Nurturing Young Public Firms over Real Business Cycles

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You can find the latest version of the paper on my personal website.

Abstract

In this paper I develop a theory of financial intermediation in a general equilibrium environment, to study the interactions between households, financial intermediation, and entrepreneurs over real business cycles. In my model the financial intermediary, who resembles real-life private equity (PE) groups and investment bankers, works as a nurturer of young public firms. It performs screening and sorting on entrepreneurs, then allocates resources to them, borrowed from the households. However, the effort intensity in screening decreases when the financial intermediary is flooded by resources, so do the average quality of financial services and the commission rate, which predict the countercyclicality of those variables. This countercyclicality of efficiency in the financial sector promises a dampening effect on economic volatility. I use the U.S. initial public offering (IPO) data, as well as selected PE data to document that the commission rate is indeed countercyclical. Its correlation with the cyclical component of total output is around -0.21. I calibrate the model to the U.S. financial market and conduct several counterfactual exercises. I find that a 20% drop in the financial intermediary's effort cost dampens the total output volatility by 0.24% and the household consumption volatility by 0.53%. While a binding commission rate cap amplifies the volatility by 0.36% and 0.54% respectively.

JEL: E22, E32, E44, G24.
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1 Introduction

The study of financial intermediation is an on-going research topic existed for decades. Real-life examples of financial intermediaries, such as commercial banks, investment banks and all kinds of investment funds, for better or for worse, have proven their importance in our economy. It is essential for us to understand the roles of those financial intermediaries, their impact on the economy, and what are the consequences if we put certain regulations on them.

In this paper, I want to study financial intermediation, especially its interactions with households and entrepreneurs over real business cycles. I focus on financial intermediaries who help direct funds from households to startup firms, by performing screening on entrepreneurs of unknown abilities. Once funded, those firms have a chance to grow large, get public, and have substantial influences on the aggregate economy. I call those financial intermediaries "nurturers of young public firms".

I want to answer two major questions. Firstly, what are the cyclical patterns of those financial intermediaries' behaviors? By behaviors I mean investment size, effort in screening entrepreneurs, efficiency in utilizing resources, etc. To answer that, I build a dynamic stochastic general equilibrium model in which the financial intermediary reacts to productivity shocks in the real sector and the financial sector promptly. Secondly, how do the cyclical behaviors reshape business cycles? In order to answer this question, I take the theory to the data, and use counterfactual exercises to evaluate the impact of financial intermediation on economic volatility and welfare.

To establish connections between my theory and the existing literature, it is necessary to briefly go through the literature of financial intermediation. Based on the natural attribute, some early researchers, such as Gurley and Shaw (1962), Benston and Smith (1976), tended to think of financial intermediaries as providing money transaction services. This is indeed a major task for commercial banks since they started to exist. But the relative importance of this task has been decreasing, even within commercial banks.

Others thought of financial intermediation as a remedy for the asymmetric information problems between investors and firms in the economy. Financial intermediaries generate social surplus by helping better allocate resources. As noted by Raymond W. Goldsmith (1969, p.400), financial intermediation "improves economic performance to the extent that it facilitates the migration of funds to the best users, i.e., to the place in the economic system where the funds will earn the highest social return".

Based on the frictions a financial intermediary solves when interacting with its counterparties, it can be performing ex-ante screening or ex-post monitoring. In the early work of Leland-Pyle (1976), Diamond (1984), financial intermediaries were modeled as solving ex-ante asymmetric information problem between lenders and borrowers. The limitation is that they were partial equilibrium analysis, so it is unlikely to say anything about the impact of financial intermediation on the economic fundamentals.

In Baron (1982), Ritter (2003), financial intermediaries were modeled to solve the asymmetric information problem faced by the firms about the financial market conditions. Firms are willing to pursue intermediaries with a good reputation, even if it means that they need to pay more. However, in those works the household side is often missing. It either appears exogenous as a stochastic demand for goods, or a stochastic supply of capital. In this paper, I'm following the classical ex-ante screening approach, but in an innovative way. I have an explicitly modeled household part, who interacts with the financial intermediary actively on different markets.

Under a grand scope, I want to develop a theory in which the following three parties and their interactions are explicitly modeled: Households who want to invest their savings but face uncertainty about the investment opportunities. Firms who need funds but face uncertainty about the fundamentals in the aggregate financial market. Financial intermediaries who interact with both parties and solve their asymmetric information problems. Financial intermediation would have a real impact on economic performance, that is, long-term growth or short-term fluctuations. An important question one could ask is whether financial intermediation dampens the economic volatility by mitigating productivity shocks, that is, a dampening effect, or the opposite, an amplification effect.

Following Galetovic (1996), Blackbur and Hung (1998), I model financial intermediation as a channel through which the economy funds firm innovations. In my model, entrepreneurs need resources to industrialize their ideas. Once funded, they have a chance to create a new variety of intermediate goods, which promises a flow of future profits. However, entrepreneurs are heterogeneous in abilities, which determine the probability of successfully creating a new variety of intermediate goods. The financial intermediary borrows resources from the households, performs screening on the entrepreneurs, and allocates resources to them.

Screening is costly to the financial intermediary, so does borrowing resources from the households. To maximize profit, the financial intermediary reacts optimally to the economic fundamentals. What I care most about are the effort intensity, measured by effort in screening per unit of investment, and the efficiency of intermediation, measure by firms created per unit of investment. If those variables are countercyclical, we could expect a dampening effect to appear, which is rarely achievable in general equilibrium models regarding financial intermediation. The intuition is that in bad (good) times, the financial intermediary is more (less) efficient in producing new varieties of intermediate goods, which mitigates the effect of productivity shocks.

It's worth mentioning that the amplification effect is somewhat prevailing in the literature studying financial stability. Diamond and Dybvig (1983) talked about the fragility of the banking system, and how it causes panic to spread during a crisis. Bernanke and Gertler (1989), Kiyotaki and Moore (1997) discussed how the worsening of credit conditions could amplify negative productivity shocks originated in the real sector. Veldkamp and Wolfers (2007) talked about coordination in information acquisition, and how it reshapes business cycles. They emphasized on how an overly-grown financial sector could undermine economic stability. My paper, on the other hand, is one of the few who try to shed light on the bright side. I want to examine whether a properly regulated financial intermediation market, who responds to business cycles promptly, can improve economic stability by reducing volatility of the fundamentals. Another difference between their works and mine is that their works are mainly on crisis, while mine is on regular business cycles.

In the theory part of the paper, I have established conditions under which there is a negative correlation between the effort intensity and the investment size, especially when the financial intermediary is flooded by resources. As a matter of fact, there exists an endogenously determined threshold value, above which the financial intermediary's optimal effort level would stop reacting to changes in its investment size. As in most macroeconomic models, investment size is procyclical, this negative correlation promises a countercyclical effort intensity, as well as the intermediation efficiency. I'm able to get these interesting qualitative results under a fairly clear and general setup. Another advantage of the model is that it also predicts a countercyclical commission rate of the financial intermediary, which is something I can test empirically.

To provide empirical evidence for my theory, I have done some works regarding the cyclicality of the commission rate. I use the U.S. IPO market as a representative market, to construct measures for investment size and commission rate. I choose the IPO market because, in a typical IPO process, the issuer, the investment banker(s), the buyer(s) in the primary market, and the final buyer(s) in the secondary market consist of a perfect example of the theory I have developed.

The data source is SDC: Global New Issues Database. I calculate the quarterly average commission rate of investment bankers in IPO, from 1976Q1-2016Q4. Together with economic fundamentals calculated from the U.S. economy, I have documented two main empirical facts: 1. The quarterly number and total value of IPOs are procyclical; 2. The quarterly average commission rate is countercyclical, both consistent with the models prediction. As a robustness check, I run regressions of the commission rate on economic fundamentals controlling for size, on both the quarterly average level and the individual stock level. The countercyclicality of the commission rate remains significant.

[add the empirical result with PE data when done]

I calibrate the model to the U.S. economy. I follow the standard real business cycle literature when calibrating parameters of the real sector and household part in the model. I calibrate parameters of the financial sector to match moments and correlations found in my empirical study of the U.S. IPO market, using the simulated method of moments. I'm not using the correlation between the cyclical output and commission rate as a target in calibration, because I want to use it to check the wellness of fit. With the calibrated model, I have simulated the cyclical output, consumption, investment size, as well as the commission rate. The correlation between the simulated cyclical output and commission rate fits the correlation found in the data pretty well: -0.15 in simulation comparing to -0.21 in the data.

I conduct several counterfactual exercises. The first exercise is to raise (reduce) the financial intermediary's cost of effort by 20%. The output volatility[1] increases (decreases) by 0.14% (0.24%). The household consumption volatility increases (decreases) by 0.32% (0.53%). The households' welfare loss (gain) is 2.22% (3.84%).[2]

In the second counterfactual exercise, I put a binding[3] commission rate cap on the financial intermediary. The output volatility increases by 0.36%. The household consumption volatility increases by 0.53%. The households' welfare loss is 5.62%. I argue that a better way to achieve a lower average commission rate is to reduce the market power of the financial intermediary. In the third exercise I shut down the financial sector completely. The output volatility increases by 0.74%. The household consumption volatility increases by 1.55%. The households' welfare loss is 7.03%.

[1] Measured by the standard deviation to mean ratio, aka the coefficient of variation.

[2] Around 90% is due to changes in the steady-state level of consumption.

[3] Much lower than the steady-state commission rate.

The results from the counterfactual exercises demonstrate that in my model, financial intermediation could generate a dampening effect strong enough to overcome the typical amplification effect, and stabilize the economy.

To summarize, this paper contributes to the literature in at least three ways. In the theory part, the paper has provided an innovative mechanism under which the effort intensity and the intermediation efficiency of the financial intermediary are countercyclical, which promise a dampening effect of financial intermediation on productivity shocks. In the empirical part, the paper is one of the first to document the countercyclicality of the commission rate of financial intermediaries. In the quantitative part, the paper has demonstrated that the dampening effect is strong under a calibration which fits the data moments pretty well. The paper also provides normative suggestions on how to achieve a low average commission rate.

The rest of the paper is structured as follows. Section 2 lays out the model and provides qualitative results. Section 3 describes the data and empirical evidence. Section 4 discusses calibration and quantitative results. Section 5 Concludes.

2 Model

To better understand the role of financial intermediation as a nurturer of young public firms, and the interactions between households, financial intermediary, and entrepreneurs over real business cycles in a stochastic general equilibrium environment, I develop an infinite horizon discrete time model with homogeneous households, a financial intermediary, heterogeneous entrepreneurs, and aggregate uncertainty.

The households face standard consumption-saving trade-off. What's new is that they also face an investment portfolio choice when they save. They can invest to replenish the capital stock, change their holdings of firms shares, or lend to the financial intermediary in an intratemporal borrowing and lending market. The financial intermediary uses resources borrowed from households to fund entrepreneurs. A funded entrepreneur can industrialize his idea to create a new variety of intermediate goods, as well as a monopolistic firm producing it, which promises a future flow of profits.

The success rate of industrialization depends on the entrepreneur's ability. But an individual entrepreneur's ability is unknown to all unless it is verified. The financial intermediary performs screening and sorting on entrepreneurs, allocates resources, and sells the successfully created intermediate goods firms to the households on a competitive market of firms shares. The surplus is split into return for the households and commission fee for the financial intermediary, either in a competitive market or through Nash bargaining, which are equivalent if allowing a taxation on the financial intermediary's profit. The aggregate uncertainty is introduced through exogenous productivity shocks.

2.1 Final Goods

Time is discrete and infinite $t = 0, 1, 2, \cdots$. At each period, final goods are produced competitively using intermediate goods and the following generalized constant elasticity of substitution production function

$$Y_t = \Big(A_t\Big)^{\tau - \frac{1}{\sigma-1}} \left(\int_0^{A_t} y_t(\omega)^{\frac{\sigma-1}{\sigma}} d\omega \right)^{\frac{\sigma}{\sigma-1}}. \tag{1}$$

An intermediate good is indexed by its variety ω, while A_t is the measure of available intermediate goods at period t. τ governs the *love of variety* as in Dixit and Stiglitz (1977), Benassy (1996). σ governs the elasticity of substitution, and is assumed to be larger than 1. At each time t, the final goods are used as the numeraire.

Denote $p_t(\omega)$ as the price of intermediate good ω at period t, I can derive its demand function

$$p_t(\omega) = A_t^{\frac{\tau(\sigma-1)-1}{\sigma}} \left(\frac{Y_t}{y_t} \right)^{\frac{1}{\sigma}}. \tag{2}$$

2.2 Intermediate Goods

Each variety of intermediate goods is produced by a single monopolistic firm. The production of intermediate goods uses capital as the sole input and according to a concave production function

$$y_t(\omega) = \exp(\varepsilon_t) k_t^{\alpha}(\omega).$$

ε_t represents the contemporary aggregate productivity shock in the intermediate goods sector, whose law of motion will be specified in the household part later. $\alpha \in (0, 1)$ governs concavity and the capital share. An intermediate goods firm takes the demand function (2) and the capital interest rate r_t as given, and solves

$$\pi_t(\omega) = \max_{y_t(\omega)} \; p_t(\omega) y_t(\omega) - (r_t + \delta)\big[\exp(-\varepsilon_t) y_t(\omega)\big]^{\frac{1}{\alpha}},$$

where $\delta \in (0,1)$ is the capital depreciation rate.

