

Financial Constraints and Risk Aversion: A Tax-based Theory of Rising Industrial Concentration

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Abstract

I propose a theory that shows for financially constrained firms, a lower tax rate on cash returns can cause firms to hoard more cash and increase their investment in risky projects. As a result, industry sales becomes increasingly concentrated in top firms. The model has three central ingredients: (1) Risk-neutral firms behave as if they were risk-averse because of financial constraints (2) The tax rate of the return on cash is negatively related to firms' effective risk-aversion. (3) Investments in risky projects, after the resolution of uncertainty, become ex-post dispersion in firms' sales, which give rise to an increase in the level of market concentration. So when the foreign tax rate were lowered in the late 90s, the theory suggests that multinational firms' effective risk-aversion was reduced and they had the incentive to increase investments in risky projects. This, in turn, leads to an increasingly concentrated economy. Empirical evidence is consistent with the proposed risk-taking channel.

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1 Introduction

The last 20 years have witnessed a substantial increase in sales concentration across a wide range of industries in the US. The rising concentration has received a great deal of attention from academic economists and policy makers, given its significant connections with observed structural changes in the economy, including lower capital investment, a declining labor share, slow productivity growth, and declining dynamism. At the same time, the US corporate sector's aggregate cash balance soared, increasing from \$1.5 trillion in the mid-1990s to \$4 trillion by the end of 2017. That burgeoning cash balance is mostly concentrated within multinational firms' foreign subsidiaries.

In this paper, I propose that these two trends share a single common cause: a decrease in the foreign corporate tax rate. To develop this argument, I first present a model that shows how a lower tax rate on the return of firms' foreign cash leads multinational firms to hoard more cash and increase their investments in risky projects, and how the increased risk-taking in turn contributes to the rising market concentration. I then provide empirical evidence that is consistent with the proposed risk-taking channel.

The model builds on the theoretical frameworks by [Bolton, Chen, and Wang \(2011\)](#), which focuses on dynamic investment and risk management decisions for a financially constrained firm. I consider an industry consisting of a number of financially constrained firms. The financial constraints in the model can be viewed as a reduce-form of agency frictions¹. In terms of model setup, I mainly add the following: (1) firms can invest in risky projects, (2) return on their cash is taxable and (3) firms are subject to an industry-level displacement rate.

First, firms in the model can either invest in risk-less investments, which deterministically increase their capital stock, or in risky projects, which occurs according to a Poisson process, and which only increases firms' capital stock if the investment is successful. The risky projects are meant to capture investments such as mergers and acquisitions and R&D, whose outcomes, unlike physical investments, are inherently uncertain. Second, firms' return on their cash reserve, which includes interest income, is assumed to be taxable. Hence, the return on cash is decreasing in the tax rate. Third, firms are subject to a displacement shock that they take as given.

¹[Demarzo and Sannikov \(2006\)](#); [DeMarzo and Fishman \(2006\)](#) illustrate how moral hazard problem can endogenously generates financial frictions.

Once a firm receives such a shock, it exits the economy and a new firm enters. The displacement rate is meant to reflect the force of creative-destruction and within industry competition: the former is driven by R&D investments, and the latter is mostly attributable to merges and acquisitions. Therefore, it is assumed that the displacement rate is determined by the aggregate risky investments within an industry. In the model, a firm maximizes its value by optimally managing its cash reserves, as well as its investment and payout decisions.

There are two main results in my analysis. First, when the tax rate on cash is lowered, firms respond by increasing their investment in risky projects and accumulating more cash. This outcome is contrary to the traditional view, which asserts that when the tax rate on risk-free assets (cash) is lowered, all else being equal, firms should shift their resources from risky investments to risk-free assets. Central to this first conclusion is the fact that risk-neutral firms behave as if they were risk averse, because they internalize the possibility of financial constraints. Hence, a decrease in the tax rate reduces a firm's risk aversion in two ways. The first is static: lower tax rates increase the carrying return of cash, consequently reduce the probability of a firm being constrained, and hence, reduce the firm's risk aversion. The second is dynamic: when the return on cash increases, firms respond by accumulating more cash. As firms build up their cash balance, they distance themselves from constraints, and thus become less risk averse. Decreased tax rates reduce firms' risk aversion, which in turn increases their risky investments.

My second result is that a lower tax rate leads to an increasingly concentrated economy. This result is due to the fact that higher firms' risk-taking can lead to a more dispersed distribution of those firms' sales, a situation that then gives rise to an increase in market concentration. When a firm invests in risky projects, it should expect a dispersed outcome: a series of successful projects could result in a rapid expansion of sales-whereas a number of failed projects could reduce its market share. From an ex-post perspective, a firm's productivity depends upon the realization of the ex-ante risks it takes. In the model, whether a project succeeds or not is due to pure luck, as no difference in fundamental productivity exists among firms.

Hence, with lower tax rates, firms are effectively less risk-averse, and they increase investment in risky projects. After uncertainty has been resolved, firms that have succeeded in their risky investments expand their sales and become "winners", whereas those whose risky projects failed lose their market share and become "losers." Over time, the industry is increasingly char-

acterized by the pattern “winner takes most.” As a result, market share is gradually concentrated among those winners.

In the model, the amount of risk-taking present in the economy as a whole is closely linked to the ensuing degree of increase in market concentration. To discipline the magnitude of the risk-taking channel, I have calibrated the model’s parameters for risky investments to match R&D-asset ratios for both multinationals and non-multinationals. The other parameters are set to be standard in the dynamic corporate finance literature.

To assess the quantitative impact of a decrease in the foreign tax rate, I consider the check-the-box regulation that was introduced in 1997 as an unexpected deterministic negative shock that lowers the tax rate on return of cash for multinational firms, by an amount implied by the difference between average foreign tax rate and US corporate tax rate. My assumption about the effects of this regulation is based on two observations. First, the check-the-box (CTB) regulation unexpectedly improved multinational firms’ ability to defer the taxation of passive income including return on foreign cash reserve². Second, foreign tax rates have been falling since 1990³. I then study the transition dynamics of the economy from the initial stationary equilibrium to the new one.

After the negative tax shock has taken place, the risk-taking that ensues is able to generate a sizable increase in market concentration as the economy settles into a new steady state: a naive extrapolation of the simulation implies that the top sales share increased by 6% during the first 20 years of transition, a figure that represents approximately one-third of the total observed increase in the data.

Following my discussion of transition dynamics, I present a number of facts that are con-

²Before the tax regulation in 2017, U.S. multinationals are permitted to defer tax liabilities on certain foreign profits until they are repatriated. However, under the Sub-part F provision of U.S. law, “passive income” that includes interest income and dividends received from investment in securities are immediately taxable by the U.S. even if it is not repatriated ([Fritz Foley et al. \(2007\)](#)). Nevertheless, with the introduction of CTB, firms can find a way to treat such payments as internal transfers and not subject to U.S. taxation ([Faulkender et al. \(2019\)](#), [Albertus \(2018\)](#), [Zucman \(2014\)](#), [Beer et al. \(2018\)](#)). In particular, [Blouin and Krull \(2014\)](#) document a growth of subsidiaries in tax haven countries and a growth of intercompany transfers following the introduction of CTB.

³[Faulkender et al. \(2019\)](#) calculate the average top corporate tax rate across the fifteen countries with the most cash in 1998 dropped from 38.7% to 29.0% between 1998 and 2008, while the U.S. corporate tax rate did not change. [Blouin and Krull \(2014\)](#) find that on average U.S. multinational firms’ worldwide tax rates declined by 4.3% in the post-1996 period. [Zucman \(2014\)](#) reports that over the last 15 years, the effective corporate tax rate of US companies has declined from 30 to 20 percent.

sistent with the model's predictions. First, there has been an increase in aggregate cash balance since the late 1990s, an increase due mostly to the activity of multinational firms. Second, compared with non-multinational firms, under conditions of lower taxation, multinationals increase their risky investments, such as R&D expenditure. Third, if more risks may lead to a higher level of dispersion, as my model predicts, it should be expected that within multinationals, industry sales will be increasingly concentrated in a small number of firms. I show that this predicted concentration is indeed the case. Specifically, each year, I calculate the sales share accounted for by the top 10% of multinational firms. I find that the top sales share for multinationals was stable prior to 1997, rising rapidly after the introduction of CTB in that year. The sales share of non-multinational firms, however, has remained unchanged from the years prior to 1997.

The model's predictions also match patterns observed after the introduction of the Tax Cuts and Jobs Act (TCJA) on December 22, 2017. This act substantially reduced firms' repatriation costs, as well as the tax incentive for firms to hold cash abroad⁴. The TCJA was intended to stimulate corporate investment and employment. However, the evidence up to this point suggests that for the most part, the act enabled US corporations to repurchase stock using cash. My model shows that after a negative shock in repatriation costs, multinational firms' payouts increase substantially, while their investments experience only modest growth, a pattern that is consistent with the observed data.

Finally, one alternative explanation for greater sales concentration is that top firms are simply more productive than other economic actors; hence, over time, increasing concentration merely reflects existing top firms' growing importance. To distinguish the role of risks and productivity, following [Gomez \(2018\)](#), I quantify their respective contribution by decomposing the growth of top sale share into two components: a within term and a displacement term. The within term quantifies the contribution of the sales growth of top firms if the composition of top firms was fixed, and the displacement term measures the sales of firms entering the top percentile minus the sales of firms that exit the top. If rising concentration is due to top firms

⁴The TCJA has two key elements: (1) a reduction in the corporate income tax rate from 35 percent to 21 percent, and (2) a one-time tax holiday that cuts the tax on cash repatriation from foreign subsidiaries from 35 percent to 15.5 percent. Also, the US corporate tax system also moved from a worldwide tax system to a territorial system in which benefits for delayed repatriation are effectively removed.

grow faster than the average, then the composition of top firms should remain stable over time and the displacement term should be small. Alternatively, if the rising concentration is due to risk-taking in the economy, one should observe a small within term and a large displacement term.

There are two findings. First, over the last two decades, the within term has remained negative, suggesting that on average, top firms grow slower than the rest of economy. This rules out this “top grows faster” hypothesis. On the other hand, the large displacement term also indicates that risks play an important role in explaining the upward trend in market concentration. Second, over time the within term has been rising and displacement term has fallen, suggesting that it has been increasingly difficult for non-top firms to replace the existing top firms. This trend is consistent with the slowdown of industry dynamism ([De Loecker and Eeckhout \(2018\)](#)).

Taken together, my evidence complements the “superstar firms” view [Autor, Dorn, Katz, Patterson, and Van Reenen \(2017\)](#) in suggesting that these ex-post “superstar firms” are relatively new to the top percentile, and might have gained their positions by engaging in successful risk-taking. Put differently, the “superstar firms” are merely ex-ante normal firms who have legitimately competed with other firms on the merits of their innovations and other risky investments. The winners among those firms then become the ex-post “superstars”.

