) > 0$ such that if $z < \bar{z}$, even unconditionally optimal profit is less than the labor income $wx\bar{h}$. Thus, it satisfies the following equation:

$$\begin{aligned}
&\pi^*(\bar{z}(x, A, w, r), A, w, r) = wx\bar{h} \\
&\iff (\bar{z}(x, A, w, r)A)^{\frac{1}{1-\gamma}} (1-\gamma)\gamma^{\frac{\gamma}{1-\gamma}} \left(\frac{\alpha}{r+\delta}\right)^{\frac{\alpha\gamma}{1-\gamma}} \left(\frac{1-\alpha}{w}\right)^{\frac{(1-\alpha)\gamma}{1-\gamma}} = wx\bar{h} \\
&\iff \bar{z}(x, A, w, r)A = \frac{1}{A}\left(\frac{wx\bar{h}}{\mathcal{M}(w, r)}\right)^{1-\gamma} \\
&\text{where } \mathcal{M}(w, r) := (1-\gamma)\gamma^{\frac{\gamma}{1-\gamma}} \left(\frac{\alpha}{r+\delta}\right)^{\frac{\alpha\gamma}{1-\gamma}} \left(\frac{1-\alpha}{w}\right)^{\frac{(1-\alpha)\gamma}{1-\gamma}}
\end{aligned}$$

Therefore, if $z < \bar{z}$, there is no finite wealth level that makes a household choose to become an entrepreneur. Thus,

$$\text{If } z < \bar{z}, \quad a(z, x, A, w, r) = \infty$$

Now suppose $z \geq \bar{z}$.

When the financial constraint is binding ($k^c = \frac{a}{\lambda}$), the constrained optima of the labor demand, l^c, and the profit, π^c, are as follows from the first-order conditions:

$$l^c(a, z, A, w, r) = \left(\frac{zA(1-\alpha)\gamma}{w}\right)^{\frac{1}{1-(1-\alpha)\gamma}} \left(\frac{a}{\lambda}\right)^{\frac{\alpha\gamma}{1-(1-\alpha)\gamma}}$$

$$\pi^c(a, z, A, w, r) = (zA)^{\frac{1}{1-(1-\alpha)\gamma}}(1-(1-\alpha)\gamma)\gamma^{\frac{(1-\alpha)\gamma}{1-(1-\alpha)\gamma}} \left(\frac{1-\alpha}{w}\right)^{\frac{(1-\alpha)\gamma}{1-(1-\alpha)\gamma}} \left(\frac{a}{\lambda}\right)^{\frac{\alpha\gamma(1-\alpha)\gamma}{1-(1-\alpha)\gamma}} - (r+\delta)\left(\frac{a}{\lambda}\right)$$

Now we need to show there exists $\bar{a} \geq 0$ such that

$$a \geq \bar{a}(z, x, A, w, r) \iff \pi^c(\bar{a}(z, x, A, w, r), z, A, w, r) \geq wx\bar{h}$$

I prove this in the following steps:

i)

$$\pi^c(0, z, A, w, r) = 0 < wx\bar{h}$$
$$\pi^c(k^*(z, A, w, r), z, A, w, r) \geq wx\bar{h}$$

The second inequality is from the fact that π^c is maximized at k^* and $z \geq \bar{z}$. $z \geq \bar{z}$ implies there exists a wealth level where becoming an entrepreneur is better than working as a labor, and k^* is the optimal level of capital.

If the second weak inequality's equality holds, then define $\bar{a} = k^*$. Otherwise, there exists at least one wealth level $\overline{a} \geq 0$ that satisfies

$$\pi^c(\overline{a}, z, A, w, r) = wx\overline{h}$$

due to intermediate value theorem. In other words, the left hand side is a continuous function of a.

ii) Now, we will prove $\pi^c(a, z, A, w, r)$ is strictly increasing in a over the interval $[0, k^*]$. This step is to prove that $\overline{a}$ found above is the unique crossing point between LHS and RHS. From the characterization of π^c above, the following is immdediate:

$$\frac{\partial \pi^c(a, z, A, w, r)}{\partial a}\Big|_{a \downarrow 0} = \infty$$
$$\frac{\partial \pi^c(a, z, A, w, r)}{\partial a}\Big|_{a = k^*} = 0$$
$$\frac{\partial^2 \pi^c(a, z, A, w, r)}{\partial a^2} < 0, \quad a \in (0, \infty)$$

The first fact is from the Inada condition of Cobb-Douglas function. Therefore, $\frac{\partial \pi^c(a,z,A,w,r)}{\partial a}$ strictly decreases in a until a reaches k^*. Therefore, $\frac{\partial \pi^c(a,z,A,w,r)}{\partial a} > 0$ for $a \in (0, k^*)$. Therefore, there exists the unique $\overline{a} = \overline{a}(z, x, A, w, r)$ such that

$$\pi^c(\overline{a}(z, x, A, w, r), z, A, w, r) = wx\overline{h}$$

iii) π^c is strictly increasing in $a \in (0, k^*)$. Therefore,

$$a \geq \overline{a}(z, x, A, w, r) \iff \pi^c(\overline{a}(z, x, A, w, r), z, A, w, r) \geq wx\overline{h}$$

■

A.2 Proof for Corollary 1

Corollary 1. *(Minimum requirement for managerial ability)*

Given (x_t, A_t, w_t, r_t)*, there exists* $\bar{z}_t = \bar{z}(x_t; A_t, w_t, r_t)$ *such that a household with* $z_t < \bar{z}_t$ *cannot become an entrepreneur at any wealth* $a_t > 0$*.*

Proof.