Solving the profit maximization problem above, I have the optimal quantity

$$y_t^*(\omega) = \left(\frac{\sigma - 1}{\sigma} \frac{\exp(\varepsilon_t/\alpha)}{r_t + \delta} \alpha A_t^{\frac{\tau(\sigma-1)-1}{\sigma}} Y_t^{\frac{1}{\sigma}} \right)^{\frac{\alpha\sigma}{\alpha+\sigma-\alpha\sigma}}. \tag{3}$$

And most importantly, the intermediate goods firm earns a profit $\pi_t(\omega) > 0$. I assume that the profit is paid to shareholders of the firm each period as dividend. One can see that intermediate goods firms are symmetric in this economy.

Each intermediate goods firm acts as a monopolist because it owns the patent to produce a certain variety of intermediate goods. New varieties of intermediate goods are created by entrepreneurs. Once funded, an entrepreneur has the chance to industrialize his idea to create a new variety of intermediate goods, as well as a firm producing it. The newly created firm is temporarily owned by the financial intermediary who funds the entrepreneur, and is sold to the households right after on a competitive firm's shares market, while the entrepreneur gets a one-time payment for successfully industrializing his idea. One can see a direct and intuitive connection between the process described above, and the real-life initial public offering (IPO), private equity (PE), or investment banking. I will be more specific about this point in the latter entrepreneur and financial intermediary part.

After finishing the current period production, all incumbent intermediate goods firms face an exogenous death rate of $\eta \in (0,1)$. I define Q_t as the post-dividend expected present value of an intermediate goods firm that survives period t. It is written as[4]

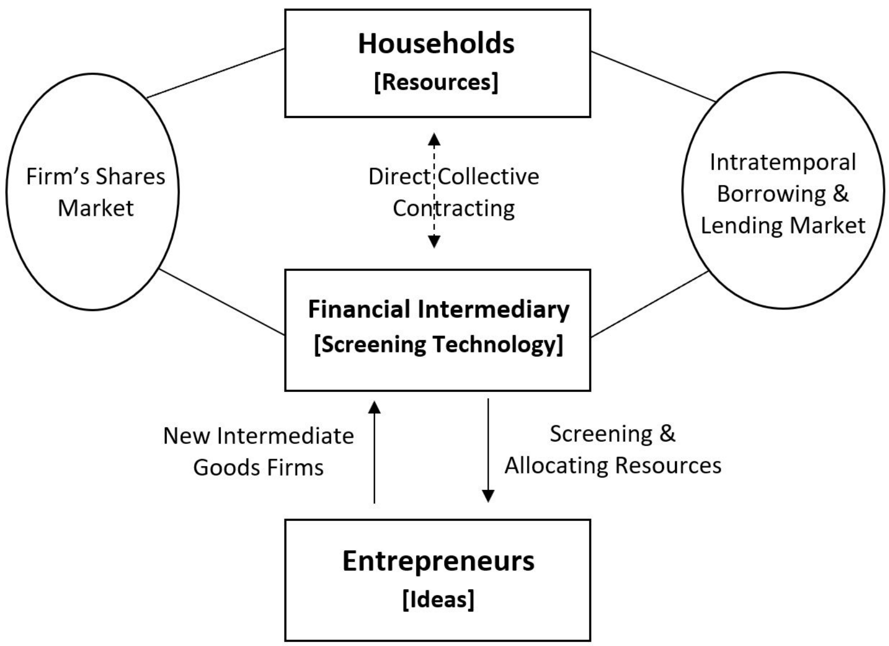
$$\begin{aligned} Q_t \equiv & \quad \mathbb{E}_t \left[\sum_{\tau=1}^{\infty} (1-\eta)^{\tau-1} \frac{\beta^\tau u'(c_{t+\tau})}{u'(c_t)} \pi_{t+\tau} \right] \\ = & \quad \mathbb{E}_t \left[\frac{\beta u'(c_{t+1})}{u'(c_t)} \Big(\pi_{t+1} + (1-\eta) Q_{t+1} \Big) \right], \end{aligned} \tag{4}$$

which is derived in equation (20). Q_t is a crucial endogenous variable for the financial market, because it is essentially the price of a newly created intermediate goods firm in period t. Since in this economy a new intermediate goods firm is equivalent to a new variety of intermediate goods, I will use these two terms interchangeably later.

[4]The formula shall be derived from the individual household's optimization problem. Since households in my model are homogeneous, I use c_t to denote the per capita consumption at time t, which is common across households in equilibrium.

Now that I have described the goods production sector, it's time to look at the three main parties of agents in this economy. They are, entrepreneurs who have ideas and need resources. Households who have resources and try to find users promising highest returns. The financial intermediary who has access to a screening technology and generate social surplus by helping better allocate resources to entrepreneurs. Here is a graph illustrating interactions between the three parties in the economy.

Graph 2.1: Interactions Between Agents in the Economy



2.3 Entrepreneurs

The economy is populated by a large[5] continuum of one-period lived, risk-neutral entrepreneurs, each of whom is endowed with an idea that might be industrialized, into a new variety of intermediate goods. Entrepreneurs require $\xi > 0$ amount of final goods to industrialize the idea, but are heterogeneous in their abilities $z \in [0, 1]$. That is, an entrepreneur with ability z, upon spending ξ units of final goods, will have a probability z to successfully create a new variety of intermediate goods. To be consistent with the pricing formula (4), I assume that an intermediate goods firm created in period t survives the current period for sure, and starts

[5]By large I mean it has the same measure as the real line $\mathbb{R}$, so the pool of entrepreneurs (ideas) will never be exhausted by the financial intermediary. This point will be more clear in the financial intermediary part.

to produce in period $t+1$. I will drop the subscript t from now on, because it is irrelevant in the rest of this section.

The measure of entrepreneurs is assumed to be large, comparing to the measure of households, which is normalized to 1. I make this assumption because I believe ideas are plenty, but the resources needed to make them realize are always constrained. The cost of industrialization ξ should be thought of as an amount of resources no individual household could afford alone. Also notice that ξ is exogenous and fixed across entrepreneurs, while in the data we do observe entrepreneurs of different scope asking for a different amount of investment, and end up creating firms of various sizes. This assumption is a solid one in my model though, for two reasons. First is that in the model intermediate goods firms are symmetric, so there is no room for "dream bigger, ask for more". Second is that I can bring in heterogeneous demand for investment even under this framework, by allowing one entrepreneur having multiple ideas. However, it complicates the model while bringing about little new intuition.

The creation of a new intermediate goods firm is publicly observable, but I assume that a particular entrepreneur's ability z is unknown to all, including the entrepreneur himself, unless verified by a financial intermediary. This serves as the main friction in the economy. The reservation utility of the entrepreneurs is assumed to be time-invariant and normalized to 0.[6] The population distribution of entrepreneur abilities is characterized by a cumulative distribution function $H(z)$, which is common knowledge. Denote the population mean of abilities as $\mathbb{E}(z) \equiv \int_0^1 z \, dH(z)$.

Assumption 1. *The distribution of abilities $H(z)$ has a density $h(z)$ which satisfies*

$$h(z) > 0, \ \forall z \in [0, 1].$$

This assumption is to make sure that $H(z)$ has a well-defined inverse function on $[0, 1]$, and both $H(z)$ and its inverse function are differentiable.

[6] I can assume this because the entrepreneurs are not aware of their own abilities, so they are ex-ante homogeneous.

2.4 Financial Intermediary

The economy has one[7] risk-neutral financial intermediary, who is assumed to be impatient.[8] The financial intermediary solves a static profit maximization problem every period. It has access to a screening technology.[9] Once screened by the financial intermediary, an entrepreneur's ability z becomes known to the financial intermediary and the entrepreneur himself, but not to any other agents in the economy.

Every period, upon putting in effort level $e \in \mathbb{R}_+$, the financial intermediary screens a measure e of entrepreneurs, randomly drawn from the population. The population of entrepreneurs (ideas) is assumed to be so large that it can not be exhausted by the financial intermediary.[10] Screening gives the financial intermediary a pool of verified entrepreneurs, among whom the exact mapping between individuals and abilities are known by the financial intermediary. Sorting is thus automatic within the pool of verified entrepreneurs. Those who are left out consist of a pool of unverified entrepreneurs, among whom the mapping between individuals and abilities remains unknown. Since e is a positive measure and drawing is random, both the pool of verified entrepreneurs and the pool of unverified ones should inherit the original population distribution of abilities $H(z)$. This turns out to be an important property later in determining the optimal allocation rule of resources.

The screening effort is observed only by the financial intermediary, and incurs a private cost $F(e)$ in unit of final goods.

Assumption 2. *The cost function $F(e)$ has the following properties:*

(I) $F(0) = 0,\ F'(0) = 0$*;*

(II) $F'(e) > 0,\ F''(e) > 0,\ \forall e \in \mathbb{R}_{++}$*;*

(III) $F(e)$ may have a small fixed cost component.

Basically, I want the cost of screening effort to be strictly increasing and strictly convex. The requirement for a very small fixed cost component is to guarantee an interior solution of the optimal effort level. It is important to point out that screening is costly, but randomly

[7]One could think of it as a unity of all financial intermediaries, or the financial sector.

[8]This assumption is to rule out intratemporal decisions of the financial intermediary such as hoarding. One can think of the financial intermediary as being replaced by a new one every period.

[9]I'm not assuming that an individual household can not operate such technology. But because of the economy of scale, the financial intermediary could operate the technology more efficiently.

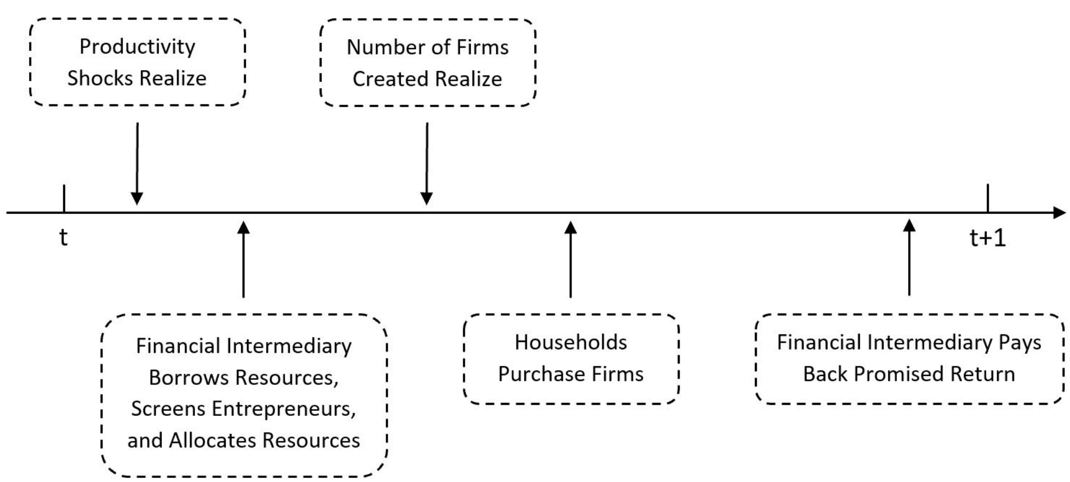
[10]Basically, the financial intermediary can draw entrepreneurs with replacement.

drawing entrepreneurs from the population is not. The financial intermediary can draw cost-freely as many entrepreneurs as it wants at any time, without screening them.

As stated in the intermediate goods production part, a variety of intermediate goods defines a monopolistic firm. And the expected present value of a new intermediate goods firm is Q. Remember that in this economy the entrepreneurs and the financial intermediary are assumed to be one-period lived and myopic respectively, they don't own any resources or hold any firm's shares at the beginning of a period. The households are the ultimate provider of resources, and the only candidate for purchasing and holding intermediate goods firms. Every period, after observing the productivity shocks, the financial intermediary borrows X amount of final goods from the households, with a promised intratemporal return rate R, in an intratemporal borrowing and lending market that is either competitive or centralized. It then performs screening, and allocates resources to entrepreneurs. After the new intermediate goods firms are created, the financial intermediary sells the ownership to the households on a competitive firm's shares market, and pay the promised return to the households. The commission fee would be the difference between the value of the firms and the return promised to the households. The rest of the section is to characterize how the amount of intermediated investment X and the screening effort level e are determined.

The result that the intermediate goods firms are owned by various households is consistent with what's happening in reality. In the U.S., the shareholders of public firms are on average highly diversified, comparing to startup firms before going public. I would think of those public firms as intermediate goods firms in the model, while those small private firms as ideas, solely owned by one or a few persons.