Related Literature My paper relates to the theoretical literature studying the dynamic impacts of financial constraints. In this line of work, firms’ financial constraints can be exogenously introduced, as in [Bolton, Chen, and Wang \(2011, 2013\)](#), or endogenously generated from moral hazard problem, as in [Demarzo and Sannikov \(2006\)](#); [DeMarzo and Fishman \(2006\)](#) ⁵. While existing work mostly focuses on the impact of financial frictions on physical investment, my model emphasizes the role of finance-induced risk aversion and its macroeconomic implications. Importantly, since I show that more risk-taking can later lead to an increase in market concentration, my work suggests a novel mechanism through which financial frictions affect the macroeconomic environment, and also creates room for a broader series of potential policy considerations. Specifically, policies that ameliorate financing constraints are often considered

⁵See also [Biais, Mariotti, Plantin, and Rochet \(2007\)](#); [DeMarzo and Fishman \(2007\)](#); [Demarzo, Fishman, He, and Wang \(2012\)](#), and more recently [Hartman-Glaser, Mayer, and Milbradt \(2019\)](#).

separately from industrial policies. By identifying firms' financing-induced risk aversion as a potential cause of industrial concentration, my work lends support to the need for a joint analysis of financial development and industrial regulation.

The paper also contributes to research studying the causes of rising concentration. [Philippon and Gutierrez \(2019\)](#) argue that declined competition resulting from regulation has contributed to increased concentration. [Grullon, Larkin, and Michaely \(2019\)](#) provide supportive evidence for this view. [Autor, Dorn, Katz, Patterson, and Van Reenen \(2017\)](#), on the other hand, argue that rising concentration may result from adoption of technologies that improve productivity for large firms. [Crouzet and Eberly \(2018b,a\)](#) explore the role of intangibles in rising concentration. My model suggests that increased concentration may be one result of a lower foreign tax rate. While financial constraints result in firms being risk averse, lower tax rates reduce risk aversion and thus increase firms' risk taking, leading in turn to a rise in concentration. Hence, my paper complements the "superstar" view in suggesting these ex post productive superstars have gained their dominant positions through successful engagement in ex-ante risky projects.

Another related literature is the work on tax avoidance [Albertus \(2018\)](#); [Xu and Zwick \(2018\)](#); [Zwick and Mahon \(2017\)](#). Most of the existing literature focuses on the impact of transfer pricing and the strategic location of intellectual property. My paper focuses instead on the role of debt shifting and intra-company loans that affect the returns of passive income. I find that the presence of debt shifting reduces firms' risk aversion, and thus incentivizes risk-taking, which may lead to a more dispersed economy—a mechanism absent from the current literature.

Finally, this paper also relates to the literature on corporate cash holdings [Bates, Kahle, and Stulz \(2009\)](#); [Pinkowitz, Stulz, and Williamson \(2015\)](#). US multinational firms have accumulated large stocks of cash and financial securities in their foreign subsidiaries ([Fritz Foley, C. Hartzell, Titman, and Twite \(2007\)](#); [Faulkender, Hankins, and Petersen \(2019\)](#); [Graham and Leary \(2018\)](#)). My findings are consistent with existing literature that states that falling foreign tax rates, coupled with relaxed restrictions on tax avoidance, play an important role in explaining firms' cash reserve abroad.

2 Model

The model builds on [Bolton, Chen, and Wang \(2011\)](#), which developed a tractable framework for a firm's dynamic investment and liquidity management decisions in continuous time. I consider an industry that consists a large number of such firms, and study how the industry changes as one changes the carry cost of cash. I first describe the firm's physical production and investment technology. Next, I introduce the firm's external financing costs and its carry cost of holding cash. Finally, I state firm optimality.

2.1 Production

A firm's operating revenue is proportional to its capital stock K_t and is given by $K_t dA_t$, where dA_t is the firm's productivity shock over dt . The productivity shock of firm i is assumed to follow an arithmetic Brownian motion

$$dA_t = \mu dt + \sigma dB_t^i$$

Where dB_t^i is a standard Brownian motion. μ and σ denote the drift and volatility of the firm. Different firms in the industry have the same μ and σ but have independent productivity shock dB_t^i , that is $\text{corr}(dB_t^i, dB_t^j) = 0$.

2.2 Investment and Risk

There are two types of investments that firms can do to increase their capital stock K_t

The first is the standard risk-less investment whose opportunities are always available. By investing I_t , the capital stock increases but it also incurs a quadratic adjustment cost $G(I, K) = \frac{\theta}{2} i^2 K$ where $i = \frac{I}{K}$. This functional form is standard in the literature and the parameter θ measures the degree of the adjustment cost.

The second is the risky investment, whose opportunity comes as a Poisson process with intensity λ . The firm can only invest in risky project when the opportunity arrives. When it arrives, the firm decides whether to invest in it. If the firm does invest, the firm needs to pay the cost fK which is proportional to the existing capital stock. Otherwise, the opportunity is

forgone. The investment project is risky: with probability π the project succeeds, in which case the capital stock increases by ξ , with probability $1 - \pi$ the project fails and the capital stock remain unchanged. The uncertainty resolves instantaneously.

The setup of risky investment is very similar to [Krieger, Li, and Papanikolaou \(2019\)](#), where the firm has a spectrum of risky projects to choose from. To highlight the mechanism, there is only one type of risky project in our model, but it can be easily extended to multiple projects. In our model, the risky project can either be interpreted as acquiring a new customer base, as in [Krieger, Li, and Papanikolaou \(2019\)](#), or be thought of as gaining market share from other companies within the same industries, such as merges & acquisition activities. In the former interpretation, the risky project develops a new market and it does not affect other firms in the same industry. In the later interpretation, it facilitates creative destruction within the industry. I assume that firms are subject to random death in the industry, corresponding to the creative destruction within an industry. The death rate of an individual firm, which firms take as exogenously given, is proportional to the aggregate proportion risky investment projects in the economy. When a firm dies, it will be replaced by a new firm to ensure a stationary equilibrium. I will specify the relationship between death rate and aggregate risky investment later.

Therefore, the firm's capital stock evolves according to

$$dK_t = (I_t - \delta K_t)dt + \xi K_t dN_t 1_{invest \& success} - K_{t-} d\tilde{N}_t \quad (1)$$

where dN_t is the Poisson process that governs the opportunity of risky investment. As I will show later, firms may not always invest in risky projects. The last term is the indicator function that equal to one when the firm has the opportunity to invest and the project turns out to be successful. In case of the project failure or the firm decides to forego this opportunity, the indicator function equals to zero. The last term represents the random death of the firms. The death process is a Poisson process $d\tilde{N}_t$ with intensity γ . When it occurs, the firm's entire capital stock is wiped out. Here, $K_{t-} = \lim_{s \uparrow t} K_s$ denotes the left limit of capital stock K_t . Intuitively, K_{t-} represents capital stock just before the catastrophic event $d\tilde{N}_t \in \{0, 1\}$ realizes.

The firm's operating profit dY_t over time increment dt is then given by

$$dY_t = K_t dA_t - I_t dt - G(I, K) dt - fK dN_t 1_{invest} \quad (2)$$

Where $K_t dA_t$ is the firm's operating revenue, $I_t dt$ is the investment cost over time dt , $G(I, K) dt$ is the adjustment cost associated with risk-less investment, and fK is the investment cost of risky investment. Here, I do not impose tax on firm's operating income so that I can explore the impact of the tax rate on the return of cash holdings.

2.3 Liquidity Management

Let W_t denote the liquidity or the cash balance of the firm. If the firm has both domestic cash and foreign cash, as most of multinational firms do, I use to W_t denote the cash balance if all the cash were repatriated back to the US. This way, I am able to compare cash balance between multinational firms and non-multinational firms.

If the firm runs out of cash, in which case $W_t = 0$, it needs to raise funds to continue operating, otherwise its assets will be liquidated. To simplify the notation and highlights the central mechanism between carry cost of cash and risk preference, I assume that the firm has no access to capital market. Therefore, the firm has to liquidate its asset when the cash holding W_t reaches zero. In addition, the firm can liquidate its asset at any time. In liquidation, the firm recovers l_t per unit of capital where $0 < l_t < 1$. As I will show later on, firms' operations are productive so they will not voluntarily liquidate when $W > 0$.

The assumption that the firm has no access to finance is not consequential. In fact, even if the firm has access to the financial market, as long as the external finance is costly, the risk neutral firm will operate as if it was risk-averse. Admittedly, having no access to the financial market is an extreme form of costly external finance, and the degree of risk-aversion is positively related to severity of frictions in the financial market.

The firm can invest its cash holding in the market and earns interest rate r . The firm has to pay tax on its interest earnings, and it is characterized by a tax rate τ . So the dynamics for the

firm's cash W as follows:

$$dW_t = dY_t + r(1 - \tau)W_t dt - dU_t \quad (3)$$

Where dY_t is the firm's operating cash flow, $r(1 - \tau)W_t dt$ is the passive earning from investing cash holdings, and dU_t is the payout to investors.

2.4 Tax and Multinational firms

Background on US Tax Code The U.S. tax code affects not only the incentives of firms to hold foreign earnings abroad or to repatriate them back, but also the decisions of whether investments in risky projects should be made. This section describes the tax rules and how I map those rules into our theoretical analysis.

Almost all countries tax the income of corporations that operate within their borders. Besides, the U.S. and other countries tax the foreign income of their residents. To avoid double taxation, U.S. tax code grants tax credits for foreign income taxes paid abroad. U.S. multinational firms are allowed to defer their tax liabilities on certain foreign profits until they are repatriated. And when they do get repatriated, the taxes due are equal to the difference between foreign income taxes paid and tax payments that would be due if they were taxed at the U.S. rate⁶.

The extent to which multinational firms can defer tax liabilities is limited. Under the Subpart F provisions of U.S. tax code, the income classified as "passive income" are immediately taxable by the U.S. even if it is not repatriated. Passive income includes interest income and passive earnings and dividend received from investment in securities⁷. Therefore, multinational firms have to pay U.S. corporate tax rate on passive earnings even though the cash is invested abroad. The main purpose of Subpart F is to prevent U.S. citizens, resident individuals, and corporations from deferring the recognition of otherwise taxable income through the use of foreign entities,

⁶ This is the typical way of avoiding double taxation for countries under worldwide tax system: the residence country grant a tax credit against its own tax so that the tax is limited to the excess of the residence country's effective tax rate over that in the country in which the income is generated [Beer et al. \(2018\)](#)

⁷ Multinational firms (MNCs) generate income in two ways: selling products or services, which is known as active income, or investing their cash on hand, which is passive. The taxing rights of MNC income is based on the source of the income and the residence of the corporate taxpayer.

thereby creating a fair environment for economic entities to operate. Thus under the Subpart F, the net return on firm's cash holding should be $r(1 - \tau_D)$, where r is the earning of investments, and τ_D is the U.S. tax rate.

Tax Regulation and its Impact However, in 1997, the U.S. treasury enacted “check-the-box”(CTB) regulations, also known as Treasury Decision 8697, to allow firms to self-identify subsidiaries for tax purposes ([Albertus \(2018\)](#)). Originally, CTB was introduced to reduce the burden for small firms to apply to unincorporated business entities. The name “Check-the-box” means that small firms can elect their tax designation by simply checking a box on IRS form 8832.