From the proof of Proposition 1,

$$\pi^*(\bar{z}(x, A, w, r), A, w, r) = wx\bar{h}$$

$$\iff (\bar{z}(x, A, w, r)A)^{\frac{1}{1-\gamma}}(1-\gamma)\gamma^{\frac{\gamma}{1-\gamma}}\left(\frac{\alpha}{r+\delta}\right)^{\frac{\alpha\gamma}{1-\gamma}}\left(\frac{1-\alpha}{w}\right)^{\frac{(1-\alpha)\gamma}{1-\gamma}} = wx\bar{h}$$

$$\iff \bar{z}(x, A, w, r)A = \frac{1}{A}\left(\frac{wx\bar{h}}{\mathcal{M}(w, r)}\right)^{1-\gamma}$$

$$\text{where } \mathcal{M}(w, r) := (1-\gamma)\gamma^{\frac{\gamma}{1-\gamma}}\left(\frac{\alpha}{r+\delta}\right)^{\frac{\alpha\gamma}{1-\gamma}}\left(\frac{1-\alpha}{w}\right)^{\frac{(1-\alpha)\gamma}{1-\gamma}}$$

Therefore, if $z < \bar{z}$, the unconditionally optimal profit is less than the labor income ($\pi^* < wx\bar{h}$). Thus, a household with $z < \bar{z}$ would not choose to become an entrepreneur at any wealth $a > 0$. ■

A.3 Proof for Corollary 2

Corollary 2. *(Monotonicity of threshold)*

Given $(z_t, x_t, A_t, w_t, r_t)$*, for* $z_t > \bar{z}_t$*,*

$$\tilde{z}_t > z_t \implies \bar{a}(\tilde{z}_t, x_t, A_t, w_t, r_t) < \bar{a}(z_t, x_t, A_t, w_t, r_t)$$

Proof.

From the proof of Proposition 1, $\overline{a} = \overline{a}(z, x, A, w, r)$ satisfies

$$\pi^c(\overline{a}(z, x, A, w, r), z, A, w, r) =$$
$$(zA)^{\frac{1}{1-(1-\alpha)\gamma}}(1-(1-\alpha)\gamma)\gamma^{\frac{(1-\alpha)\gamma}{1-(1-\alpha)\gamma}}\left(\frac{1-\alpha}{w}\right)^{\frac{(1-\alpha)\gamma}{1-(1-\alpha)\gamma}}\left(\frac{\overline{a}}{\lambda}\right)^{\frac{\alpha\gamma(1-\alpha)\gamma}{1-(1-\alpha)\gamma}} - (r+\delta)\left(\frac{\overline{a}}{\lambda}\right) = wx\overline{h}$$

Suppose $\tilde{z} > z$. Define $\tilde{a} := \overline{a}(\tilde{z}, x, A, w, r)$.

It can be easily checked that π strictly increasing in z. Thus,

$$\pi^c(\overline{a}, \tilde{z}, A, w, r) > \pi^c(\overline{a}, z, A, w, r)$$

And the following equation holds:

$$\pi^c(\tilde{a}, \tilde{z}, A, w, r) = \pi^c(\overline{a}, z, A, w, r) = wx\overline{h}$$

Suppose $\tilde{a} \geq \overline{a}$. Then, as π^c is strictly increasing in a,

$$\pi^c(\tilde{a}, \tilde{z}, A, w, r) > \pi^c(\overline{a}, \tilde{z}, A, w, r) > \pi^c(\overline{a}, z, A, w, r)$$

which contradicts $\pi^c(\tilde{a}, \tilde{z}, A, w, r) = \pi^c(\overline{a}, z, A, w, r)$.

Therefore,

$$\tilde{z} > z \implies \tilde{a} = \overline{a}(\tilde{z}, x, A, w, r) < \overline{a}(z, x, A, w, r)$$

■

B Appendix: Other Calibration

Parameters	Target Moments	Data	Model	Level
ξ	Employment/Population	58.7	57.4	1.27
λ	Debt/Asset of path-through businesses	83.2	82.8	0.13
A	Value-Add ratio between path-through and C-corp.	11.0	9.1	0.259
γ	Top 10% income share	35.1	49.4	0.9
ρ_z	Top 1% income share	11.4	15.2	0.706
σ_z	Top 0.1% income share	4.3	4.7	0.162
ρ_x	Top 10% business income share	18.5	8.9	0.701
σ_x	Top 1% business income share	27.1	26.2	0.294
	Top 0.1% business income share	24.1	31.7	

Table B.1: Fixed parameters: Early 1980s

Parameters	Target Moments	Data	Model	Level
ξ	Employment/Population	58.9	59	1.16
λ	Debt/Asset of path-through businesses	45.6	84.3	0.13
A	Value-Add ratio between path-through and C-corp.	75.3	11.7	0.265
γ	Top 10% income share	46.3	51.1	0.9
ρ_z	Top 1% income share	19.0	16.6	0.701
σ_z	Top 0.1% income share	8.9	5.5	0.162
ρ_x	Top 10% business income share	20.9	8.5	0.728
σ_x	Top 1% business income share	33.2	23.5	0.289
	Top 0.1% business income share	37.1	26.3	

Table B.2: Fixed parameters: Counterfactual

C Appendix: Fixed parameters

Parameters	Description	Value
α	Capital share	0.36
β	Discount factor	0.985
δ	Depreciation rate	0.02
$\overline{h}$	Labor hour	0.33
θ_0	Tax level parameter	0.94
θ_1	Tax progressivity parameter	0.15

Table C.3: Fixed parameters