Graph 2.2: A Timeline of Events for the Financial Intermediary



Let's start with the simplest piece of the puzzle, the entrepreneurs. The entrepreneurs are rather passive in this economy. They can be paid at different times, but nevertheless getting paid the reservation utility. To see this, think of an entrepreneur before being screened. He is definitely getting paid the reservation utility because there are abundant of them in the economy. Now think of an entrepreneur who has already been screened by the financial intermediary, his outside option doesn't change because this piece of information about his ability is not shared with any third party. The financial intermediary only needs to pay the entrepreneurs enough to induce participation.

This setup of entrepreneurs allows for interesting extensions though. For example, imagine that there exists a moral hazard problem between the financial intermediary and the entrepreneurs. After receiving ξ amount of final goods from the financial intermediary, an entrepreneur could use it to industrialize idea as described before, or to divert it into personal consumption, which yields him a utility of $\phi\xi$. The financial intermediary observes the outcome of industrialization, but can't directly control the action taken by the entrepreneur. An optimal contract thus arises between the financial intermediary and a funded entrepreneur whose ability is z: If the industrialization is successful, the entrepreneur gets paid $\dfrac{\phi\xi}{z}$, otherwise 0. The contract would make it incentive compatible for the entrepreneurs to use the resources for industrialization. This simple extension is equivalent to a setup in which the ex-ante reservation utility is $\phi\xi$ rather than 0.

The real interesting interaction arises between the households and the financial intermediary. At each period, there is an intratemporal borrowing and lending market, decentralized or centralized, between the households and the financial intermediary. The financial intermediary makes three decisions, first it decides how much resources X to borrow from the households. Then it decides how much effort e to put in screening entrepreneurs. At last, it decides how to allocate resources to the entrepreneurs, verified or unverified. In funding entrepreneurs, I assume the following concave technology

Assumption 3. *With X unit of resources, the financial intermediary can fund a maximum number of $N = exp(\chi)\dfrac{n(X)}{\xi}$ entrepreneurs, where χ represents the aggregate productivity shock in the financial sector. $n(X)$ is continuously differentiable and satisfies*

(I) $0 \leq n(X) \leq X$, $\forall X \in [1, \infty)$;

(II) $n'(X) > 0$, $n''(X) < 0$, $\forall X \in \mathbb{R}_{++}$.

The assumption implies that there is efficiency loss as the size of intermediated investment X gets large. This efficiency loss can be rationalized by a higher cost of bookkeeping, or as a reduced representation of a higher cost of monitoring entrepreneurs. The introduction of an aggregate productivity shock χ in the financial sector is for quantitative purposes. One can also regard it as a reduced representation of variations in the cost of industrialization: $\exp(-\chi)\xi$. Given χ, there is a one-to-one mapping between how much resources to be allocated X and how many entrepreneurs to be funded N. Since the financial intermediary makes decisions after observing the productivity shocks, later on I will treat the decision of X and the decision of N as equivalent.

Now that I have described the technologies available for the financial intermediary, it's time to specify the market structure in the financial sector, that is, the firm's shares market and the intratemporal borrowing and lending market. I assume that the firm's shares market is competitive. The financial intermediary is a price-taker even though it supplies a positive measure of firms.[11] As for the intratemporal borrowing and lending market, I assume that it also operates competitively each period, for the financial intermediary to borrow resources from the households. The return rate R serves as the price. Since it is an intratemporal market with no other frictions, the households' supply of resources is perfectly elastic.[12]

The financial intermediary takes the price of firms Q and the return rate to households R as given, and maximizes its profit (consumption) after observing the productivity shocks. I denote the number of firms created as S, and give the maximization problem

$$\underset{X,e,\text{allocation rule}}{max} \; Q \bullet S(X, e, \text{allocation rule}) - F(e) - R \bullet X. \tag{5}$$

To solve the problem, I break it into three steps, one for each decision the financial intermediary has to make. Let's start with the resource allocation rule. For any given size of entrepreneurs to be funded N[13] and screening effort level e, the financial intermediary would want to choose an allocation rule that maximizes the number of new firms created. The space of all feasible allocation rules is huge, and can not be summarized by a finite number of variables. Fortunately, each allocation rule maps into a distribution of abilities of those entrepreneurs who are funded, which I can use to calculate the number of firms created.

[11]This assumption is to rule out strategic behaviors of the financial intermediary when supplying newly created firms to the market.

[12]That is, when the return rate is less (more) than 1, an individual household supplies resources of quantity 0 (up to its income). When the return rate is 1, the household is indifferent between how much resources to supply.

[13]I'm solving the optimal allocation rule for any given N instead of X because firstly they are equivalent, secondly using N gives me neat analytical results.

Moreover, I'm going to argue that the optimal allocation rule is essentially a threshold rule. The financial intermediary first utilize the pool of verified entrepreneurs. It should start with verified entrepreneurs of the highest ability, then gradually go down as those are exhausted, until reaching the natural lower bound $\mathbb{E}(z)$. If there were any resources left, the financial intermediary should tend to the pool of unverified entrepreneurs, who promises an average success rate of $\mathbb{E}(z)$. That is, entrepreneurs whose ability is verified to be worse than the population mean shall never get funded, otherwise, they get funded in a descending order.

It is the $\frac{e}{N}$ ratio that determines who gets funded, which is also a measure of "effort intensity". To understand why the population mean $\mathbb{E}(z)$ serves as the natural lower bound, remember when screening entrepreneurs, the drawing is random. So both the verified pool and the unverified pool inherit the original population distribution of abilities $H(z)$. To summarize the allocation rule I have just described in a more rigorous way, I give the following definition.

Definition 1. *(The Descending Allocation Rule)*

Suppose the $\frac{e}{N}$ *ratio is large enough such that* $e\big[1 - H\big(\mathbb{E}(z)\big)\big] \geq N$, *only the pool of verified entrepreneurs is in use. Verified entrepreneurs whose ability is above threshold* $\underline{z}$ *shall be funded, where* $\underline{z}$ *solves*

$$e\big[1 - H(\underline{z})\big] = N. \tag{6}$$

Otherwise, both the pools of verified and unverified entrepreneurs are in use. Verified entrepreneurs whose ability is above $\mathbb{E}(z)$ *shall be funded, the remaining resources go to unverified, randomly drawn entrepreneurs.*

With the explanation above, the proof of why this descending allocation rule is the optimal allocate rule which maximizes the number of firms created for any given N and e should be straightforward. The threshold $\underline{z}$ is a decreasing function of N and an increasing function of e, which has a closed-form representation

$$\underline{z}(N, e) = H^{-1}\bigg(1 - \frac{N}{e}\bigg).$$

The optimal allocation rule is essentially a threshold rule among the verified entrepreneurs, but with the twist that some resources might also go to unverified entrepreneurs. The effective ability threshold is given by

$$\hat{z}(N, e) = max\Big\{\underline{z}(N, e), \mathbb{E}(z)\Big\}.$$

Following the descending allocation rule described in Definition 1, I can derive the number of firms created as

$$S(N,e) = \begin{cases} e\displaystyle\int_{\mathbb{E}(z)}^{1} \big(z-\mathbb{E}(z)\big)h(z)dz + N\bullet\mathbb{E}(z), & \dfrac{e}{N} < \dfrac{1}{1-H\big(\mathbb{E}(z)\big)} \\ e\displaystyle\int_{\underline{z}(N,e)}^{1} zh(z)dz, & \dfrac{e}{N} \geq \dfrac{1}{1-H\big(\mathbb{E}(z)\big)} \end{cases}, \tag{7}$$

which I call the "success function". Detailed derivation can be found in Appendix 2.1.

Several things to notice about $S(N,e)$. It is continuous in N and e but demonstrates two regions. When e is small, the verified entrepreneurs whose ability is above the population mean won't be enough to exhaust all the resources. Part of the resources will be allocated to randomly drawn, unverified entrepreneurs. In that case, the benefit of a higher effort level is on the extensive margin, that is, a reallocation of resources from unverified entrepreneurs back to the verified and qualified ones. This benefit shall be constant and large. However, when e is large enough, verified and qualified entrepreneurs will exhaust all the funds. So the benefit is on the intensive margin, namely from an improved reallocation among those verified and qualified entrepreneurs. And this benefit shall be diminishing. To be more specific about the shape of $S(N,e)$, I give the following proposition.

Proposition 1. *Under Assumption 1, the success function $S(N,e)$ is continuously differentiable, strictly increasing, and concave on $\mathbb{R}^2_+$. Moreover, it is linear when $\frac{e}{N} < \frac{1}{1-H(\mathbb{E}(z))}$ and strictly concave when $\frac{e}{N} > \frac{1}{1-H(\mathbb{E}(z))}$.*[14]

The fact that $S(N,e)$ is strictly increasing in e makes it a perfect signal of the otherwise hidden effort level. The curvature of $S(N,e)$ implies a constant marginal benefit of effort when the screening effort e is below cutoff $\frac{N}{1-H(\mathbb{E}(z))}$, and a decreasing marginal benefit of effort when above. In addition, a change of N moves the effort cutoff around, but has different effects on the marginal benefit of effort below or above the cutoff. To summarize rigorously, I given the following corollary.

[14] Being linear means $S\big(\varphi N_1 + (1-\varphi)N_2, \varphi e_1 + (1-\varphi)e_2\big) = \varphi S(N_1,e_1) + (1-\varphi)S(N_2,e_2)$, $\forall \varphi \in (0,1)$. Being strictly concave means $S\big(\varphi N_1 + (1-\varphi)N_2, \varphi e_1 + (1-\varphi)e_2\big) > \varphi S(N_1,e_1) + (1-\varphi)S(N_2,e_2)$, $\forall \varphi \in (0,1)$.

Corollary 2. *The marginal benefit of effort, measured by $Q \cdot S_e(N, e)$, has the following properties:*

(I) The marginal benefit of effort is bounded above by $Q \int_{\mathbb{E}(z)}^{1} \big(z - \mathbb{E}(z)\big)h(z)dz$, and is weakly decreasing in e. To be more specific, it is constantly at the upper bound when e is below the cutoff, and is strictly decreasing once e exceeds the cutoff;

(II) An increase of N does not affect the marginal benefit of effort on its constant region, but enlarges the constant region. It shifts up the marginal benefit of effort on the decreasing region;

(III) An increase of Q shifts up the marginal benefit of effort proportionally everywhere.

The proof of Proposition 1 and Corollary 2 is given in Appendix 2.2. These properties about the marginal benefit of effort, $Q \cdot S_e(N, e)$, are crucial when determining the optimal effort level. They also carry the intuition of why e does not respond to N if it is too large.

So far I have introduced the optimal rule of allocating resources to the entrepreneurs for any given funded entrepreneurs' size N, or equivalently, intermediated investment size X, and effort level e. I have also established the properties of the success function $S(N, e)$, which measures the number of firms created under the optimal allocation rule. I give the following profit maximization problem, which is updated from the original profit maximization problem (5) using the optimal allocation rule.

$$\max_{X,e} Q \cdot S(N, e) - F(e) - R \cdot X \tag{5'}$$

s.t.

$$N = \exp(\chi)\frac{n(X)}{\xi}.$$

In Proposition 1, I have established the concavity of the $S(N, e)$ function. The objective function in maximization problem (5') is strictly concave as long as $F(e)$ is strictly convex and $n(X)$ is strictly concave, which are guaranteed by Assumption 2 and 3 respectively. The maximization problem yields a unique solution of the optimal borrowing size X^* and the optimal effort level e^*, which are characterized by the following first order conditions

$$Q \cdot S_N(N, e) \cdot \exp(\chi)\frac{n'(X)}{\xi} = R. \tag{8}$$

$$Q \cdot S_e(N, e) = F'(e), \tag{9}$$

I have the optimal size of entrepreneurs to be funded as $N^* = \exp(\chi)\dfrac{n(X^*)}{\xi}$. The number of firms created is

$$S^* = S(N^*, e^*). \tag{10}$$

The commission fee for the financial intermediary is

$$M^* = Q \bullet S^* - R \bullet X^*, \tag{11}$$

while the profit (consumption) of the financial intermediary is

$$M^* - F(e^*).$$

As has been discussed in the introduction part of the paper, what I care most about in the financial market are three ratios. First is the effort-to-size ratio, measured either by $\dfrac{e^*}{X^*}$ or by $\dfrac{e^*}{N^*}$. I refer to it as the "effort intensity", and this ratio measures how hard the financial intermediary works per unit of investment. Second is the success-to-size ratio, measured either by $\dfrac{S^*}{X^*}$ or by $\dfrac{S^*}{N^*}$. I refer to it as the "average ability of funded entrepreneurs", or as the "average quality of financial services". This ratio measures the financial intermediary's efficiency in turning input (final goods) into output (intermediate goods firms). The last one is the commission-to-size ratio, measured by $\dfrac{M^*}{X^*}$. And it is the "commission rate" which we could observe from the data.