One unintended consequence of the enactment of CTB is that multinational firms are also allowed to elect their organization designation for their foreign subsidiaries, for U.S. federal purposes. For example, a subsidiary in a foreign country can elect to be taxed as disregarded entity (DE) for U.S. federal tax purposes, and a DE reports on a consolidated basis with its parent under U.S. tax code [Albertus \(2018\)](#). Therefore, financial payments such as interest payments between a parent firm and a DE are not separately reported to U.S. tax authorities.

In effect, CTB allowed U.S. multinationals to defer passive incomes by treating those as internal transfers and not subject to U.S. taxation⁸, thereby reducing the tax rate on the passive income. Specifically, multinational firms may use internal loan to strip its foreign earnings. There are various empirical studies that confirm the presence of such behavior, by showing that international tax differentials have a positive and significant effect on internal debt of German MNCs ([Weichenrieder \(1996\)](#); [Buettner and Wamser \(2013\)](#); [Mintz and Weichenrieder \(2010\)](#)), on intra-firm interest and debt ratio of U.S. MNCs ([Grubert \(1998\)](#), [Altshuler and Grubert \(2003\)](#)), and on internal leverage of MNCs in Europe ([Barrios et al. \(2012\)](#)).

Although the aforementioned debt-related tax avoidance comes in various form, the essence of it involves a foreign subsidiary borrowing from a DE and paying interests to DE, which locates in low-tax countries, and deducting interest payments from tax liabilities in high-tax countries. Assuming that the operating subsidiary's income is subject to a positive foreign tax rate, the interest payment will generally be effective in reducing the tax burden on that entity's operations

⁸After 1997, there was a proliferation of Hybrids that was disregarded by the U.S. tax laws (DE) but were treated as a corporation in foreign jurisdiction [Faulkender et al. \(2019\)](#). [Albertus \(2018\)](#) discusses how the passive incomes such as patent royalties can meet the requirements for deferral.

because the disregarded entity will bear little or no foreign tax on its interest income.

Model's Tax Assumption In our model, the firms' active earnings Y_t are taxed at the U.S. tax rate τ_D . This tax rate applies to both multinational firms and non-multinational firms. That is, the model does not take into account the economic impact of deferring firms' active earnings, and that the cash balance W_t keeps track of the amount of cash if all the foreign cash were repatriated back to the U.S.. Instead, the model highlights the *difference on their passive earnings* between Multinational firms (MNC) and Non-multinational firms.

For Non-multinational firms, the tax rate on their passive income is the U.S. domestic tax rate τ_D . However, due to the reasons I layed out above, the effective tax rate for multinational firms is assumed to be lower: $\tau_{MNC} < \tau_D$. Indeed, if the firm has $D < 1$ fraction of domestic cash, over the next year its cash holding becomes:

$$W(1 + r(1 - \tau_{MNC})) = (DW)(1 + r(1 - \tau_D)) + ((1 - D)W)(1 + r(1 - \tau_F))$$

Where τ_F is the foreign tax rate at the place the cash resides. Thus, the effective tax rate for multinational firms can be written as a weighted average of domestic tax rate and foreign tax rate:

$$\tau_{MNC} = D\tau_D + (1 - D)\tau_F < \tau_D \quad (4)$$

There are two observations worth noting on the effective tax rate. First, if $\tau_F < \tau_D$, then overtime the cash abroad is growing faster and the fraction of domestic cash D is coming down. As a result, the effective tax rate τ_{MNC} will decreases. Second, over time the average foreign tax rate τ_F has been declining [Faulkender, Hankins, and Petersen \(2019\)](#). These two observations mean that the effective tax rate τ_{MNC} has been declining over the past decades. The theoretical analysis will be focusing on its impact on risk-taking, cash holdings, and on the aggregate level, industrial concentration.

2.5 Entry and Exit: Creative Destruction

Firms are subject to an exogenous shock that wipes out the value of its entire capital K and trigger immediate liquidation. This shock arrives according to a Poisson process with intensity γ . The Poisson process conceptually captures the endogenously creative destruction within an industry. When a firm succeeds in doing risky projects, it may acquire market share from other firms within the same industry. Thus, the intensity of this shock γ , is assumed to positively related with the fraction of successful risky projects in the economy. Similar assumptions were made in endogenous growth literature (e.g. [Jones and Kim \(2018\)](#)). Specifically, I assume that

$$\gamma = \gamma_0 \frac{\int_{W,K \in R^2} K dN_t 1_{\text{invest \& success}} g(W, K) dW dK}{\int_{W,K \in R^2} K g(W, K) dW dK} \quad (5)$$

$$1 = \int g(W, K) dW dK \quad (6)$$

Where $g(W, K)$ is the probability density function of the cross-sectional distribution over W and K . The parameter γ_0 measures the extent of creative destruction in the exogenous death. When $\gamma = 1$, it means that all the gains from risky projects are coming from the obsolete capital from firms in the same industry. When a firm receives such shock, it exits the market. At the same time, it is replaced with a new firm with capital stock K_0 and cash holding W_0 . This assumption is needed to guarantee a stationary equilibrium and ensures the model is well-behaved.

2.6 Industry Equilibrium

In equilibrium, firms decisions depend on individual state variable specific to a particular firm, and aggregate state variable that are common to all firms in the industry. The individual state variables are capital stock K_t and cash holdings W_t . The aggregate state variable is the exogenous replacement rate γ , which is affected by the cross-sectional distribution of firms over their individual state variables $g(W, K)$.

In such industry, each individual firm takes the aggregate variable – the exogenous replacement rate γ – as given. A firm chooses its risk-less investment I , whether to take risky invest-

ment R_t , cumulative payout policy U , and liquidation time to maximize the firm value.

$$P(W_t, K_t) = \max_{I_t, R_t, U_t, \tau} E_t \left(\int_t^\tau e^{-r(s-t)} dU_s + e^{-\tau r} (L_\tau + W_\tau) \right)$$

The first term is the discounted value of net payouts to shareholders, and the second term is the discounted value upon liquidation. When the liquidation value l is low, firm never voluntarily liquidate when cash holdings is positive $W_t = 0$. That is, firm only liquidates when the cash is zero. The liquidation value $L_t = lK_t$ when the firm is run out of cash, and $L_t = 0$ when the firm receives a shock that depletes all its capital.

On the aggregate level, the exogenous replacement rate is a function of individual firm's choice and the cross-sectional distribution of firms, as given by 5. The cross-sectional distribution evolves according to the following equation (see appendix for derivation):

$$\begin{aligned} \frac{dg_t(W, K)}{dt} = & -\frac{\partial}{\partial K} [\mu_K(W, K)g(W, K)] - \frac{\partial}{\partial W} [\mu_{W,t}(W, K)g(W, K)] + \frac{1}{2} \frac{\partial^2}{\partial W^2} [\sigma^2 K_t^2 g(W, K)] \\ & + \lambda \mathbf{1}_{\text{Invest}}(W - fK, \frac{K}{1+\xi}) \pi P(W - fK, \frac{K}{1+\xi}) - \lambda \mathbf{1}_{\text{Invest}}(W, K) P(W, K) \\ & + \mathbf{1}_{\text{Invest}}(W + fK, K) (1 - \pi) P(W + fK, K) - \gamma g_t(W, K) + \gamma g_0(W_0, K_0) \end{aligned} \quad (7)$$

where $\mathbf{1}_{\text{invest}}(W, K)$ is the indicator function of whether to invest in the risky project for a firm with W and K , and

$$\mu_K(W, K) = I(W, K) - \delta K \quad (8)$$

$$\mu_W(W, K) = (r - \lambda)W + \mu K - I(W, K) - G(I, K) \quad (9)$$

are the drifts of capital stock and cash holdings, respectively. The equation (7) is known as Kolmogorov Forward Equation. The first term on the right hand side of (7) captures the evolution of distribution g due to the dynamics of capital stock. The second and third terms captures the effect of drift, diffusion of cash holdings. The fourth, fifth, and sixth terms captures the change of distribution due to the risky investments: the fourth term captures the density inflow from state $(W - fK, \frac{K}{1+\xi})$ if risky investments are made and succeeded at that state. The fifth term

captures the density outflow if firms invest in (W, K) . The sixth terms captures the density inflow from state $(W + fK, K)$ if investments are made and failed at that state. The last two terms captures the entry and exit.

3 Model Solution

This section characterizes the solution of the firm's problem. Since a firm has to cease operation when the cash becomes zero, the firm's value depends on both its capital stock and its cash holding W_t . Due to tax friction the internal earning rate is lower than r , one would expect that the firm pays out some of its cash when the stock is beyond certain levels \bar{W}_t . The firm will find itself in one of the following regions (i) liquidation region ($W_t = 0$) (ii) interior region ($0 < W_t < \bar{W}_t$) and (iii) the payout region ($W_t \geq \bar{W}_t$).

When the firm's cash holdings W_t is in the interior region $(0, \bar{W}_t)$, the firm value $P_t(K, W)$ at time t satisfies the following Hamilton-Jacobi-Bellman (**HJB**) equations:

$$\begin{aligned} rP_t(W, K) = \max_I & (I - \delta K)P_{K,t} + [(r - c)W + \mu K - I - G(I, K)]P_{W,t} + \frac{\sigma^2 K^2}{2} P_{WW,t} \\ & + \lambda 1_{Invest} [\pi P_t(W - RK, (1 + \xi)K) + (1 - \pi)P_t(W - RK, K) - P(W, K)] \\ & + \gamma_t(W - P(W, K)) + \frac{1}{dt} E[dP_t(W, K)] \end{aligned} \quad (10)$$

The first term represents the marginal value of net investments on firm value. The second and the third term captures the effects of the expected change in the firm's cash holdings and volatility of cash holdings on firm value, respectively. The third term represents the effects of risky investments on firm values. The last term represents the change associated with exogenous death.

The aggregate variable depends on the cross-sectional distribution of W, K :

$$\gamma_t = \gamma_0 \frac{\int_{W, K \in R^2} K dN_t 1_{invest \& success} g_t(W, K) dW dK}{\int_{W, K \in R^2} K g_t(W, K) dW dK} \quad (11)$$

and the distribution $g(W, K)$ evolves according to the Kolmogorov Forward Equation (**KFE**):

$$\begin{aligned} \frac{dg_t(W, K)}{dt} = & -\frac{\partial}{\partial K}[\mu_K(W, K)g(W, K)] - \frac{\partial}{\partial W}[\mu_{W,t}(W, K)g(W, K)] + \frac{1}{2}\frac{\partial^2}{\partial W^2}[\sigma^2 K_t^2 g(W, K)] \\ & + \lambda \mathbf{1}_{\text{Invest}}(W - fK, \frac{K}{1+\xi})\pi P(W - fK, \frac{K}{1+\xi}) - \lambda \mathbf{1}_{\text{Invest}}(W, K)P(W, K) \\ & + \mathbf{1}_{\text{Invest}}(W + fK, K)(1 - \pi)P(W + fK, K) - \gamma g_t(W, K) \end{aligned} \quad (12)$$

I define **Steady State** as an equilibrium with constant aggregate replacement rate γ and time-invariant distribution $g(W, K)$.