From the first order conditions (8) and (9), one can see the optimal borrowing size and effort level are functions of Q and χ. Using simple comparative statics, one can check that $X^*(Q, \chi)$ is strictly increasing in Q and χ, while $e^*(Q, \chi)$ is strictly increasing in Q but not necessarily in χ. Generally speaking, X^* and e^* are moved around by Q and χ across the cycles. With different values of Q and realizations of χ, there could be two scenarios. One is the optimal X^* and e^* are such that

$$\frac{e^*}{N^*} < \frac{1}{1 - H\big(\mathbb{E}(z)\big)}. \tag{12}$$

I'm particularly interested in this scenario because it lays the foundation of achieving a negative correlation between the optimal effort intensity $\dfrac{e^*}{X^*}$ and the borrowing size X^*. More specifically, I'm going to show that if in equilibrium (12) is met, $e^*(Q, \chi) = e^*(Q)$.

To take a closer look at the scenario above, I further break the maximization problem (5') into two steps. First, the financial intermediary chooses the effort level e while taking N as given, that is

$$\max_e \; Q \bullet S(N, e) - F(e),$$

which yields an effort policy function $e(N)$. Then it chooses the optimal borrowing size X^*, taking into consideration of its effect on $e(N)$, that is

$$\max_X Q \bullet S\big(N, e(N)\big) - F\big(e(N)\big) - R \bullet X \tag{5''}$$

s.t.

$$N = \exp(\chi)\frac{n(X)}{\xi}.$$

The eventual optimal effort level would be $e^* = e(N^*)$.

The properties of the $e(N)$ function are crucial for understanding why when X (or equivalently N) is large, the effort intensity necessarily drops. I give the following theorem

Theorem 3. *Under Assumption 1 and 2, for any given Q, there exists a threshold value $\bar{N}(Q)$ such that $e(N)$ intersects with $\dfrac{N}{1-H\big(\mathbb{E}(z)\big)}$ at $\bar{N}(Q)$ and*

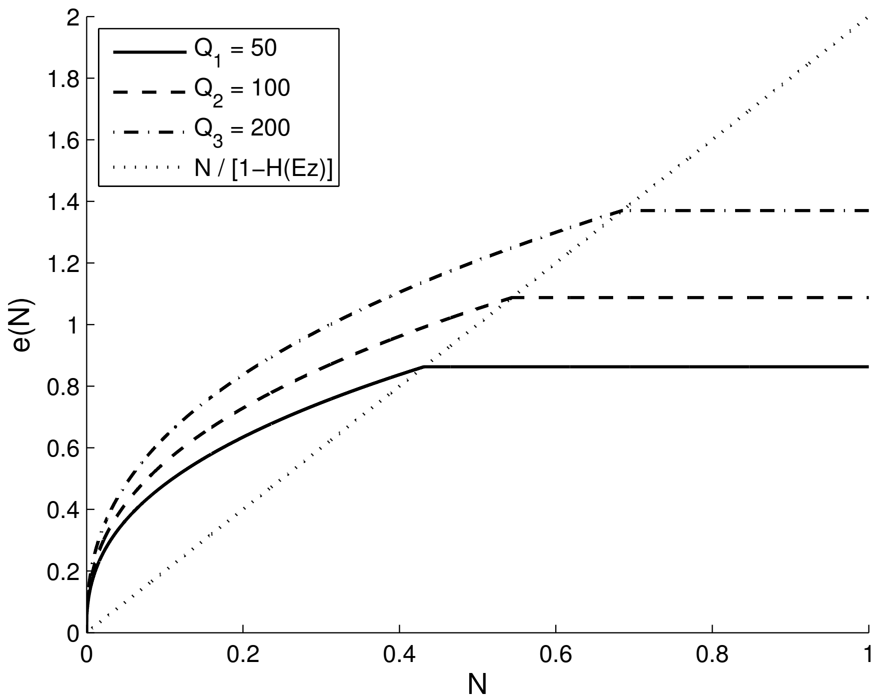
When $N < \bar{N}(Q)$, $e(N)$ is strictly increasing in N and $e(N) > \dfrac{N}{1-H\big(\mathbb{E}(z)\big)}$;

When $N > \bar{N}(Q)$, $e(N)$ is constant in N and $e(N) < \dfrac{N}{1-H\big(\mathbb{E}(z)\big)}$.

In addition, the threshold value $\bar{N}(Q)$ is strictly increasing in Q.

The proof of Theorem 3 is given in Appendix 2.3. Much to be said about this effort policy function. The function is continuous but with kink points at $N = \bar{N}(Q)$. And it is bounded above when N increases, which indicates that a larger size of investment won't necessarily induce a higher level of screening effort. As a matter of fact, when flooded by resources, the financial intermediary will only screen a fixed amount of entrepreneurs, and allocate the excessive resources to randomly drawn, unverified ones. More specifically, When $N < \bar{N}(Q)$, the intersection of $Q \bullet S_e(N, e)$ and $F'(e)$ must yield an effort level e above the effort cutoff, so only the verified entrepreneurs are funded. But once $N > \bar{N}(Q)$, the intersection will yield an e below the effort cutoff, and part of the resources goes to unverified entrepreneurs. I call $\big(\bar{N}(Q), \infty\big)$ the "excess region" of N, and the corresponding $\big(\bar{X}(Q), \infty\big)$ the "excess region" of X.

Graph 2.3: The $e(N)$ Function with Different Values of Q



From the first order conditions (8) and (9), one can see that χ affects the optimal effort level e^* only if N affects (9). Based on Theorem 3, I conclude if the optimal borrowing size X^* is such that $N^* > \bar{N}$, the optimal effort level $e^* = e(N^*)$ is constant w.r.t. χ, and we are in the scenario specified by (12). An increase of X^* or N^* due to χ will necessarily reduce the effort intensity. This sheds light on the countercyclicality of the effort intensity, as well as the average quality of financial services and the commission rate. In data, as well as predicted by my model, the size of aggregate investment is highly procyclical. In booms (recessions), households invest more (less) in general, they also invest more (less) through the financial intermediary. So a negative correlation between the investment size and the effort intensity is essential for achieving the countercyclicality of those variables. On the excess region, the negative correlation holds for sure. Below the excess region, however, the correlation between $\frac{e^*}{X^*}$ and X^* remains ambiguous. So we should expect the countercyclical pattern to be more prominent during booms, cause X^* is more likely to stay in the excess region.

I have proved the existence of an excess region, and established the fact that the optimal effort level doesn't vary with the financial sector productivity shock when the optimal borrowing size lies in that region. However, both e^* and X^* are still moved around by the price of firms Q across the cycles. The intuition behind is straightforward, if the value of an intermediate goods firm gets higher, the financial intermediary should react with a larger investment size, and put more effort into screening entrepreneurs. As in most macro-asset pricing models, Q is procyclical. So to guarantee the countercyclicality of the effort intensity, the average quality financial services, and the commission rate, I need two conditions: 1. The steady-state X^*_{ss} is on its excess region; 2. $e^*(Q)$ is less sensitive to Q comparing with $X^*(Q, \chi)$, which shall be satisfied if the elasticity of $F'(e)$ is larger than that of $\frac{1}{n'(X)}$. Unfortunately, I couldn't provide a more precise characterization regarding condition 2 without further specifying some functional forms.

I have described the determination of the optimal allocation rule, borrowing size, and screening effort level, under a setup which is as general as possible. I have also elaborated on the mechanism through which a negative correlation between the effort intensity and the investment size could be generated. To provide more analytical results, I need to specify the functional forms of $F(e)$ and $n(X)$.[15]

Assumption 4. *The cost function has the following form*

$$F(e) = \mathbb{1}\{e > 0\} f^0 + \frac{f}{1+\kappa} e^{1+\kappa};\ \kappa > 0.$$

And the fixed cost component f^0 is very small.

The technology of handling resources has the following form

$$n(X) = X^{\lambda};\ \lambda \in (0, 1).$$

I further require

$$\kappa > \frac{1-\lambda}{\lambda}.$$

Functional forms specified in Assumption 4 are chosen to be consistent with Assumption 2 and 3, and being easy to handle. The requirement of a large enough κ is to guarantee that $F'(e)$ more elastic than $\frac{1}{n'(X)}$. Suppose the optimal X^* and e^* are indeed such that (12) is met, which shall be verified later. Together with the functional forms, I can solve for

$$X^* = \left(\frac{\exp(\chi) \lambda \mathbb{E}(z) Q}{R\xi} \right)^{\frac{1}{1-\lambda}},$$

[15] What I need is that $F'(e)$ is more elastic compared to $\frac{1}{n'(X)}$. Using the following functional forms, this property is easy to characterize.

$$N^* = \frac{1}{\xi}\left(\frac{\exp(\chi)^{\frac{1}{\lambda}}\lambda\mathbb{E}(z)Q}{R\xi}\right)^{\frac{\lambda}{1-\lambda}},$$

and

$$e^* = \left(\frac{\Delta_{H(z)}Q}{f}\right)^{\frac{1}{\kappa}},$$

where $\Delta_{H(z)} \equiv \int_{\mathbb{E}(z)}^{1}\big(z - \mathbb{E}(z)\big)h(z)dz$ is a constant determined solely by the population distribution of abilities $H(z)$.

I give the condition under which (12) is met as

$$Q > \left[\left(\frac{\xi}{\exp(\chi)}\right)^{\kappa}\Big(1 - H\big(\mathbb{E}(z)\big)\Big)^{(1-\lambda)\kappa}\left(\frac{\Delta_{H(z)}}{f}\right)^{1-\lambda}\left(\frac{R}{\lambda\mathbb{E}(z)}\right)^{\lambda\kappa}\right]^{\frac{1}{\lambda\kappa-(1-\lambda)}}.$$

Which is more likely to happen in booms cause both Q and χ are procyclical.

Now I can check the ratios, what move them around in equilibrium are the price of firms Q and the financial sector productivity shock χ. Let's start with the effort-to-size ratio, or the "effort intensity". One can easily check that

$$\frac{e^*}{X^*} = \left(\frac{\Delta_{H(z)}}{f}\right)^{\frac{1}{\kappa}}\left(\frac{R\xi}{\exp(\chi)\lambda\mathbb{E}(z)}\right)^{\frac{1}{1-\lambda}}Q^{\frac{1}{\kappa}-\frac{1}{1-\lambda}},$$

and

$$\frac{e^*}{N^*} = \xi\left(\frac{\Delta_{H(z)}}{f}\right)^{\frac{1}{\kappa}}\left(\frac{R\xi}{\exp(\chi)^{\frac{1}{\lambda}}\lambda\mathbb{E}(z)}\right)^{\frac{\lambda}{1-\lambda}}Q^{\frac{1}{\kappa}-\frac{\lambda}{1-\lambda}}.$$

Based on Assumption 4, I have

$$\frac{1}{\kappa} < \frac{\lambda}{1-\lambda} < \frac{1}{1-\lambda},$$

which indicates a negative correlation between $\frac{e^*}{X^*}$ and Q, so are $\frac{e^*}{N^*}$ and Q. Also notice that χ only shows up in the denominator, so $\frac{e^*}{X^*}$ and $\frac{e^*}{N^*}$ are negatively correlated with χ as well.

Now let's check the success-to-size ratio, or the "average quality of financial services". Remember that when (12) is met,

$$S^* = e^* \cdot \Delta_{H(z)} + N^* \cdot \mathbb{E}(z).$$

And one can check $\frac{N^*}{X^*}$ is decreasing in Q and constant in χ. Thus both $\frac{S^*}{X^*}$ and $\frac{S^*}{N^*}$ are negatively correlated with Q and χ.

The last is to check the commission-to-size ratio, or the "commission rate". One can derive that

$$\begin{aligned}\frac{M^*}{X^*} &= \frac{Q \bullet S^*}{X^*} - R \\ &= \Delta_{H(z)} \frac{Q \bullet e^*}{X^*} + \mathbb{E}(z) \frac{Q \bullet N^*}{X^*} - R\end{aligned}$$

And one can check $\frac{Q \bullet e^*}{X^*}$ is decreasing in Q and χ, while $\frac{Q \bullet N^*}{X^*}$ is constant in both Q and χ. That is, $\frac{M^*}{X^*}$ is also negatively correlated with Q and χ.

As I have mentioned previously, the price of firms is higher when the economy experiences a positive productivity shock in the intermediate goods sector. Meanwhile, a positive productivity shock in the financial sector boosts up future output. These two facts, together with the properties discussed above, promise the countercyclicality of those ratios.

So far, I have laid out the setup of the financial sector and established conditions under which the effort intensity, the average quality of financial services and the commission rate are countercyclical. However, there is a shortage to this competitive setup. That is, one can not vary the "market power" or profit of the financial intermediary easily because both the supply of resources and the demand for firm's shares are perfectly elastic. It causes problems for me to take the model to the data. That is why I have introduced an alternative centralized setup in Appendix 2.4, in which the market power of the financial intermediary is varied by its bargaining power γ in a Nash bargaining with the households. I have also established the equivalence between these two setups. What I need in the competitive setup is to add a taxation on the financial intermediary's profit, and use it to compensate the households with a lump-sum transfer

$$T = \underbrace{(1-\gamma)}_{\text{tax rate}} \big[Q \bullet S(N^*, e^*) - F(e^*) - R \bullet X^* \big].$$

This taxation scheme has a pure redistribution effect in the sense that it won't affect any participants' incentives in the financial sector.