In steady state, the dynamic system is given by

$$\begin{aligned} \textbf{HJB: } rP(W, K) = & \max_I (I - \delta K)P_K + [(r - c)W + \mu K - I - G(I, K)]P_W + \frac{\sigma^2 K^2}{2}P_{WW} \\ & + \lambda \mathbf{1}_{\text{Invest}}[\pi P(W - RK, (1 + \xi)K) + (1 - \pi)P(W - RK, K) - P(W, K)] \\ & + \gamma(W - P(W, K)) \end{aligned} \quad (13)$$

$$\begin{aligned} \textbf{KFE: } 0 = & -\frac{\partial}{\partial K}[\mu_K(W, K)g(W, K)] - \frac{\partial}{\partial W}[\mu_{W,t}(W, K)g(W, K)] + \frac{1}{2}\frac{\partial^2}{\partial W^2}[\sigma^2 K_t^2 g(W, K)] \\ & + \lambda \mathbf{1}_{\text{Invest}}(W - fK, \frac{K}{1+\xi})\pi P(W - fK, \frac{K}{1+\xi}) - \lambda \mathbf{1}_{\text{Invest}}(W, K)P(W, K) \\ & + \mathbf{1}_{\text{Invest}}(W + fK, K)(1 - \pi)P(W + fK, K) - \gamma g_t(W, K) \end{aligned} \quad (14)$$

I solve for the steady state equilibrium using the iterative approach in the literature, which consists of the following steps:

Step 1. Make an educated guess of the displacement rate in the equilibrium γ_0 .

Step 2. Solve the HJB equation for a single firm using γ_0 as given.

Step 3. Simulate the model so that I obtain a stationary distribution, and calculate the displacement rate γ_1 .

Step 4. Replacing the γ_0 in step 2 with the γ_1 calculated from step 3, and repeat step 2 - step 3 until γ_0 and γ_1 are sufficiently close.

Among these steps, step 3 is straightforward, so I focus on our discussion on step 2, which is similar to the problem in the dynamic finance literature.

The production technology in our model is essentially the same as the one used in [Bolton, Chen, and Wang \(2011\)](#), [Demarzo, Fishman, He, and Wang \(2012\)](#). In these papers, the homo-

geneity in the production technology, adjustment costs and risky investment costs allow us to study the impact of corporate tax code on corporate investment, liquidity hoarding, risk-taking in an analytically tractable framework.

Because firm value is homogeneous of degree one in W and K in each state, I can write $P(K, W) = p(w)K$, where $w = \frac{W}{K}$ is the cash-capital ratio. Substituting this expression into the previous equation and simplifying, I obtain the following ordinary differential equation for $p(w)$:

$$\begin{aligned} r p(w) = & (i(w) - \delta)(p(w) - w p'(w)) + ((r - c)w + \mu - i(w) - g(i(w))) p'(w) + \frac{\sigma^2}{2} p''(w) \\ & + \lambda 1_{Invest} \left(\pi(1 + \xi) p\left(\frac{w - R}{1 + \xi}\right) + (1 - \pi) p(w - R) - p(w) \right) + \gamma(w - p(w)) \end{aligned}$$

The first order condition for the investment capital ratio $i(w)$ is

$$i(w) = \frac{1}{\theta} \left(\frac{p(w)}{p'(w)} - w - 1 \right)$$

Where $p'(w) = P_W(K, W)$ is the marginal value of cash.

Payout Boundary \bar{W} : The firm starts paying out dividend when the marginal value of cash inside the firm is less than the marginal value of dividend. Therefore, the payout boundary $\bar{w} = \bar{W}/K$ thus satisfies the following value matching condition

$$p'(\bar{w}) = 1$$

In other words, the marginal value of cash when the firm decides to payout is one, which is equal to the risk neutral valuation of dividend. Otherwise, the firm can do better by holding more cash. In addition, the payout boundary is optimally chosen, so that the boundary also satisfies the super-contact condition

$$p''(\bar{w}) = 0$$

When the marginal value of cash is less than 1, the firm is better off paying out a lump-sum

dividend and reducing its cash holding to \bar{w} . Therefore, when $w \geq \bar{w}$, I have

$$p(w) = p(\bar{w}) + (w - \bar{w})$$

Liquidation: Recall that the firm always has the option to liquidate the firm and recover l per unit of capital. Under our assumptions, the firm's capital is productive so the firm never voluntarily liquidates itself before it runs out of cash. The firm has to liquidate when it exhausts its cash holdings, then:

$$p(w) = l \text{ for } w \leq 0$$

when the firm receives the exogenous shock with intensity γ , the remaining capital is completely obsolete and therefore has no market value. In this case, I have $p(w) = 0$.

3.1 Risk-taking Policy

There are two sub-regions in the interior region, and they differ in whether the firm invests in risky project. I show that when the cash balance is low, the firm optimally forego risky investment opportunities. The firm only chooses to invest in risky investment when they have sufficient liquidity buffer W .

For a firm with cash holdings W and capital stock K , the net present value of a risky investment is

$$NPV(W, K) = \pi P(W - RK, (1 + \xi)K) + (1 - \pi)P(W - RK, K) - P(W, R)$$

The first term is the value of the firm when the risky project becomes successful, which is with probability π . If the risky project fails, which comes with probability $1 - \pi$, the firm's cash balance is reduced, which is represented by the second term. The third term is the firm's original value. Since the firm value and production is homogeneous of degree one in K , I can write

down the Net Present Value (NPV) of the risky investment project per unit of capital:

$$NPV(w) = \underbrace{\pi(1 + \xi)p\left(\frac{w - R}{1 + \xi}\right) + (1 - \pi)p(w - R) - p(w)}_{\text{Expected value}}$$

the firm only invests in the risky project when its NPV is positive.

The NPV of the project is increasing in the firm's cash holding. This result is intuitive. The risky investment project trades off the upside expansion ξK , which the firm gets in case of success, with the liquidity loss RK , which the firm suffers in case of project's failure. Because the firm has to costly liquidate when the cash holdings become zero, it accumulates cash to reduce the cost of potential liquidation in the future. The higher the cash holding, the lower the probability of future liquidation. Therefore, marginal value of cash $p'(w)$ is decreasing in w . When the cash balance is low, the project failure gets firm closer to the liquidation region, which is very costly to the firm and makes the risky project unappealing. On the contrary, when the cash balance is high, the benefit of success outweighs the liquidity loss associated with the failure, so the NPV becomes positive.

Figure 10 illustrates this tradeoff. With the cutoff strategy, I can write down the dynamics in these two sub-regions⁹: (1) The cash accumulation region where the firm optimally foregoes the risky investment. (2) The risk-taking region where the firm chooses to invest in risky projects.

Cash accumulation region : $w_t \in (0, \tilde{w})$. In this region, a firm forego all the risky investment opportunities, so that its HJB is:

$$(r + \gamma)p(w) = \gamma w + (i(w) - \delta)(p(w) - wp'(w)) + ((r - c)w + \mu - i(w) - g(i(w)))p'(w) + \frac{\sigma^2}{2}p''(w)$$

⁹From figure 10 one can observe that firms also invest in risky projects when the cash ratio is very close to zero. This risk-shifting behavior is caused by the fact that the downside of failure is limited when cash ratio is sufficiently small. But its impact in our model is very limited. See some citations for its relevance..

where the dynamics of cash holdings and capital stock are given by:

$$\begin{aligned} dK_t &= (I_t - \delta K_t) dt \\ dW_t &= K_t dA_t - I_t dt - G(I, K) dt + (r - \lambda) W_t \end{aligned}$$

Risk-taking region : $w_t \in (\tilde{w}, \bar{w})$. In this region, a firm invests in all the available risky projects, so that its HJB is:

$$\begin{aligned} (r + \gamma)(w) &= \gamma w + (i(w) - \delta)(p(w) - wp'(w)) + ((r - c)w + \mu - i(w) - g(i(w)))p'(w) + \frac{\sigma^2}{2} p''(w) \\ &\quad + \lambda \left(\pi(1 + \xi)p\left(\frac{w - R}{1 + \xi}\right) + (1 - \pi)p(w - R) - p(w) \right) \end{aligned}$$

The dynamics of cash holdings and capital stock are given by:

$$\begin{aligned} dK_t &= (I_t - \delta K_t) dt + \xi dN_t 1_{success} \\ dW_t &= K_t dA_t - I_t dt - G(I, K) dt - RK dN_t + (r - \lambda) W_t \end{aligned}$$

And the switching threshold is characterized by the condition that the NPV of the risky project is zero. This condition determines the value of \tilde{w} .

$$\pi(1 + \xi)p\left(\frac{\tilde{w} - R}{1 + \xi}\right) + (1 - \pi)p(\tilde{w} - R) - p(\tilde{w}) = 0$$

When the cash holdings is low, the firm does not invest in risky projects and retains profits to accumulate cash. When the firm has sufficient cash, the liquidation concern is low so it invests in risky projects. This insight can be applied to household setting, and [Liu \(2014\)](#) shows that it could lead to asset selection when household has a desire to guarantee a minimum level of wealth. When the cash balance is so high that the marginal value of cash is equal to the marginal value of dividend payout, the firm starts paying out dividend.

3.2 Ex-ante Risks and Ex-post Dispersion

Firms take more risks by investing in risky projects when they have sufficient liquidity. I show that ex-ante risks, after realization, manifest themselves as ex-post dispersion in firms' sizes. First, I characterize this result in a simplified theoretical framework to illustrate the logic between risks and dispersion. In the next section, I show that the numerical results are consistent with the theoretical analysis.

The dynamics for firm's size can be written as

$$dK_t = (I_t(w_t) - \delta K_t)dt + \xi \pi dN_t K_t \mathbf{1}_{risky} \quad (15)$$

The indicator functions $\mathbf{1}_{risky}$ is one in the risk taking region and zero in the cash accumulation region.

Firms in the model exit the market for two reason: first, firms may exhaust their cash holdings due to operations; second, firms may exit due to exogenous shocks that change their cash holdings to zero. If one firm exits the industry, I assume another firm enter the industry with capital stock K_0 and capital-cash ratio w_0 . Under our assumptions, capital are productive – the drift of productivity is sufficiently high – so that most of the exits are due to exogenous shocks rather than cash decreasing to zero because of operational expenses. Thus, I can approximate the dynamics of capital stock in our model by assuming that it is only subject to a random reset with Poisson density γ .

The following proposition provides the theoretical link between risks and dispersion in a simplified framework.

Proposition : Suppose that K have the following dynamics

$$dK = (I - \delta K)dt + \xi \pi K dN_t \mathbf{1}_{risky} \quad (16)$$

and that the process subject to Poisson reset with positive rate γ . The resulting stationary distribution of K is a Pareto distribution. The Pareto parameter a ¹⁰ is smaller for the case with

¹⁰The parameter a is also known as Pareto Index. A Pareto Index of 1.16 means top 20% of the population has about 80% of the sales, corresponding to the 80-20 rule. See [Gabaix \(2009\)](#) for its use in modeling income and

risky investment than the case without risky investment, meaning that the former distribution is more dispersed than the latter.

To see this, note that the Kolmogorov Forward Equation (KFE) of K is (see Appendix for derivation)

$$\frac{\partial p(k, t)}{\partial t} = -(i - \delta) \frac{\partial}{\partial k} [p(k, t) k_t] + \lambda \pi \left[\frac{p(\frac{k}{1+\xi}, t)}{1+\xi} - p(k, t) \right] - \gamma p(k, t) + \gamma p(k_0, t)$$

It is known in the literature that one candidate solution to this problem is Pareto Distribution. If I insert the Pareto distribution density $p(k, t) = C k^{-a-1}$:

$$\gamma = (i - \delta) a + \lambda \pi ((1 + \xi)^a - 1) \mathbf{1}_{risky} \quad (17)$$

The Pareto coefficient a is determined by 17. Since $(1 + \xi)^a - 1$ is positive, the a that solves the equation with risky investments should be lower than the one without risky investments. Therefore, the resulting distribution has a fatter tail (i.e., more dispersed) in the presence of risky investments.

4 Quantitative Results

I first calibrate the model, then provide a quantitative analysis of the effects of the reduced tax rates on investment, cash and on the aggregate level, the industrial concentration.

4.1 Parameter Choices

In the choice of parameters, I select plausible numbers based on existing literature to the extent that is available. For those parameters on which there is no empirical evidence I make a guess to reflect the situation I am seeking to capture in the model.

I adopt the parameters values that are in line with the estimates in [Eberly, Rebelo, and Vincent \(2008\)](#), who provide empirical evidence in support of [Hayashi \(1982\)](#). In particular, I set the

wealth inequality.

mean and volatility of the productivity shock to $\mu = 0.18$ and $\sigma = 0.09$, respectively. The risk free rate is 0.07 and the depreciation rate is 10%. The liquidation value l is 0.9, as suggested in [Hennessy and Whited \(2007\)](#).

I set the U.S. domestic tax rate as 35%, and the effective foreign tax rate as 20%. These numbers are consistent with [Zucman \(2014\)](#). The tax rates imply that the carry cost of cash are $0.07 * 0.35 = 2.4\%$ and $0.07 * 0.2 = 1.4\%$ for Non-MNCs and MNCs, respectively.

No empirical study exists on which I can rely for the estimates of the return distribution of risky investments. The choice for the risky projects parameter reflects the fact that risky investments are inherently uncertain. The success probability π is set at 0.10, which means that 1 out of 10 projects will be a success. The jump size ξ is set at 0.20, meaning that the firm's capital base increases by 20% if the projects succeeds.

I calibrate the frequency of risky projects λ , and the cost of the risky projects R to match the median R&D-assets ratio for US multinationals and non-multinationals. For the median firm, the R&D-assets ratio is 0.4 for MNCs and 0.29 for non-MNCs. If the frequency of risky projects is high, firms will have high R&D ratios. And if the costs are low, then the difference between the R&D ratio of multinational firms and non-multinational firms is small. Hence, the level of R&D ratio together with the difference between multinational firms and non-multinational firms would help pin down the parameter values. The details of data construction are given in Appendix. I then obtain $\lambda = 2.7$ and $R = 0.02$. This implies that a firm on average invests two to three projects per year, and that each project requires an amount of investment that equal to 2% of the total assets. Table 1 summarizes the parameters in the model.

4.2 The Numerical Solution

The goal of the model is to assess the impact of foreign tax rate on (1) risky investments and (2) market concentration. In this subsection, I study its effect on risky investment by solving for the policy functions for MNCs and non-MNCs, with the only difference between these two groups being their tax rates.

Based on our baseline parameter values, the payout boundaries are 0.18 for MNCs and 0.14 for Non-MNCs. Moreover, as I discussed in the previous section, MNCs generally find risky investments more attractive: MNCs start investing in risky projects as long as the cash ratio

Table 1: Summary of Key Variables and Parameters

Parameter List		
Parameter	Symbol	Value
<i>Production</i>		
Risk-free rate	r	0.07
Rate of depreciation	δ	0.10
Mean of productivity	μ	0.18
Volatility of productivity	σ	0.09
Adjustment cost	θ	1.50
Capital liquidation value	l	0.90
<i>Tax</i>		
Tax rate for multinationals	τ_{MNC}	0.20
Tax rate for non-multinationals	τ_{nonMNC}	0.35
Carry cost for multinationals	c_{MNC}	0.14
Carry cost for non-multinationals	c_{nonMNC}	0.24
<i>Risky Projects</i>		
Frequency of risky projects	λ	2.70
Success Probability	π	0.10
Jump size (if success)	ξ	0.20
Cost	R	0.02

Notes: The table reports parameter values.

is higher 0.12. Non-MNCs, on the contrary, are more conservative, and their risky investment boundary is 0.13. The value function is above the liquidation value for all $w > 0$, which validates the assumption that firms won't liquidate unless they have to.

Figure 8 plots the value of MNCs and Non-MNCs $p(w)$ and their investments and payout boundaries $w_{\text{risky mnc}}$, \bar{w}_{mnc} , respectively. For MNCs, when the cash ratio reaches the upper bound \bar{w}_{mnc} , it is optimal for the firm to pay out any cash in excess of \bar{w}_{mnc} . The value function becomes linear beyond the payout threshold. At the boundary, the marginal value of liquidity inside the firm is equal to the marginal value of payout. When the cash is between the risky

investment region $w \in (w_{riskymnc}, \bar{w}_{mnc})$, the firm invests in risky projects once it has the opportunity. When the cash ratio is lower than the risky investment region, the firm accumulates cash and forego all the risky investments. Indeed, in the cash accumulation region, the firm finds the downside of risky project too costly relatively to its upside.

It is important to note that higher return on cash holdings effectively lowers MNCs' risk-aversion, even with the same level of cash. To understand why, first note that risk neutral firms behave as if they are risk averse because the presence of costly liquidation when the cash balance is zero. In the dynamic environment, even firms that are away from the liquidation region are taking into account the future possibility of the costly liquidation. The probability of the potential liquidation is decreasing in firms' cash holdings, so that firms are less risk-averse when they have sufficient liquidity holding. Because of this, the dynamics of cash holdings also affect the possibility of liquidation in the future: the higher the drift of cash dynamics, the less likely the firms will run out of cash and liquidate in the near future. Therefore, even with the same cash holdings, MNCs are less risk averse than Non-MNCs.

On the other hand, the lower tax rate on cash incentives firms to accumulate more cash as its returns increase. And over time, with higher level of cash, the firm's risk-aversion is also diminished.

The difference in their effective risk aversion cause them to have difference preference over risky projects. In the model, the NPV of a risky project involves a trade-off between a size growth (success) and a higher probability of liquidation (failure). One would expect that MNCs firms, with relatively lower risk aversion, find risky projects more attractive than non-MNCs.

Figure 11 plots the net present value of risky projects for MNCs and Non-MNCs. The NPV of the risky project increases as the firm becomes less constrained and liquidation becomes less likely. The curvature of the curve confirms that firms behave as if they were risk averse. Intuitively, the marginal value of a dollar is lower when the cash ratio is higher $p''(w) < 0$. MNCs have a lower accepting threshold for risky projects $w_{riskymnc} < w_{riskynonmnc}$. Also, the higher carry return of cash lowers the gap between the marginal value of inside liquidity and outside dividend, and increases the payout boundary for MNCs.

Figure 9 plots the investment-capital ratio $i(w)$. Similar to the previous models, the investment-capital ratio $i(w)$ is increasing in w and reaches the peak at the payout boundary \bar{w} . The

investment-capital ratio drops rapidly when cash-capital ratio is close to the liquidation. Relative to MNCs, lower carry return on cash increases the severity of financing constraints for Non-MNCs, therefore leading to more underinvestment.

To summarize, because of the difference in tax rates, relative to Non-MNCs, MNCs have

- Higher carry return on their cash
- Lower threshold for risky investments
- Higher payout boundary

4.3 The Impact of Tax on Market Concentration

In this subsection, I analyze the impact of foreign tax rate on market concentration. To this end, I simulate the steady state when there is no tax rate difference between MNCs and Non-MNCs, so all the firms are identical in their fundamentals. Next, I implement the CTB policy change in the model by lowering the tax rates on cash for MNCs and calculate the level of market concentration for MNCs and non-MNCs, respectively.

Next, I investigate the stationary distributions for the key variables tied to the optimal firm policies. Before the introduction of CTB in January 1997, all the firms' passive earnings are taxed at the U.S. rates. That is, I assume away the distortion of tax policy, if any, before 1997. Two observations lend support to this assumption. First, CTB was known to facilitate the practice of tax avoidance. Second, the foreign tax rates on average had been higher than U.S. tax rates until late 1990s. ([Faulkender et al. \(2019\)](#)).

I simulate 20000 Non-MNCs and MNCs with the same initial condition: $K_0 = 100$ and cash $W_0 = 10$. The time interval dt is 0.1 year in our model, so each year consists of 10 periods. Once a firm exits, it is replaced with a new firm with (K_0, W_0) . In this case, both types of firms have the same tax rates and are therefore identical. Nevertheless, the stochastic realization in their diffusion process and risky investments can generate sizable cross-section heterogeneity. To get the stationary distribution, I simulate the model for 100 years and use the last 10 years data as the stationary distribution.

Figure 12 plots the stationary distribution of cash-capital ratio. The cash holding of a firm are close to the boundary for the most of the time, meaning that the firm's policy is effective at

maintaining sufficient liquidity and keeping itself away from the liquidation. Figure 13 shows the distribution of capital stock in the steady state. Most firms in the economy are relatively small. In fact, the majority of firms don't grow beyond their injection point $k_0 = 100$ due to depreciation and underinvestment. However, a few firms are quite large and lies on the right tail of the distribution. In our model, firms grow larger because of both positive realization in diffusion process and risky projects. Initially, firms grow because of positive realization of the diffusion process. After a positive realization of productivity shock, the firm generates revenue and invests in its capital stock. Once the firm's cash holdings is sufficiently high, it start taking risky projects. The risky project has low probability of success, but once it succeeds, it produces substantial returns in term of firm's size. In the aggregate level, the realization of the uncertainty associated with risky projects generate a sizable dispersion in the size distribution.

Figure 14 plots the time series of the fraction of capital accounted for by the top 10% of the firms. The initial condition sets the starting point to be 10%. The number grows rapidly in the beginning and it gradually slows down as the convergence at the tail is considerably slower than the mass of the distribution (Gabaix, Lasry, Lions, and Moll (2016)). Over time, the top 10% firms account for increasingly large share of the economy. The number converges to 45% when all firms are taxed at the U.S. domestic rate.

4.4 The Impulse Response of Check-The-Box

The enactment of CTB in Jan 1997, effectively allowed U.S. multinationals to defer passive incomes by treating those as internal transfers and not subject to U.S. taxation. I map the introduction of CTB in the model by changing the tax rate of passive income for MNCs firms from U.S. domestic rate $\tau_{Non-MNCs} = 35\%$ to a lower tax rate $\tau_{MNCs} = 20\%$, in the year of 1997. These number bring the carry return of cash to 5.6% for MNCs and 4.6% for Non-MNCs. Previous sections show that the small difference in tax rates leads to a meaningful distinction on firm's liquidity decisions and investment policies. In this section, I ask if these differences can generate substantial implication on market concentration.

To answer this question, I start from the stationary distribution obtained in the last section and change the passive tax rate for MNCs to 20%. I then simulate the path to the new steady state. The detail for calculating the path is in appendix, and it basically involves the following

steps: (1) Guess and verify the new steady state, as in the previous section (2) Using the average of the displacement rate as the displacement rate on the path, and then calculate the path. The time interval dt is 0.1 year in our model, so each year consists of 10 periods.