2.5 Households

The economy is populated by a continuum of infinitely lived, risk-averse, and homogeneous households, whose measure is normalized to 1. Households own the capital stock and the stock of intermediate goods firms in the economy. Each period, an individual household's wealth consists of the rent and value from holding capital stock k_t, the pre-dividend value of holding intermediate goods firm's shares a_t, and a lump-sum transfer T_t. It then decides how much to consume c_t, how much capital stock k_{t+1} and intermediate goods firm's shares a_{t+1} to take to the next period, and how much x_t^h to lend to the financial intermediary in the intratemporal borrowing and lending market. I denote s_t^h as the net change in an individual household's holding of firm's shares.[16] The households make decisions after observing the contemporary productivity shocks ε_t, χ_t.

An individual household is a price-taker in the financial markets and the capital renting market. The household's utility from consumption is $u(c)$, satisfying $u'(c) > 0$, $u''(c) < 0$, and $\underset{c \to 0}{lim}\ u'(c) = \infty$, with time discount factor $\beta \in (0, 1)$. I give the individual household's optimization problem as the following.

$$\underset{\{c_t, k_{t+1}, a_{t+1}, x_t^h\}_{t=0}^{\infty}}{max} \quad \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t u(c_t)$$

s.t. $\forall t$ and realization of the productivity shocks $\varepsilon_t,\ \chi_t$

$$c_t + k_{t+1} + Q_t a_{t+1} = (1 + r_t)k_t + \big[\pi_t + (1 - \eta)Q_t\big]a_t + (R_t - 1)x_t^h + T_t, \tag{13}$$

$$x_t^h \leq (1 + r_t)k_t + \big[\pi_t + (1 - \eta)Q_t\big]a_t, \tag{14}$$

$$\begin{pmatrix} \varepsilon_{t+1} \\ \chi_{t+1} \end{pmatrix} = \begin{pmatrix} \rho_{11} & \rho_{12} \\ \rho_{21} & \rho_{22} \end{pmatrix} \begin{pmatrix} \varepsilon_t \\ \chi_t \end{pmatrix} + \begin{pmatrix} \nu_{t+1} \\ \mu_{t+1} \end{pmatrix}, \tag{15}$$

$$c_t,\ k_{t+1},\ a_{t+1} \geq 0. \tag{16}$$

As a reminder, ε_t represents the contemporary productivity shock in the intermediate goods sector, χ_t represents the contemporary productivity shock in the financial sector, while ν_{t+1} and μ_{t+1} are Gaussian white noises with constant standard deviations. T_t is a lump-sum transfer from taxation on the financial intermediary's profit, which mimics the results of a Nash bargaining between the unity of households and the financial intermediary.

The optimization states that at each period t, after the realization of the productivity shocks, an individual household takes the contemporary interest rate of capital r_t, the profit

[16] I use non-capital letters for the individual household's optimization variables, and capital letters for the aggregate variables. To distinguish from their counterparts in the financial intermediary's profit maximization, I add a superscript "h" to both the net purchase of firm's shares s_t^h and the supply of resources in the intratemporal borrowing and lending market x_t^h.

of intermediate goods firms π_t, the price of newly created or survived incumbent intermediate goods firms Q_t, and the return rate of lending to the financial intermediary R_t as given, and maximizes its life-long expected utility, subject to the budget constraint (13), an resource constraint (14), the evolution of aggregate productivity shocks (15), and the non-negativity constraint (16). As usual, net investment into the capital stock is defined by

$$i_t = k_{t+1} - (1-\delta)k_t. \tag{17}$$

Net purchase of firm's shares is defined by

$$s_t^h = a_{t+1} - (1-\eta)a_t. \tag{18}$$

In order to understand the necessity of the resource constraint (14), remember that the financial market for borrowing and lending between the financial intermediary and the households operates intratemporarily. That implies each household has a perfectly elastic supply function of resources. It is necessary for me to put a natural upper bound for how much an individual household could afford to lend, which in this case is the total wealth a household owns. In equilibrium, though, both the total and per-capita size of borrowing and lending shall be determined by the demand side as in equation (8) and (9), and (14) will never be binding.

First order conditions of the individual household's optimization give the following three equations

$$\mathbb{E}_t\left[\frac{\beta u'(c_{t+1})}{u'(c_t)}(1+r_{t+1})\right] = 1, \tag{19}$$

$$Q_t = \mathbb{E}_t\left[\frac{\beta u'(c_{t+1})}{u'(c_t)}\Big(\pi_{t+1} + (1-\eta)Q_{t+1}\Big)\right], \tag{20}$$

$$R_t = 1. \tag{21}$$

They are the non-arbitrage conditions for investment into the capital stock, investment into the shares of firms, and lending to the financial intermediary respectively. Equation (20) provides the foundation for the pricing equation (4). To see it is the non-arbitrage condition for firm's shares, notice what's on the left hand side is the cost of purchasing one unit share of firms today, and what's on the right is the expected return of owning one unit share of firms tomorrow, they must be equalized in equilibrium.

2.6 Aggregation and the Equilibrium

The aggregation of the economy is straightforward.[17] Since the measure of households is normalized to 1, I have

$$C_t = c_t,\ I_t = i_t,\ S_t^h = s_t^h,\ X_t^h = x_t^h,\ K_t = k_t,\ A_t = a_t.$$

I close the economy with the final goods market clearing condition

$$C_t + I_t + X_t^* + M_t^* = Y_t, \tag{22}$$

the capital market clearing condition

$$\int_0^{A_t} \Big(\exp(-\varepsilon_t) y_t^*(\omega)\Big)^{\frac{1}{\alpha}} d\omega = K_t, \tag{23}$$

the borrowing and lending market clearing condition

$$X_t^* = X_t^h, \tag{24}$$

and the firm's shares market clearing condition

$$S_t^h = S_t^*. \tag{25}$$

I give the following definition of equilibrium of the economy, see a full characterization of it in Appendix 2.6.

Definition. *A* ***D****ynamic* ***S****tochastic* ***G****eneral* ***E****quilibrium of the economy is a set of state-dependent prices, aggregate variables, and individual variables*

$$\Big\{ \underbrace{r_t, p_t, Q_t, R_t}_{\textit{prices}} \ ; \ \underbrace{K_t, A_t, \varepsilon_t, \chi_t}_{\textit{state variables}} \ ; \ \underbrace{c_t, k_{t+1}, a_{t+1}, x_t^h}_{\textit{households}} \ ; \ \underbrace{X_t^*, e_t^*, M_t^*, S_t^*}_{\textit{financial intermediaries}} \ ; \underbrace{Y_t, y_t, \pi_t}_{\textit{firms}} \Big\}_{t=0}^{\infty}$$

such that

Given r_t and the demand function, $\{y_t, \pi_t\}$ solve the intermediate goods firm's problem;

Given Q_t and R_t, $\{X_t^*, e_t^*, M_t^*, S_t^*\}$ solve the individual financial intermediary's problem;

Given r_t, Q_t and R_t, $\{c_t, k_{t+1}, a_{t+1}, x_t^h\}$ solve the individual household's problem.

The rest of the variables are pinned down by corresponding equations. Aggregate state variables evolve according to their law of motions. All the aggregation and market clearing conditions are met.

[17] I use capital letters to denote the aggregate variables and non-capital letters to denote the per-capita variables.

3 Data and Empirical Evidence

I choose the U.S. initial public offering (IPO) market as a representative market for testing my theory. The IPO market fits my model of financial intermediation well for several reasons. Firstly, a typical IPO injects a large amount of funds to the issuing firm on the primary market, and it is a necessary prerequisite for the firm's shares to be traded publicly among households on the secondary market. Secondly, unlike other real-life intermediation activities that may take years to process and mature, the IPO is usually more time-sensitive and prompt to changes in the economic conditions. Thirdly, the commission fee of the investment bankers helping issue IPO is based on the expectation of the long-term performance of the stock. So as in the model, the commission rate of the investment bankers should contain information about their effort intensity, as well as the quality of services they provide.

One more thing to clarify before going to some details of the data. I call the IPO market a "representative market" in the sense that those investment bankers are only part of the financial intermediary I have in the model. Thus the commission fee they get is also only a portion of what's in the model. I'm assuming that the portion is fixed, so I can still calculate the correlations of variables precisely, but not the levels. This is why in the quantitative part, I'm only going to use the correlations of variables found in the data, instead of their levels.

The data source for the U.S. IPO market is the SDC: Global New Issues Database. For what I need, it provides: issue date, gross spread amount,[18] principal amount,[19] offer price, type of the security, etc. I'm only looking at IPOs in the U.S. market, issued by U.S. firms and issuing common stocks,[20] between 01/01/1976 and 12/31/2016. There are 11509 stocks with all the information needed available. I choose the U.S. market because related studies show that investment bankers in the U.S. have been frequently colluding since the 70s, to avoid price competition. They as a group has certain monopoly power, so I don't need to worry about large changes in market power over time.

To document their correlations with the economic fundamentals, I construct quarterly time series of the aggregate size, number, and the commission rate[21] of investment bankers in IPO.

[18] The amount of money paid to the investment bankers.

[19] One commonly accepted measure of the total value of an IPO.

[20] This includes common stock, ordinary stock, class A stock, and class B stock.

[21] Speaking from an accounting point of view, the total payment that investment bankers receive from IPO includes not only just commission fee. But for simplicity, I call all of those payments commission in the paper.

For each quarter in 1976Q1-2016Q4, I define the *quarterly total size* of IPOs as

$$\text{size}_t = \sum_i \text{Principal Amount}_t^i \times \text{Inflation Adjustment}_t,$$

which maps to X_t. The principal amount measures the value of a firm on its offering price, that is, the value in the primary market. I regard it as a fair price paid to the entrepreneurs to make them break even, which maps to ξ for each individual entrepreneur and X_t aggregately. The value of a firm in the secondary market, after being traded publicly, maps to Q_t in the model. The inflation adjustment is constructed using CPI (1=2010\$). Again I denote the *quarterly total number* of IPOs as N_t.

I define the *quarterly average gross spread rate* as

$$\text{ags}_t = \frac{\sum_i \text{Gross Spread Amount}_t^i}{\sum_i \text{Principal Amount}_t^i},$$

which is a measure of the average commission fee paid to the financial intermediaries per unit value of IPO issued within that quarter, that is, the quarterly average commission rate.

I construct two variables as economic fundamentals. The first one is the cyclical component of real GDP. I take an HP filter with smoothing parameter 1600 on the log of quarterly real GDP to get $\text{ln}y_t^c$. I define the GDP's deviation from trend as $\text{dev}_t = 1 - \exp(\text{ln}y_t^c)$. The second one is the unemployment rate. I construct a quarterly series of unemployment rate ur_t by taking average of the BLS monthly data.[22]

Table 3.1: Correlations between Variables of Interest

Correlation	Cyclical GDP ($\text{ln}y_t^c$)	Unemployment Rate (ur_t)
Commission Rate (ags_t)	-0.21	0.24
Total Size (size_t)	0.15	-0.01
Total Number (N_t)	0.06	0.04

From the table, one can see that the quarterly total size of IPO is procyclical, while the quarterly average commission rate is countercyclical, consistent with the model's prediction. The quarterly total number of IPO is acyclical, this is because the quarterly average size of IPO is also procyclical, which is not captured in my model.[23]

[22] Civilian unemployment rate (U-3), seasonally adjusted.

[23] In the model, the average size of IPO, measured by ξ, is fixed and time-invariant.

The IPO literature states that an individual IPO's commission rate is negatively correlated with its size. For example, in Chen and Ritter (2000), Ritter (2003), they ran regressions of the individual IPO's commission rate on its size, and other firm-specific characteristics. The coefficient of the size term is always negative and significant. To control for the individual IPO size effect, I define the *quarterly average size* of IPO as

$$\text{asz}_t = \frac{\text{size}_t}{N_t}.$$

This is a measure of the size of a representative IPO issued within the quarter.

I further divide those 11509 stocks into two subgroups: information-creating (I) group and non-information-creating (NI) group. The division is based on three key factors: 1. The offer price; 2. The primary market where the stock is listed or traded; 3. The firm's main business. The idea of this division to get rid of the "penny stocks", which are not traded publicly even after the IPO. I put them in the NI group and use it as a control group. Detailed selection criteria can be found in Appendix 3.1, and I end up with 7605 information-creating stocks and 3904 non-information-creating stocks.

I run OLS regressions of the average gross spread rate (commission rate) on the average size and each of the fundamentals.

Table 3.2: Regression Results on the Quarterly Average Level

Dep. Var.: ags, **information-creating group**, 1976Q1-2016Q4[24]

	(1)	(2)	(3)
asz	-3.77^{***}	-3.77^{***}	-3.61^{***}
$\ln y^c$	-6.81^{*}		
dev		-6.76^{*}	
ur			0.08^{**}
R^2	0.54	0.54	0.55
NO.	163	163	163

$[p < 0.05(*),\ p < 0.01(**),\ p < 0.001(***)]$

[24] There's one quarter missing because the number of information-creating IPO in 1978Q1 is 0.

Dep. Var.: ags, **non-information-creating group**, 1976Q1-2016Q4[25]

	(1)	(2)	(3)
asz	-4.62^{***}	-4.62^{***}	-4.71^{***}
$\ln y^c$	9.07		
dev		9.32	
ur			0.09
R^2	0.46	0.46	0.46
NO.	163	163	163

$[p < 0.05(*),\ p < 0.01(**),\ p < 0.001(***)]$

The regression results show that the average gross spread rate (commission rate) in the information-creating group is countercyclical even after controlling for the average size. While its counterpart in the non-information-creating group doesn't show such a pattern. As a robustness check, I've also run regressions with individual stocks rather than the quarterly aggregates, the cyclical patterns stay the same. Regression results regarding individual stocks are provided in Appendix 3.2.

[add the private equity results when done]

To summarize, I have documented the fact that in the U.S. IPO market, the total size of IPO is procyclical, while the commission rate of investment bankers is countercyclical, even after controlling for the average or individual IPO size. These empirical results, especially the correlations are consistent with my model's prediction, and will be used in the following quantitative part of the paper.

[25] There's one quarter missing because the number of non-information-creating IPO in 2008Q4 is 0.

4 Quantitative Results

In Section 2, I lay out the model and provide several important qualitative results regarding the correlation between the optimal effort intensity (effort-to-size ratio) and the investment size. Most importantly, I have established the existence of an "excess region" of the investment size. In that region, the effort intensity, the average quality of financial services (success-to-size ratio), and the commission rate (commission-to-size ratio) are all negatively correlated with the investment size. The negative correlation implies a countercyclical efficiency of the financial intermediary in utilizing resources, which lays the foundation of the dampening effect that I'm about to examine quantitatively in the current section.

To take the theory to the data, I calibrate the model to the U.S. economy, including the correlation between the cyclical GDP and the investment size documented in Section 3. I want to check how much the calibrated model can explain the documented correlation between the cyclical GDP and the commission rate. I also conduct several counterfactual exercises, to show that the financial intermediary's cyclical behavior in exerting screening effort helps reduce the output and household consumption volatility, thus a dampening effect. Let's start with a specification of functional forms for the remaining functions.

4.1 Model Specification

I have specified the functional forms for the cost of screening effort $F(e)$ and the technology of handling resources $n(X)$ in Assumption 4. To proceed, I need to specify the population distribution of abilities $H(z)$, and the household's utility function $u(c)$.

Assumption 5. *(Functional Form Specification)*

$$H(z) = z, \ \forall z \in [0, 1].$$

$$u(c) = \frac{c^{1-\psi}}{1-\psi}; \ \psi > 0.$$

That is, I assume a uniform distribution of abilities and a constant relative risk aversion utility function. The distribution function is consistent with Assumption 1. I use these specifications because they allow for closed-form solutions. The main qualitative results would remain with other specifications.

Since $H(z) = z$, one can easily derive that $\mathbb{E}(z) = \dfrac{1}{2}$, $\Delta_{H(z)} = \dfrac{1}{8}$, $\underline{z}(N, e) = 1 - \dfrac{N}{e}$, and the effort cutoff is $2N$. I give the maximum success function as

$$S(N,e) = \begin{cases} \dfrac{e}{8} + \dfrac{N}{2}, & \dfrac{e}{N} < 2 \\ N\Big(1 - \dfrac{N}{2e}\Big), & \dfrac{e}{N} \geq 2 \end{cases}. \tag{7'}$$

The marginal benefit of effort is

$$Q \bullet S_e(N,e) = \begin{cases} \dfrac{Q}{8}, & \dfrac{e}{N} < 2 \\ \dfrac{Q}{2}\Big(\dfrac{N}{e}\Big)^2, & \dfrac{e}{N} \geq 2 \end{cases}.$$

One can check that these two equations are consistent with what has been described in Proposition 1 and Corollary 2.

Using the first order condition $Q \bullet S_e(N,e) = F'(e)$, I can solve for the effort policy function in the two-step maximization problem

$$e(N) = \begin{cases} \left(\dfrac{Q \bullet N^2}{2f}\right)^{\frac{1}{2+\kappa}}, & N \leq \dfrac{1}{2}\left(\dfrac{Q}{8f}\right)^{\frac{1}{\kappa}} \\ \left(\dfrac{Q}{8f}\right)^{\frac{1}{\kappa}}, & N > \dfrac{1}{2}\left(\dfrac{Q}{8f}\right)^{\frac{1}{\kappa}} \end{cases}. \tag{26}$$

The threshold value of N is $\bar{N}(Q) = \dfrac{1}{2}\Big(\dfrac{Q}{8f}\Big)^{\frac{1}{\kappa}}$. One can check that $e(N)$ is consistent with what has been described in Theorem 3. The corresponding threshold value of X is $\bar{X}(Q) = \big[\exp(-\chi)\xi \bullet \bar{N}(Q)\big]^{\frac{1}{\lambda}}$. Different from $\bar{N}(Q)$ though, $\bar{X}(Q)$ is increasing in Q but decreasing in χ, so the cyclicality of $\bar{X}(Q)$ is ambiguous.

Again, suppose the equilibrium X^* and e^* are such that $\dfrac{e^*}{N^*} < 2$, I have

$$X^* = \left(\frac{\exp(\chi)\lambda Q}{2R\xi}\right)^{\frac{1}{1-\lambda}},$$

$$e^* = \left(\frac{Q}{8f}\right)^{\frac{1}{\kappa}}.$$

And the condition under which $\dfrac{e^*}{N^*} < 2$ shall be met is

$$Q > \left[2^{\lambda\kappa-(1-\lambda)(3+\kappa)}\left(\frac{\xi}{\exp(\chi)}\right)^{\kappa}\left(\frac{1}{f}\right)^{1-\lambda}\left(\frac{R}{\lambda}\right)^{\lambda\kappa}\right]^{\frac{1}{\lambda\kappa-(1-\lambda)}}.$$

The equilibrium X^* and e^* in the other scenario, namely when $\frac{e^*}{N^*} > 2$, can be solved numerically from the first order conditions (8) (9). Unfortunately, they don't have a closed-form solution like the ones here.

4.2 Calibration

I calibrate the model to the U.S. economy, as well as some important correlations found in the empirical part of the paper. I have in total of 19 parameters to calibrate. Among those some I calibrate to match the long-term mean of the economy, some I calibrate jointly using the simulated method of moments. To be consistent with the real business cycle literature, parameters are calibrated on the quarterly frequency. Here is a table for my current benchmark calibration.

Table 4.1: Benchmark Calibration

	Param	Value	Target
Firms	α	0.38	capital share
	δ	0.012	Cooley and Prescott (1995)
	η	0.02	BDS statistics
	σ	6	average markup
	τ	0	equilibrium stability
Households	β	0.987	Cooley and Prescott (1995)
	ψ	2	literature
Shocks	std(ν)	1.3×10^{-5}	std GDP
	ρ_{11}	0.71	autocorr GDP
	std(μ)	2.7×10^{-5}	corr GDP & IPO size
	ρ_{22}	0.68	autocorr IPO size
	ρ_{12}, ρ_{21}	0	no structural corr
Intermediary	γ	0.29	IPO commission rate
	ξ	9.72	S&P 500 P/B ratio[26]
	λ	0.75	work in progress
	κ	0.5	work in progress
	f	9.72	work in progress
	f^0	0	unimportant parameter

[26] I calculate the average "Price-to-Book" (P/B) ratio of the S&P 500 firms from 1999/12/31 to 2019/10/31, and the value is 3.56.

For the firm's part, I calibrate the concavity parameter α to match the long-term average capital share calculated for the U.S. economy. I take the capital depreciate rate δ from Cooley and Prescott (1995). I calibrate the death rate of incumbent intermediate goods firms η to match the quarterly average death rate of firms reported by the BDS statistics. I calibrate the elasticity of substitution between intermediate goods σ to match the long-term average markup, calculated for the U.S. economy in another working paper of mine: "Antitrust Policy in a Globalized Economy". At last, I set the *love of variety* parameter τ to be 0 because the model won't have a stable equilibrium with a large τ.

For the household's part, I take the time discount factor β from Cooley and Prescott (1995), and the risk aversion parameter ψ from the literature.

For the productivity shock in the intermediate goods sector, I calibrate the standard deviation of the white noise ν and the self-persistence parameter ρ_{11} jointly, using the simulated method of moments, to match the standard deviation and autocorrelation of the cyclical real GDP. For the productivity shock in the financial sector, I calibrate the standard deviation of the white noise μ and the self-persistence parameter ρ_{22} jointly, using the simulated method of moments, to match the correlation between the cyclical real GDP and the quarterly total size of IPO found in Table 3.1, and the autocorrelation of the quarterly total size of IPO.[27] I set the cross-persistence parameters $\rho_{12} = \rho_{21} = 0$ because I want to rule out structural correlations between productivity shocks in different sectors.

For the financial intermediary's part, I calibrate the taxation (bargaining weight) parameter γ to match the 7% average commission rate in the U.S. IPO market. I calibrate the cost of industrialization ξ to match the average S&P 500 "Price-to-Book" ratio.[28] The calibration for the concavity parameter λ in the technology of handling resources, and parameters governing the cost of effort κ and f, is still work in progress. I set the fixed cost of effort $f^0 = 0$ and it is a trivial parameter in my model.

Under the benchmark calibration, I have solved the model numerically, and simulated time series of cyclical GDP Y, investment size X^*, effort level e^*, commission fee M^*, etc. I'm particularly interested in how well the calibrated model can explain the documented correlation between the cyclical real GDP and the commission rate.

[27]Notice that when it comes to the statistics of the IPO market, I use only normalized terms: correlation, autocorrelation, instead of levels such as standard deviation. I have explained the reason in the empirical part of the paper.

[28]In the model, $\frac{Q_t}{\xi}$ can be regarded as the "Price-to-Book" ratio.

Table 4.2: Simulated Correlations with $\kappa = 0.5$

Correlation with Y	M^*/X^*	e^*/X^*	S^*/X^*	C
Simulation	-0.15	-0.17	-0.32	0.74
Data	-0.21	n/a	n/a	0.76

The simulated correlation between the cyclical real GDP and the commission rate explains 71% of the correlation documented in the data. The model also provides simulated correlations regarding the effort intensity and the financial intermediary's efficiency in utilizing resources, which are difficult to observe directly from the data.[29]

At last, to examine whether the financial intermediary's cyclical behavior in exerting screening effort helps dampen the economic volatility, I conduct several counterfactual exercises.

Table 4.3: Counterfactual Results with $\kappa = 0.5$

Counterfactual		Y Volatility	C Volatility	Household Welfare
Vary $F(e)$	20%	0.14%	0.32%	-2.22%
	-20%	-0.24%	-0.53%	3.84%
Commission Rate Cap		0.36%	0.54%	-5.62%
Shut Down Intermediary		0.74%	1.55%	-7.03%

In the first counterfactual exercise, I raise (reduce) the financial intermediary's cost of effort by 20%. The output volatility[30] increases (decreases) by 0.14% (0.24%). The household consumption volatility increases (decreases) by 0.32% (0.53%). In addition, the households' welfare loss (gain) is 2.22% (3.84%).[31]

As for the second exercise, I put a binding[32] commission rate cap on the financial intermediary. The output volatility increases by 0.36%. The household consumption volatility increases by 0.54%. And the households' welfare loss is 5.62%. Based on this counterfactual exercise, I argue that it is inefficient to drive down the commission rate level by using a price

[29] There is hope in measuring S^* by the long-term performance of the firms after IPO. I'm working on it as an extension of the empirical exercises of the paper.

[30] Measured by the standard deviation to mean ratio, aka the coefficient of variation, because the variable's mean changes a lot too.

[31] The welfare changes are mainly (around 90%) due to changes in the steady-state level of consumption.

[32] The cap is set to be 3%, which matches the commission rate level in the European IPO market, and is much lower than the model's steady-state commission rate level.

cap. A better way is to introduce competition to the financial market, which is equivalent to reducing γ in the model.

Lastly, I shut down the financial intermediary completely by setting $e \equiv 0$ and $\gamma = 0$. The output volatility increases by 0.74%. The household consumption volatility increases by 1.55%. And the households' welfare loss is 7.03%. From the counterfactual exercises, I conclude that the cyclical patterns of the financial intermediary's behaviors, especially its effort intensity in screening entrepreneurs, help dampen the volatility of output and household consumption, and improve welfare.