Figure 10 shows that once the passive tax rate is lower, a multinational firm increases its payout boundary and is more willing to invest in risky projects. After the tax policy change, one would expect that (1) cash ratio to rise and (2) higher ratio of risky investment. Figure 15 shows the cash ratios of MNCs rise rapidly after the tax policy change. This is not surprising given that most firms are close to the payout boundary. Once the tax rate comes down, the payout boundary becomes higher and firms accumulate cash to reach the new boundary. At the same time, the risky investment threshold also decreases. MNCs under the lower tax rate are willing to take risky projects that they would not have taken had the rate not decrease. As a result, the fraction of risky investment within the MNCs rises. Figure 16 plots the average ratio of risky investment over capital stock and it shows that it is increasing for MNCs. The initial distance between their risky investment ratios due to the fact that the threshold for risky investment comes down so a number of firms can start investing in risky projects immediately. To summarize, MNCs hoard more cash and invest more in risky projects relative to Non-MNCs.

More importantly, I argue that ex-ante risk, after realization, manifest themselves as ex-post dispersion. In a simplified theoretical framework, I have shown that the presence of risky projects increases the dispersion in the stationary distribution. On the other hand, the higher fraction of risky investment may facilitate creative destruction in the aggregate level, raising the displacement rate, and thus reduces the dispersion. Under our parameter values, the sensitivity of creative destruction with the total amount of risky projects is relatively low, so that the rise in death rate is far from offsetting the increased dispersion from risky projects. This observation in the model is also consistent with the literature documenting a recent decline in business dynamism.

Figure 17 plots the within group concentration for MNCs and Non-MNCs. It calculates the fraction of capital stock accounted for by the top 10% of firms in each period, and then take average for each year. The blue line corresponds to the ratio for MNCs. The capital accounted for by the top 10% for MNCs has increased significantly: from 40% in 1997 to 47% in 2017, an approximately 20% increase. This pattern is consistent with Autor, Dorn, Katz, Patterson, and

[Van Reenen \(2017\)](#). It is worth noting that the new steady state is not reached after 20 years of convergence, in fact, it takes a very long time to converge, and I am indeed showing the initial transition path.

4.5 Summary of Model's Predictions

The model stresses the important of tax differential on firm's policies, and therefore it can be tested by comparing MNCs and non-MNCs in the data. To summarize, the model has the following predictions:

- Multinationals accumulate more cash than non-multinationals.
- Multinationals, relative to non-multinationals, increase their investment in risky projects.
- Multinationals become increasingly concentrated over time, meaning that the top firms in multinationals take increasingly amount of market share.

In the next section, I provide empirical evidence on these predictions.

4.6 Empirical Evidence on the Risk-Taking Channel

In this section, I present evidence that is consistent with model's predictions. Specifically, I show that

- Cash ratio has been rising since late 1990s, and the rise is mostly accounted for by the MNCs.
- In the late 1990s, MNCs increase their R&D investment, which is a form of risky projects ([Hall and Lerner \(2014\)](#); [Brown et al. \(2009\)](#)).
- The sales among multinational firms are becoming increasingly concentrated than that of non-multinational firms: the share accounted for by the top 10% in multinational firms has been increasing, while that of non-multinational has remained flat.

The Definition of Multinational Firms The accounting data is from Compustat-CRSP Merged database. Compustat contains information about the geographical segments where firms operate. The segments information allows us to classify whether the firm is a multinational. Financial accounting standards (FAS) No.131 requires firms to report foreign operations if foreign assets, income or revenue exceed 10% of total activities. The SEC also stipulates that firms to report foreign income taxes if these exceed 5% of total income before taxes. I follow [Fillat and Garetto \(2015\)](#) and [Fritz Foley et al. \(2007\)](#) in defining multinationals: firms that (1) report the existence of a foreign geographical segment associated with positive sales and (2) not missing both Pretax income (Data item 273) and Income tax –Foreign account (Data Item 64) are classified as multinationals. All other firms are classified as domestic.

Rising Sale Concentration Figure 1 plots the fraction of sales accounted for by the largest 5 firms in each NAICS 3-digits industries. The blue line first calculate the sum of sales for all the top 5 firms in each year, and then divide it by the total sales in the given year. It initially decreased from 75% in early 1980s to 55% in 1997. After 1997, it starts to rise and reaches 62% in 2015. In the dashed line, I first calculate the fraction of sales accounted for by Top 5 firms in each NAICS 3-digits industries, and then take the average. Both lines exhibit the same pattern and the turning point 1997 is the same time when CTB was introduced and foreign tax rate starts to become lower than the U.S. domestic tax rate. This is consistent with the finding from [Grullon et al. \(2019\)](#).

Cash Ratio The large increase in corporate cash balances in recent years has received much attention from the academic literature. Figure 4 plots the mean, median and aggregate cash for U.S. public firms from Compustat. Although the rise of average of cash starts as early as 1990, the aggregate cash ratio has been flat until the late 1990s. While recent changes in characteristics of publicly traded firms can account for the rise in average cash ratios ([Graham and Leary \(2018\)](#)), the changes in aggregate cash since 2000 are mostly driven by macroeconomic variables and repatriation taxes ([Faulkender et al. \(2019\)](#)). If repatriation tax is responsible for the recent rise in aggregate cash, one should expect that the rise in cash is mostly coming from multinational firms. Figure 4 shows that this is the case: the cash ratio for MNCs increased from

7% in 1995 to 12% in early 2000s and finally reached 14% in 2010s. Contrary to the MNCs, the cash ratio of non-multinational firms remain relatively stable over the last twenty years.

Cause: Risky Investments With the additional cash holdings and their higher carry returns, MNCs in our model are expected to take more risks. Figure 5 plots the aggregate R&D investment ratio over the last 30 years. The R&D ratio for non-MNCs has been relatively stable until 2000, where it starts to decline rapidly. Contrary to non-MNCs, MNCs have kept their R&D investment at a relatively higher level than that of Non MNCs. Overall, multinational firms account for increasingly share of R&D investment in the economy.

Effect: Concentration within MNCs and Non-MNCs One model prediction is that multinational firms should increase their investment in risky projects and as a result become more concentrated over time. I examine whether the concentration is increasing within multinational firms.

To this end, each year I divide the firms into two groups: MNCs and Non-MNCs. I then calculate the sales share accounted for by the top 10% firms within each group for each industry. I find that the shares accounted for by the top 10% firms is increasing for MNCs, and this upward trending is not observed in Non-MNCs group, which is consistent with the model prediction.

Tax Cuts and Jobs Act : The model's predictions also match patterns observed after the introduction of the Tax Cuts and Jobs Act (TCJA) on December 22, 2017. I discuss this in appendix.

5 The Emergence of Superstar Firms

One alternative explanation for the rising concentration is that top firms grow faster than the average economy, and thus over time the rising concentration is merely a reflection of an increasing importance of these highly productive firms ('superstar' firms).

To distinguish the role of risk-taking and high productivity, following [Gomez \(2018\)](#), I decompose the growth of top sale share into two components: within growth and displacement. I first discuss the methodology, then I present the results.

5.1 The Decomposition Framework

The growth of the top sale share S_t between t and $t + \tau$ can be decomposed into a term due to the average sale growth of firms at the top, and a term due to entry and exit:

$$\frac{S_{t+\tau} - S_t}{S_t} = \underbrace{\frac{\sum_A x_{i,t+\tau}}{\sum_A x_{i,t}} - 1}_{\text{within}} + \underbrace{\frac{\sum_E x_{i,t} - \sum_X x_{i,t}}{\sum_A x_{i,t}}}_{\text{displacement}} \quad (18)$$

Where $x_{i,t}$ is the normalized sale for firm i at time t , A_t is the set of top firms in each industry, E is the set of firms that enter the top distribution and X is the set of firms that exit the top distribution.

The idea is that if rising concentration is because top firms grow faster than the average, then the composition of top firms should remain stable over time. As a result, I should expect the within term to be large and displacement term should be small. Alternatively, if the rising concentration is due to increasing risk-taking in the economy, I expect a large displacement term.

Next, I first derive the model's predictions about the displacement term. Then, I examine whether the predictions are consistent with the data.

5.2 Displacement rate in the Model

In the model, the dynamics of capital stock in our setting is

$$dK_t = (I - \delta K)dt + \xi K_t dN_t \quad (19)$$

According to [Gomez \(2018\)](#), if the distribution can be approximated by a Pareto distribution with coefficient a , then the change in top shares can be written as

$$\frac{dS_t}{S_t} = \mu dt + \lambda \frac{\mathbb{E}^f[e^{Ja} - 1]}{a}$$

In our setting $e^J = (1 + \xi)^{11}$. Therefore, the change in shares for a distribution with tail parameter a is

$$\frac{dS_t}{S_t} = \mu dt + \lambda \pi \frac{[(1 + \xi)^a - 1]}{a} \quad (20)$$

The RHS is increasing in a , meaning the displacement decreases as the economy becomes more concentrated. This is confirmed in the simulation. Figure 2 plots the displacement rate in the simulation, which is measured by the fraction of firms that exit the top 5 percentile. In the simulation, the displacement goes up after the 1997 tax policy shock, after that the displacement rate gradually declines over time. In our theoretical framework, the decrease in displacement can be fully attributable to the decline of the tail parameter a , as other parameters are fixed as constants. Intuitively, sale concentration increased so much that firms with positive shocks now have a harder time entering the top.

5.3 Displacement rate in the Data

In this section, I decompose the growth of the sale share of Top 5 firms in each NAICS 3-Digits industry. The data is COMPUSTAT-CRSP Merged Database. There are two main findings:

Fact 1: Displacement is positive and within term is negative Table 2 reports the result of the accounting decomposition. The first line reports each term geometrically averaged over the entire time period. From 1990 to 2015, the displacement term is positive and within term is negative: the within term is on average 3.9% yearly decline and the displacement term is on average 3.7% yearly growth. The first columns of the table is consistent with the time trend in figure 1: the U.S. public sector experienced a decline in sale concentration between 1990 and 1996, followed by a rapid rise between 1997 and 2007 and a mild increase after 2007.

The entire sample period is subdivided into three periods: 1990-1996, 1997-2007 and 2008-2015. I choose these three periods because under the theoretical framework, we expect the displacement to rise after the tax policy change in 1997, and to decline as the economy becomes

¹¹Here, I ignore the effect of the dynamics of the distribution of cash ratio w . It can be shown numerically that as the economy converges to new distribution, its impacts on capital distribution is limited.

more concentrated. This is confirmed in the data: the displacement term increases from 4.0% in 1990-1996, to 4.7% in 1997-2007, and finally drops to 2.1% in the final sample period 2007-2015. The decrease in the last period is due to the fact the sale distribution is getting increasingly fat-tailed as the economy converges to the new steady state. To further understand the dynamics of displacement term from the empirical perspective, I calculate the higher order cumulants of top sale distribution. The volatility and kurtosis increased after 1997 and decreased after 2007, suggesting that top firms take more risk after the tax policy change.

Fact 2: Within term has steadily increased (less negative) over time Unlike the displacement term, I find that the within term has been rising over time. More precisely, it goes from -5.6% in 1990-1997, to -4.1% in 1998-2007, and finally to -1.9% in 2008-2015. This means even though the displacement term has declined after 1997, the with in term drops faster so that the economy end up with a net rise in concentration. In other words, if the with in term had been constant over the entire period, the economy would have been less concentrated.

5.4 Discussion: Complementing the “Superstar” View

Taken together, the findings suggest that top firms grow slower than the average economy, so the argument that existing top firms take increasingly amount of share can not fully explain the rising concentration, especially in the earlier period of the last two decades. The large displacement term indicates that a number of ex-post “superstar” firms have emerged to the top distribution during the past two decades. It also raise the question of how these “superstar” firms emerge? Were they born to be highly productive or they have taken risks can then succeeded in their risk-taking?

From an ex-post perspective, being productive and having had good luck in risky investments are almost observational equivalent, if one only looks at firms’ sales trajectory. To distinguish the two, one would need to turn to data that can reflect firms’ risk-taking behaviors: if the concentration level rises without an increase in firms’ risk-taking, then it is likely that the potential “superstars” are highly productive without taking risks. On the contrary, if the rise in concentration is accompanied by an increase in risk-taking, then the risk-taking is more likely to play a role. The evidence in the previous section suggests that risk-taking channel has con-

tributed to the rise in concentration.

6 Conclusion

This paper proposes a tax-based explanation for two macro trends observed in the last two decades: increasing market concentration and rising corporate cash holdings. In the model, firms display finance-induced risk aversion because they internalize the probability of being constrained. Hence, given a lower tax rate on their liquidity holding, their return on cash is higher and their risk aversion is reduced. As a result, firms increase their risk taking by investing more in risky projects. After uncertainty has been resolved, ex ante risk taking leads to an ex post increase in market concentration. The paper also presents empirical evidence that is consistent with the proposed effects of risk-taking behaviors.

The paper's theoretical analysis sheds light on the interaction between corporate tax, firms' risk taking, and market concentration. It shows that when the possibility of financial constraint is incorporated, increasing tax on risk-free assets might reduce the incentive for making risky investments. Moreover, this analysis reveals that although a firm's financial frictions may be unrelated to overall market concentration, the two issues are in fact closely linked. Hence, the paper also opens up a space for a broader series of potential policy considerations, which I plan to investigate in future research.

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Table 2: Decomposing the Growth of Top Sale Share

Period	Total	Within	Displacement
90-15	-0.2	-3.9	3.7
90-96	-1.6	-5.6	4.0
97-07	0.6	-4.1	4.7
07-15	0.2	-1.9	2.1

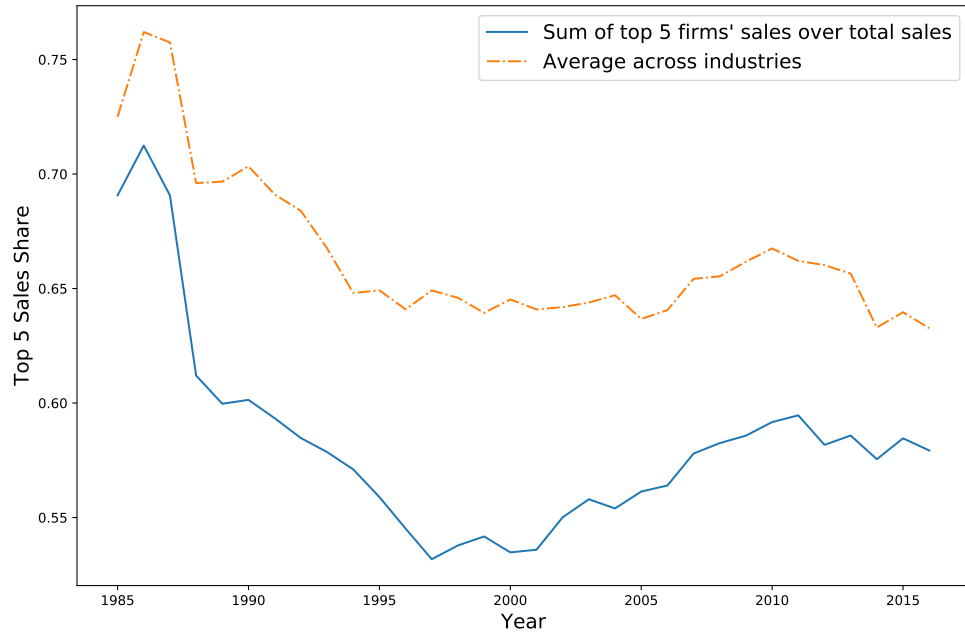
Notes: The table reports the geometric average of the growth rate of the sale share of top 5 firms in each NAICS-3 digits industry, as well as the geometric average of the within term, the displacement term. All terms in percentage.

Table 3: Moments of Sale Growth

Period	Mean	Volatility	Skewness	Kurtosis
90-16	0.09	0.26	3.51	56.98
90-96	0.11	0.26	3.29	31.48
97-07	0.11	0.28	2.13	41.07
08-16	0.05	0.23	7.47	146.79

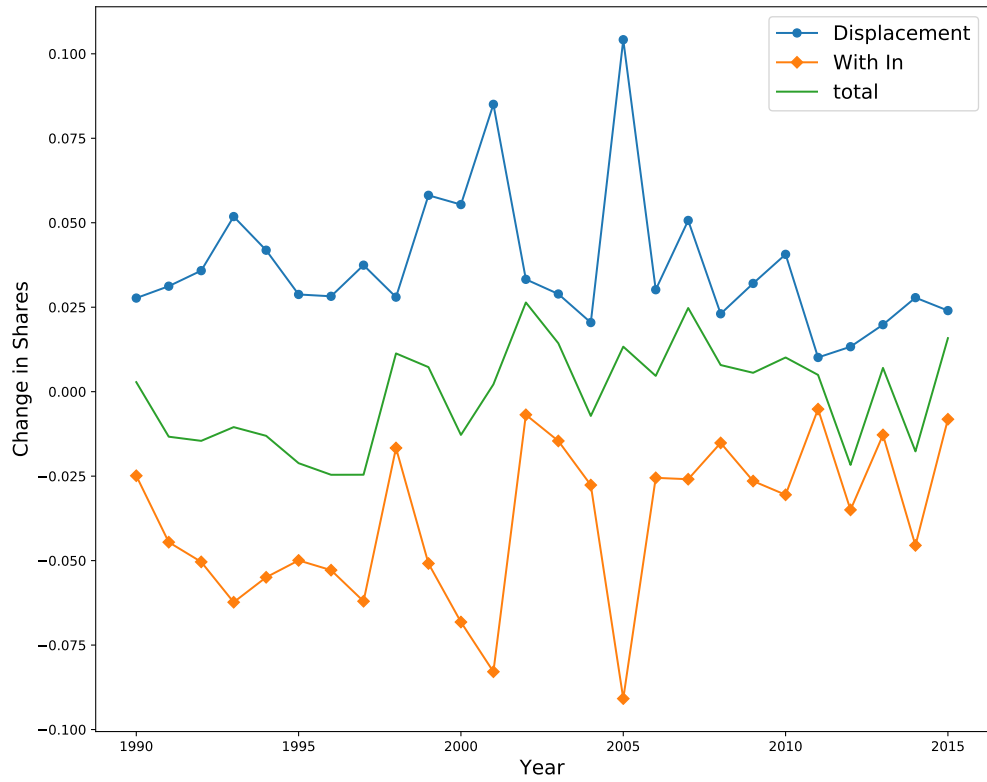
Notes: The table reports summary statistics of the sale distribution and higher-order moments of log sale growth. Data from Compustat/CRSP merged database.

Figure 1: Trends in industrial concentration



Notes: This figure shows two time series of industrial concentration. The blue line plots the ratio of the total sales of top 5 firms in each NAICS Three Digits industry over the total sales of all firms: $\frac{\sum_{\text{Top 5}} \text{sale}_i}{\sum_{\text{all firms}} \text{sale}_i}$. The orange line first calculates the fraction of sales accounted for by the top 5 firms in each NAICS three digits industry, then take an average across all industries. That is, $\frac{1}{\# \text{ of industry}} \sum_{\text{industry } j} \frac{\sum_{\text{Top 5}} \text{sale}_{i,j}}{\sum_{\text{industry } j} \text{sale}_{i,j}}$, where $\text{sale}_{i,j}$ is the firm i 's sale and firm i belongs to industry j .

Figure 2: Decomposition of the Growth of Top firms' Sale Share



Notes: The figure plots the growth of the sale share of the top 5 firms in each NAICS three-digits industry, as well as its decomposition into within term and displacement term. The within term, which is the orange line, keeps track of the difference between average growth rate of top 5 firms and that of the economy. The blue line plots the displacement term, which measures the sale share of new top 5 firms minus that of exited top 5 firms. Data is from COMPUSTAT.

Figure 3: Corporate Tax Rates: US and Foreign Rates Source: [Faulkender et al. \(2019\)](#)