The values of λ, κ and f are not calibrated yet, and I simply pick ad hoc numbers to put in the benchmark calibration table. From the closed-form solutions of X^* and e^*, one can make the conjecture that κ shall largely affect the dampening effect found in the previous counterfactual exercises. Eventually, I will calibrate those parameters to the data. But for now, let me do a robustness check with a much higher $\kappa = 3$. The corresponding simulation and counterfactual results can be found in Appendix 4.1.

5 Conclusion

Financial intermediation helps direct funds to its best uses. Financial intermediaries' reactions to changes in the economic fundamentals over business cycles may in turn reshape the cycles. What are the cyclical patterns of the financial intermediaries' behaviors? Such as their investment size, effort in screening entrepreneurs (ideas), efficiency in utilizing resources, etc. To answer this question, I develop a theory of financial intermediation under a stochastic general equilibrium framework. Given the cyclical patterns of the financial intermediaries' behaviors, how would they reshape business cycles? To answer the second question, I take the model to the data and conduct quantitative analysis. Let me summarize the main results here.

The paper provides new findings and perspectives in theory, empirical evidence, and quantitative analysis. In terms of theory, I build an innovative model of financial intermediation over business cycles to show that there could exist a dampening effect of the financial intermediary. The dampening effect is originated from the financial intermediary's optimal behaviors over the cycles. Under certain conditions, the financial intermediary's effort intensity in screening entrepreneurs is negatively correlated with its investment size. This results in a higher (lower) efficiency in utilizing resources in bad (good) times. It also implies that the commission rate of the financial intermediary should be higher (lower) in booms (recessions). I'm able to deliver these qualitative results under a fairly general setup, which can be applied to many more specialized applications.

In the empirical part, I have examined one application of the model: the cyclicality of the commission rate. I have documented the fact that the commission rate for investment bankers in the U.S. IPO market is countercyclical, which is consistent with my model's prediction. This indicates that, on average, they put more effort into screening startup firms and get paid more per unit of investment in recessions, which helps the economy to recover.

As for the quantitative analysis, after calibrating the model to the U.S. economy, I have shown that The cyclical behaviors of the financial intermediary help dampen the volatility of output, household consumption, and improve household welfare. A 20% drop in the financial intermediary's cost of effort reduces the output volatility and the household consumption volatility by 0.24%, 0.53% respectively. The households' welfare gain is 3.84%. I have also shown that price-cap is an inefficient way of reducing the level of commission fee, a better way could be introducing more competition to the financial market.

A natural extension of the model is to introduce a more active entrepreneur part. For example, I'm trying to add a labor market into the model, and the workers choose between working in an intermediate goods firm or becoming an entrepreneur to produce ideas. The main difficulty is tractability since it raises a nontrivial principal-agent problem between the financial intermediary and the entrepreneurs. But this is surely an interesting direction to explore on.

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Appendix

A2.1 Deriving the Success Function

Following **Definition 1**, for a pair of (N, e), there could be two scenarios. First is that $e\big[1 - H\big(\mathbb{E}(z)\big)\big] < N$, in this scenario the pool of verified entrepreneurs is not enough to absorb all the borrowed resources. Thus $e\big[1 - H\big(\mathbb{E}(z)\big)\big]$ many verified entrepreneurs will get funded, and the rest are randomly drawn, unverified entrepreneurs. This result in an aggregate number of success as

$$\begin{aligned} S(N,e) &= \underbrace{e\int_{\mathbb{E}(z)}^{1} zh(z)dz}_{\text{verified}} + \underbrace{\mathbb{E}(z)\Big(N - e\big[1 - H\big(\mathbb{E}(z)\big)\big]\Big)}_{\text{unverified}} \\ &= e\int_{\mathbb{E}(z)}^{1} \big(z - \mathbb{E}(z)\big)h(z)dz + N \bullet \mathbb{E}(z). \end{aligned}$$

The second scenario is that $e\big[1 - H\big(\mathbb{E}(z)\big)\big] \geq N$, where all resources go to the verified entrepreneurs in a descending order. And the threshold for getting funded is an $\underline{z}$ solved from

$$e\big[1 - H(\underline{z})\big] = N.$$

One can easily derive that $\underline{z}(N,e) = H^{-1}\left(1 - \dfrac{N}{e}\right)$, which is higher than $\mathbb{E}(z)$ in this scenario, and the resulted aggregate number of success is

$$S(N,e) = e\int_{\underline{z}(N,e)}^{1} zh(z)dz.$$

A2.2 Proof of Proposition 1 and Corollary 2

Let's start by deriving the first order partial derivatives of $S(N, e)$. Under Assumption 1, I know that $\underline{z}(N,e) = H^{-1}\left(1 - \dfrac{N}{e}\right)$ is differentiable. One can derive

$$\frac{\partial \underline{z}(N,e)}{\partial N} = -\frac{1}{eh(\underline{z})},$$

$$\frac{\partial \underline{z}(N,e)}{\partial e} = \frac{N}{e^2 h(\underline{z})}.$$

For notational purpose, I define

$$E_L = \left\{ (N,e) \in \mathbb{R}^2_+ \;\middle|\; \frac{e}{N} < \frac{1}{1 - H\big(\mathbb{E}(z)\big)} \right\}$$

and

$$E_H = \left\{ (N,e) \in \mathbb{R}^2_+ \;\middle|\; \frac{e}{N} > \frac{1}{1 - H\big(\mathbb{E}(z)\big)} \right\}.$$

Obviously $S(N,e)$ is continuously differentiable on E_L and E_H. I can derive

$$S_N(N,e) = \begin{cases} \mathbb{E}(z), & \dfrac{e}{N} < \dfrac{1}{1 - H\big(\mathbb{E}(z)\big)} \\ \underline{z}(N,e), & \dfrac{e}{N} > \dfrac{1}{1 - H\big(\mathbb{E}(z)\big)} \end{cases} \tag{27}$$

and

$$S_e(N,e) = \begin{cases} \displaystyle\int_{\mathbb{E}(z)}^{1} \big(z - \mathbb{E}(z)\big) h(z) dz, & \dfrac{e}{N} < \dfrac{1}{1 - H\big(\mathbb{E}(z)\big)} \\ \displaystyle\int_{\underline{z}(N,e)}^{1} \big(z - \underline{z}(N,e)\big) h(z) dz, & \dfrac{e}{N} > \dfrac{1}{1 - H\big(\mathbb{E}(z)\big)} \end{cases}. \tag{28}$$

When $e \xrightarrow{+} \frac{N}{1-H\left(\mathbb{E}(z)\right)}$, $\underline{z}(N,e) \xrightarrow{+} \mathbb{E}(z)$. This indicates that both $S_N(N,e)$ and $S_e(N,e)$ are continuous on $\mathbb{R}^2_+$, so $S(N,e)$ is continuously differentiable on $\mathbb{R}^2_+$. In addition, since $S_N(N,e) > 0$ and $S_e(N,e) > 0$, $S(N,e)$ is strictly increasing in both N and e on $\mathbb{R}^2_+$.

Next is to examine the curvature of $S(N,e)$. Let's take second order partial derivatives

$$S_{NN}(N,e) = \begin{cases} 0, & \dfrac{e}{N} < \dfrac{1}{1 - H\big(\mathbb{E}(z)\big)} \\ -\dfrac{1}{eh(\underline{z})}, & \dfrac{e}{N} > \dfrac{1}{1 - H\big(\mathbb{E}(z)\big)} \end{cases},$$

$$S_{Ne}(N,e) = \begin{cases} 0, & \dfrac{e}{N} < \dfrac{1}{1 - H\big(\mathbb{E}(z)\big)} \\ \dfrac{N}{e^2 h(\underline{z})}, & \dfrac{e}{N} > \dfrac{1}{1 - H\big(\mathbb{E}(z)\big)} \end{cases},$$

$$S_{ee}(N,e) = \begin{cases} 0, & \dfrac{e}{N} < \dfrac{1}{1 - H\big(\mathbb{E}(z)\big)} \\ -\dfrac{N^2}{e^3} \dfrac{1}{h(\underline{z})}, & \dfrac{e}{N} > \dfrac{1}{1 - H\big(\mathbb{E}(z)\big)} \end{cases}.$$

From those partial derivatives one can conclude that $S(N, e)$ is linear on E_L. To see that it is strictly concave on E_H, for an arbitrary vector $(x_1, x_2) \in \mathbb{R}^2$,

$$\begin{aligned} & S_{NN}x_1^2 + 2S_{Ne}x_1x_2 + S_{ee}x_2^2 \\ = & -\frac{1}{eh(\underline{z})}\Big(x_1^2 - \frac{2N}{e}x_1x_2 + \frac{N^2}{e^2}x_2^2\Big) \\ = & -\frac{1}{eh(\underline{z})}\Big(x_1 - \frac{N}{e}x_2\Big)^2 \leq 0 \end{aligned}$$

That is, the Hessian matrix of $S(N, e)$ is negative definite except for a measure 0 of points, which proves its strict concavity. Proposition 1 proved.

The last is to see how changes of N affect $S_e(N, e)$. Notice that on E_L, $S_e(N, e)$ is a constant w.r.t. both N and e, thus $S(N, e)$ is linear in e with a slope that is constant w.r.t. changes of N.

However on E_H, $S_e(N, e)$ is strictly decreasing in both e and N. To summarize, an increase of N enlarges the constant region of $S_e(N, e)$, and shifts $S_e(N, e)$ up on its decreasing region. Loosely speaking, it shifts $S_e(N, e)$ to the right.

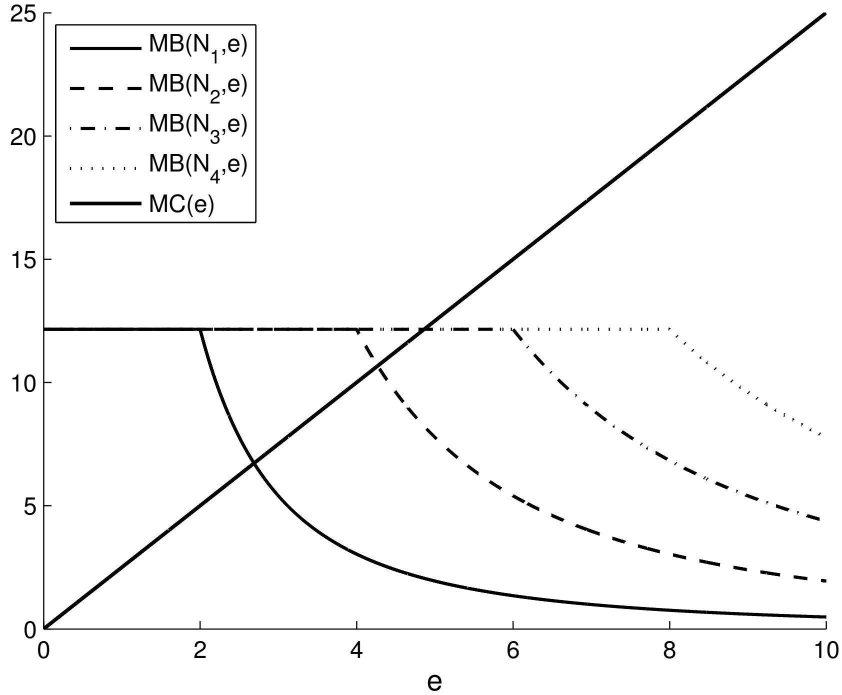
Once I take into consideration of the firm's price Q, it shifts up the marginal benefit of effort $Q \bullet S_e(N, e)$ proportionally. Corollary 2 proved.

A2.3 Proof of Theorem 3

Using results from Proposition 1 and Corollary 2, the proof is straightforward. Let's start with the existence and uniqueness of $e(N)$. As shown in the proof of Proposition 1, $S_e(N, e) > 0$. Assumption 2 states that $F'(0) = 0$ and the fixed cost component is very small, so the optimal effort level $e(N)$ must be an interior solution. In addition, since $S(N, e)$ is concave while $F(e)$ is strictly convex, $e(N)$ would be uniquely pinned down by the first order condition

$$\underbrace{Q \bullet S_e(N, e)}_{\text{marginal benefit}} = \underbrace{F'(e)}_{\text{marginal cost}}.$$

Graph A.1: Marginal Benefit v.s. Marginal Cost



Depending on different values of N, there could be two scenarios. First is that N is small so $F'(e)$ intersects with $Q \bullet S_e(N,e)$ above the effort cutoff $\frac{N}{1-H\left(\mathbb{E}(z)\right)}$. For example, N_1 or N_2 in the graph above. If that is the case, an increase of N will raise e up. Because as shown in Corollary 2, an increase of N shifts $Q \bullet S_e(N,e)$ up when e is above the effort cutoff.

The second scenario is that N is large enough so $F'(e)$ intersects with $Q \bullet S_e(N,e)$ below the effort cutoff. In this case, when N increases, the intersection point will not be affected. Because an increase of N has no effect on $Q \bullet S_e(N,e)$ when e is below the effort cutoff.

Also notice that an increase of N raises the effort cutoff, so it is basically shifting $Q \bullet S_e(N.e)$ to the right. There must exist a $\bar{N}$ such that once $N > \bar{N}$, the intersection is below the cutoff.

At last, since an increase of Q shifts $Q \bullet S_e(N,e)$ up proportionally everywhere, it raises e as well as the $\bar{N}$.

A2.4 Centralized Financial Market

In the centralized setup, I assume a collective contract between the unity of households and the financial intermediary governing the borrowing size X and effort level e, and a Nash bargaining to determine the return rate R.

Assumption 6. *The unity of households and the financial intermediary write a collective contract governing X and e. For any given Q, X, e and realization of χ, the promised return rate R, as well as the commission fee M, are determined by a Nash bargaining over the net surplus*[33]

$$Q \bullet S(N, e) - F(e) - X, \tag{5'''}$$

subject to $N = exp(\chi)\dfrac{n(X)}{\xi}$. The bargaining power of the financial intermediary is $\gamma \in (0, 1)$.

The surplus term is essentially the profit function of the financial intermediary in the decentralized financial market, since in the decentralized equilibrium the intratemporal return rate to households R must be equalized to 1. γ works as the parameter governing the financial intermediary's market power. The lower γ is, the less market power the financial intermediary has. So the act of introducing competition to the market could be done by reducing γ.

One may concern whether the split of the surplus is implementable through an incentive compatible collective contract, since it is contingent on e but the effort level is hidden from the households. To answer this question, I give the following theorem.

Theorem 4. *Any Nash bargaining over the surplus can be implemented by an incentive compatible collective contract between the unity of households and the financial intermediary.*

The proof of Theorem 4 is given in Appendix 2.5. The intuition is that as long as the financial intermediary doesn't deviate from the descending allocation rule, the number of success S serves as a perfect signal of the effort level e. So a contract written on S is equivalent to a contract written on e.

With Nash bargaining, the incentives for the unity of households and the financial intermediary in choosing X and e, as well as the allocation rule, are perfectly aligned. That is, to maximize the surplus specified in (5'''). The unity of the households and the financial intermediary negotiate on the optimal investment size and the optimal screening effort level. Again, denote the optimal investment size as X^*, and the optimal effort level as e^*. Given all

[33] At the optimal effort level it will always be non-negative.

other things equal, the X^* and e^* here should be exactly the same as their counterparts in the decentralized equilibrium.

Now the commission fee is

$$M^* = \gamma\big[Q \bullet S(N^*, e^*) - X^*\big] + (1-\gamma)F(e^*), \tag{11'}$$

And the unity of households gets

$$Q \bullet S(N^*, e^*) - M^*,$$

which shall be distributed evenly among all households.

Different from what's in the decentralized setup though, once a collective contract is finalized, an individual household is no longer allowed to freely choose how much resources to supply to the financial intermediary. This is because Nash bargaining yields a positive intratemporal net return for the unity of households.

$$\begin{aligned} R_{\text{centralized}} - 1 &= \frac{Q \bullet S(N^*, e^*) - M^*}{X^*} - 1 \\ &= \frac{(1-\gamma)\big[Q \bullet S(N^*, e^*) - F(e^*) - X^*\big]}{X^*} > 0. \end{aligned}$$

Remember that the reason for introducing a centralized financial market is to be able to vary the market power of the financial intermediary. To see how it is done, one can derive the profit of the financial intermediary through Nash bargaining as

$$M^* - F(e^*) = \gamma\big[Q \bullet S(N^*, e^*) - F(e^*) - X^*\big].$$

Which is exactly γ portion of its counterpart in the decentralized equilibrium.

As a matter of fact, I can achieve the same result in the competitive financial market by posing a tax rate of $1-\gamma$ on the financial intermediary's profit. The taxation income shall be rewarded to the households as a lump-sum transfer

$$T = (1-\gamma)\big[Q \bullet S(N^*, e^*) - F(e^*) - R \bullet X^*\big],$$

which doesn't affect an individual household's incentive on how much to lend on the competitive intratemporal borrowing and lending market. One can check that

$$Q \bullet S(N^*, e^*) = M^* + R \bullet X^* + T$$

shall always hold.

A2.5 Proof of Theorem 4

The key is to show that there exists a collective contract to incentivize the financial intermediaries to always follow the descending allocation rule. Because if they do, the resulted success function $S(N, e)$ serves as a perfect signal of e. Writing a contract in terms of S is thus equivalent to one written on e.

Consider the following simple contract written by the households to elicit a certain effort level $\hat{e}$. Given the aggregate size of entrepreneurs to be funded N, the households take the ownership of the firms, but promise to pay a financial intermediary certain amount of final goods M, which is larger or equal to the private cost $F(\hat{e})$ incurred, as long as the number of firms created by this financial intermediary is no less than $S(N, \hat{e})$, otherwise paying 0.[34]

With a simple contract described above, a financial intermediary's unique best response is to exert effort level $\hat{e}$ and follow the descending allocation rule. To see that, one should remember $\hat{e}$ is the minimum effort level required to create $S(N, e)$ many new firms. If a financial intermediary chooses an effort level low than $\hat{e}$, it will get paid 0 for sure. If the financial intermediary chooses an effort level higher than $\hat{e}$, it may get paid the same M but with a higher cost. And with the effort level being exactly $\hat{e}$, the financial intermediary can create $S(N, e)$ many firms only if it follows the optimal allocation rule, aka the descending allocation rule.

Now to fully implement the commission fee determined by the Nash bargaining, the households need to write a complex contract in which the payment M changes with e according to Assumption 6. Since the commission fee is strictly increasing in both the number of firms created S, and the inferred cost of effort $F(e)$, the financial intermediary's unique best response is still to stick with the descending allocation rule.

To summarize, the key features for the contract to work are: 1. Given N and e, $S(N, e)$ is achievable only through the descending allocation rule; 2. $S(N, e)$ is strictly increasing in e, thus serves as a perfect signal of the effort level; 3. The commission fee determined by the Nash bargaining is strictly increasing in S and $F(e)$.

[34] I assume limited liability on the financial intermediary side.

A2.6 Characterizing the Equilibrium

At each period t, after the realization of the productivity shocks ε_t and χ_t, the economy is characterized by four state variables: the aggregate capital stock K_t, the aggregate variety stock A_t, the realized productivity shock in the intermediate goods sector ε_t, and the realized productivity shock in the financial sector χ_t.

I claim that the dynamic stochastic general equilibrium of the economy is characterized by the following equations.

For $\forall t$ and $K_t, A_t, \varepsilon_t, \chi_t$,

$$Y_t = A_t^{\tau+1} y_t^*; \tag{29}$$

$$p_t = A_t^{\tau}; \tag{30}$$

$$y_t^* = \left(\frac{\sigma - 1}{\sigma} \frac{\exp(\varepsilon_t/\alpha)}{r_t + \delta} \alpha A_t^{\tau} \right)^{\frac{\alpha}{1-\alpha}}; \tag{31}$$

$$\pi_t = p_t y_t^* - (r_t + \delta)\big(\exp(-\varepsilon_t) y_t^*\big)^{\frac{1}{\alpha}}; \tag{32}$$

$$\mathbb{E}_t\left[\frac{\beta u'(c_{t+1})}{u'(c_t)} (1 + r_{t+1}) \right] = 1; \tag{33}$$

$$Q_t = \mathbb{E}_t\left[\frac{\beta u'(c_{t+1})}{u'(c_t)} \Big(\pi_{t+1} + (1-\eta) Q_{t+1} \Big) \right]; \tag{34}$$

$$R_t = 1; \tag{35}$$

$$Q_t \bullet S_e(N_t^*, e_t^*) = F'(e_t^*); \tag{36}$$

$$Q_t \bullet S_N(N_t^*, e_t^*) \bullet \exp(\chi_t) \frac{n'(X_t^*)}{\xi} = R_t; \tag{37}$$

$$N_t^* = \exp(\chi_t) \frac{n(X_t^*)}{\xi}; \tag{38}$$

$$S_t^* = S(N_t^*, e_t^*); \tag{39}$$

$$M_t^* = \gamma \big[Q_t \bullet S_t^* - R_t \bullet X_t^*\big] + (1-\gamma) F(e_t^*); \tag{40}$$

$$T_t = (1-\gamma)\big[Q_t \bullet S_t^* - F(e_t^*) - R_t \bullet X_t^*\big]; \tag{41}$$

$$C_t = c_t;\ K_t = k_t;\ A_t = a_t^h;\ X_t^h = x_t^h; \tag{42}$$

$$I_t = K_{t+1} - (1-\delta) K_t; \tag{43}$$

$$\begin{pmatrix} \varepsilon_{t+1} \\ \chi_{t+1} \end{pmatrix} = \begin{pmatrix} \rho_{11} & \rho_{12} \\ \rho_{21} & \rho_{22} \end{pmatrix} \begin{pmatrix} \varepsilon_t \\ \chi_t \end{pmatrix} + \begin{pmatrix} \nu_{t+1} \\ \mu_{t+1} \end{pmatrix}; \tag{44}$$

$$C_t + I_t + X_t^* + M_t^* = Y_t; \tag{45}$$

$$A_t \Big(\exp(-\varepsilon_t) y_t^*\Big)^{\frac{1}{\alpha}} = K_t; \tag{46}$$

$$X_t^* = X_t^h; \tag{47}$$

$$A_{t+1} - (1-\eta) A_t = S_t^*; \tag{48}$$

Equation (29) - (32) are from the final goods and intermediate goods firm's static profit maximization problem. Equation (33) - (35) are from the individual household's optimization problem. Equation (36) - (41) are from the financial intermediary's static profit maximization problem, with a taxation on profit. Equation (42) and (43) are the aggregation conditions. Equation (44) governs the evolution of the productivity shocks. Equation (45) - (48) are the market clearing conditions for final goods, capital, inratemporal borrowing and lending, and firm's shares market respectively.

The economy exhibits a saddle-path stable steady-state when the *love of variety* τ is close to 0. Following the real business cycle literature, I solve a dynamic stochastic general equilibrium around the steady-state, using perturbation method. I'm not going to write out the equations characterizing the steady-state, cause they are just repetitions of equation (29) - (48), without the productivity shocks of course.

A3.1 Criteria for Group Division

I did the following selection, what's left are in the information-creating group, what's taken out is in the non-information-creating group.

First, I take out stocks whose offer price is below 5$. This is based on SEC's definition of a "penny stock". These stocks are not traded frequently or widely after the IPO, so they are still considered to be unknown or unavailable to the general public.

Second, I take out stocks that are not listed or traded on a "national securities exchange".[35] For the same reason that these stocks are not traded frequently or widely after IPO.

Third, I take out IPO that are issued by firms whose main business are: open/close-end funds, special financial vehicles, blank check companies (SPACs), REITs. Because these stocks are issued for special purposes.

[35] SEC has a detailed list of national securities exchanges.

A3.2 Regression Results Regarding Individual Stocks

I pool all individual stocks together, and run regression of their gross spread rates (gs_t^i) on sizes (sz_t^i) and the unemployment rate (ur_t).

Dep. Var.: gs, **all stocks**, 1976Q1-2016Q4

	(1)	(2)
sz	-1.71^{***}	-1.68^{***}
ur		0.15^{***}
R^2	0.09	0.10
NO.	11509	11509

I do the same for the information-creating group.

Dep. Var.: gs, **information-creating group**, 1976Q1-2016Q4

	(1)	(2)
sz	-1.73^{***}	-1.73^{***}
ur		0.03^{***}
R^2	0.13	0.13
NO.	7605	7605

And for the non-information-creating group.

Dep. Var.: gs, **non-information-creating group**, 1976Q1-2016Q4

	(1)	(2)
sz	-1.62^{***}	-1.60^{***}
ur		0.23^{***}
R^2	0.08	0.09
NO.	3904	3904

$[p < 0.05(*),\ p < 0.01(**),\ p < 0.001(***)]$

A4.1 Robustness Check

In this robustness check, I set the convexity parameter in the cost of effort to be $\kappa = 3$, which is 6 times to its benchmark value. The corresponding table of correlations is as follows.

Table 4.4: Simulated Correlations with $\kappa = 3$

Correlation with Y	M^*/X^*	e^*/X^*	S^*/X^*	C
Simulation	-0.18	-0.20	-0.26	0.74
Data	-0.21	n/a	n/a	0.76

The corresponding table of counterfactual results is as follows.

Table 4.5: Counterfactual Results with $\kappa = 0.5$

Counterfactual		Y Volatility	C Volatility	Household Welfare
Vary $F(e)$	20%	0.02%	0.11%	-0.37%
	-20%	-0.03%	-0.15%	0.48%
Commission Rate Cap		0.43%	2.03%	-6.64%
Shut Down Intermediary		1.51%	4.01%	-3.79%

Comparing to the benchmark calibration, the wellness of fit of the correlation between Y and $\frac{M^*}{X^*}$ has improved. However, the magnitude of the dampening effect has been greatly weakened.