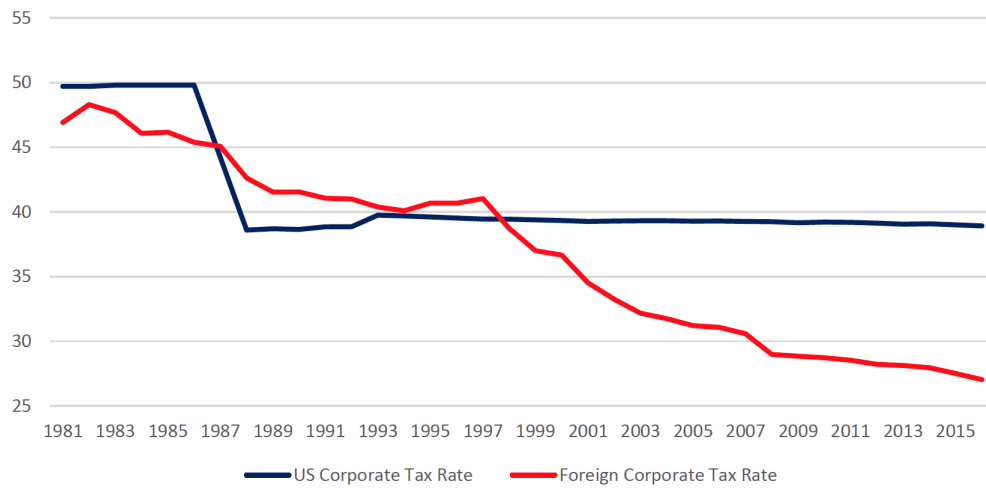
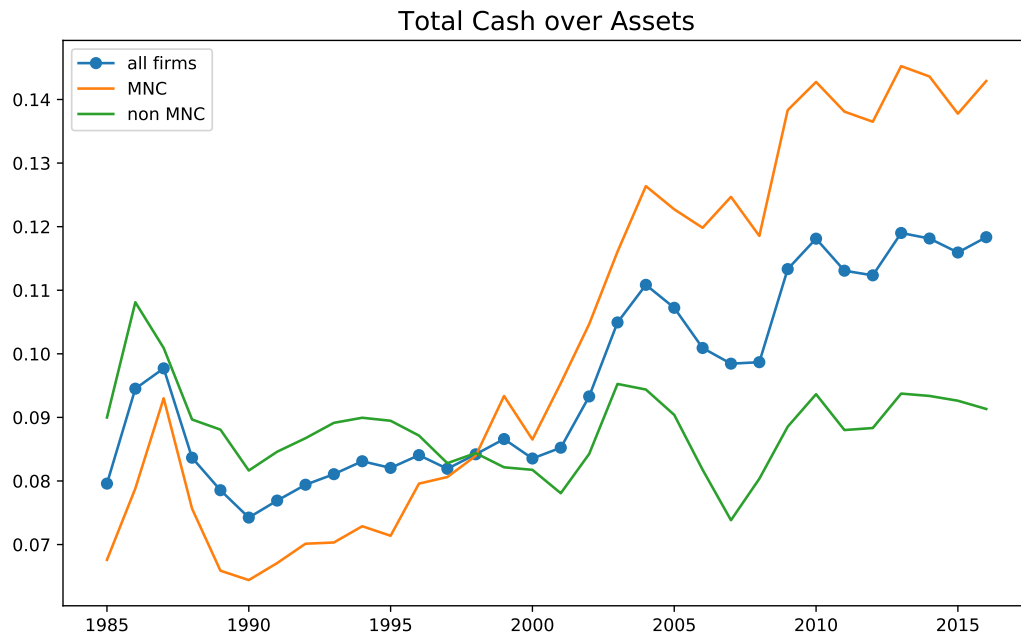
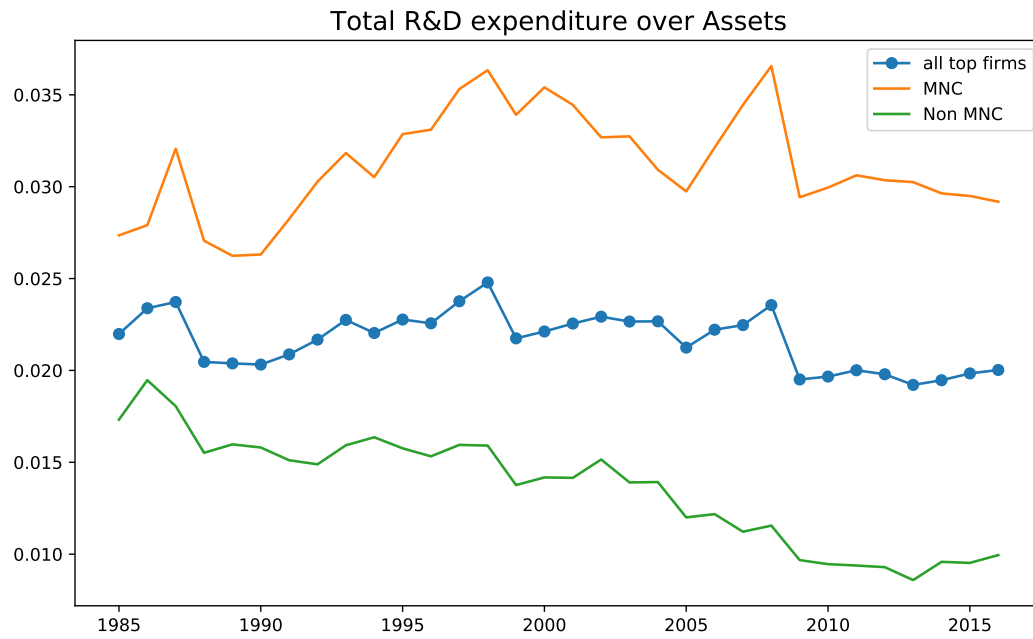


Figure 4: Trends in aggregate corporate cash holding



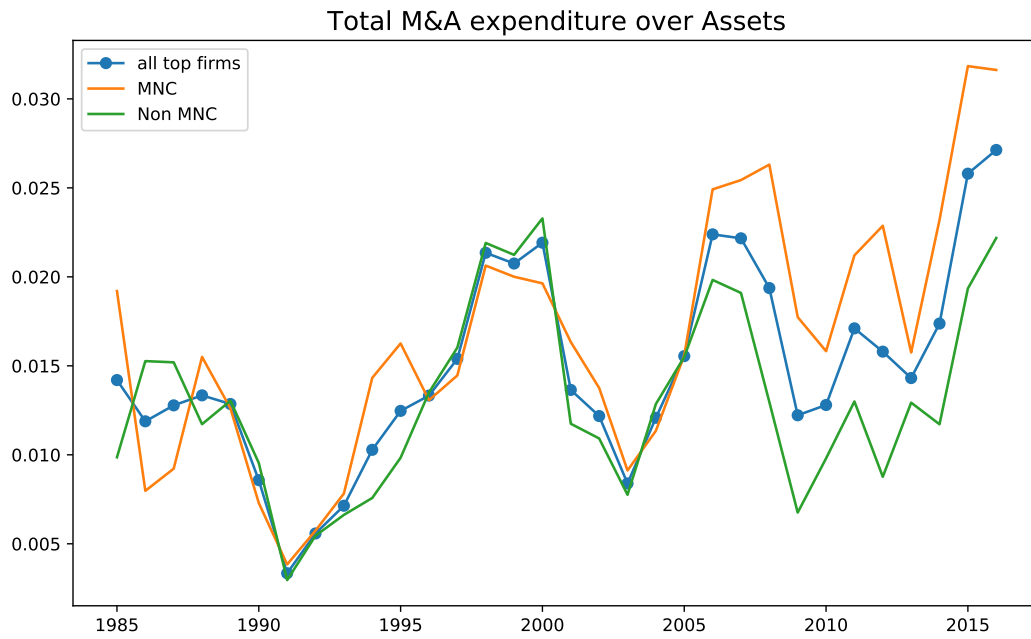
Notes: The figure shows the time-series trend in aggregate cash holdings measured by the ratio of total cash over total assets. The blue dotted line plots the ratio for all firms; the orange line tracks the ratio of multinational firms and the green line for non multinational firms.

Figure 5: Trends in aggregate R&D intensity



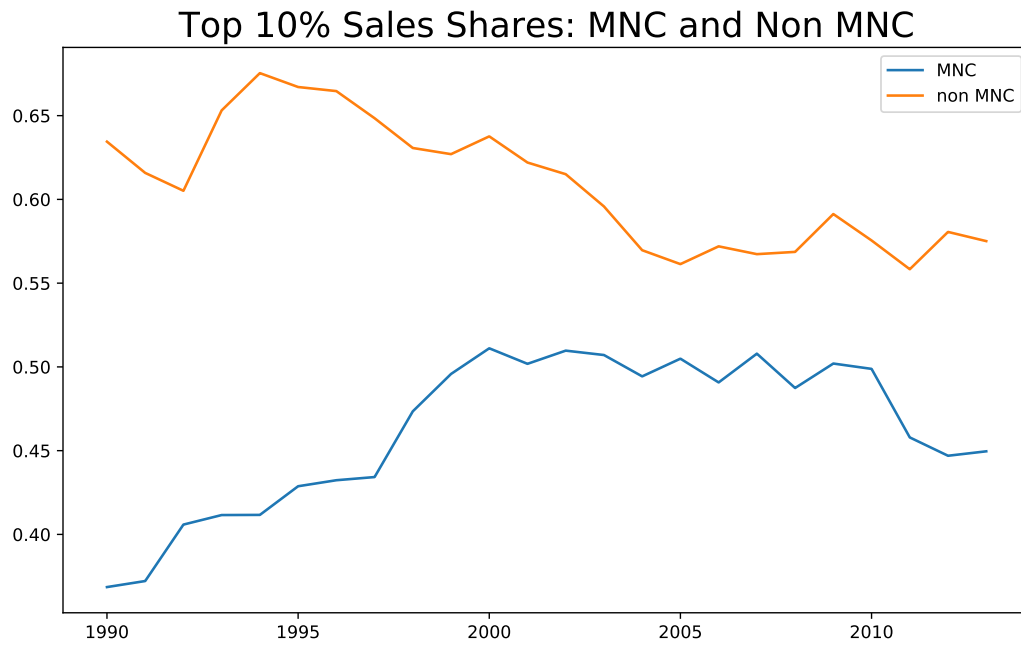
Notes: The figure shows the time-series trend in aggregate R&D intensity measured by the ratio of total R&D over total assets. The blue dotted line plots the ratio for all firms; the orange line tracks the ratio of multinational firms and the green line for non multinational firms.

Figure 6: Trends in Mergers and Acquisitions



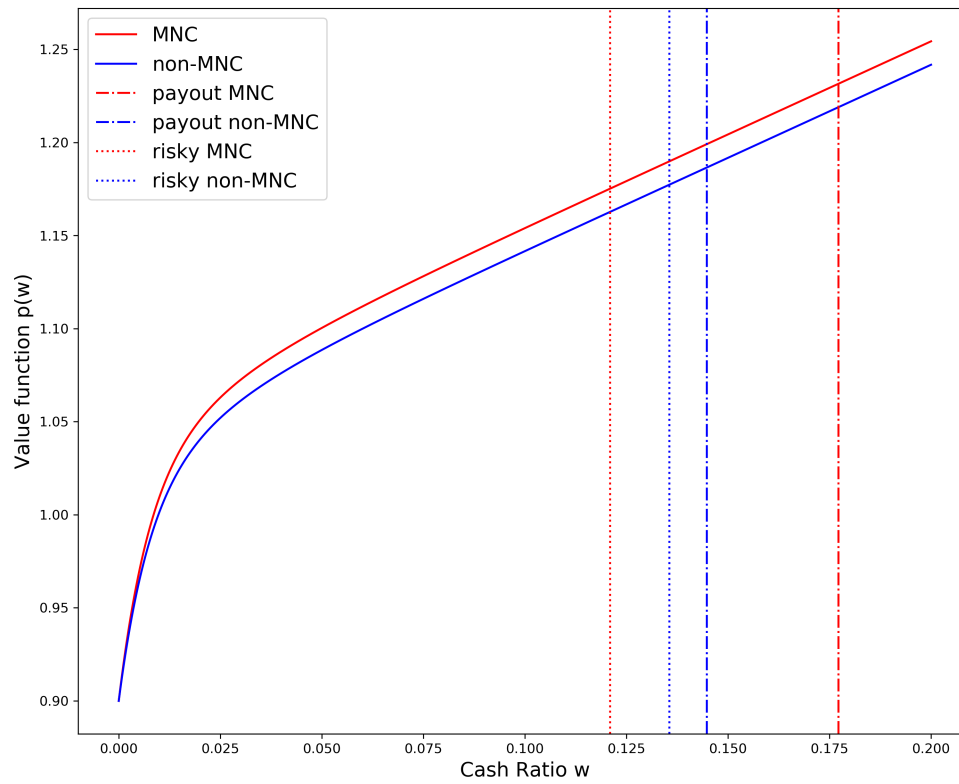
Notes: The figure shows the time-series trend in aggregate M&A intensity measured by the ratio of total mergers and acquisitions over total assets. The blue dotted line plots the ratio for all firms; the orange line tracks the ratio of multinational firms and the green line for non multinational firms.

Figure 7: Sales concentration: multinationals vs non multinationals



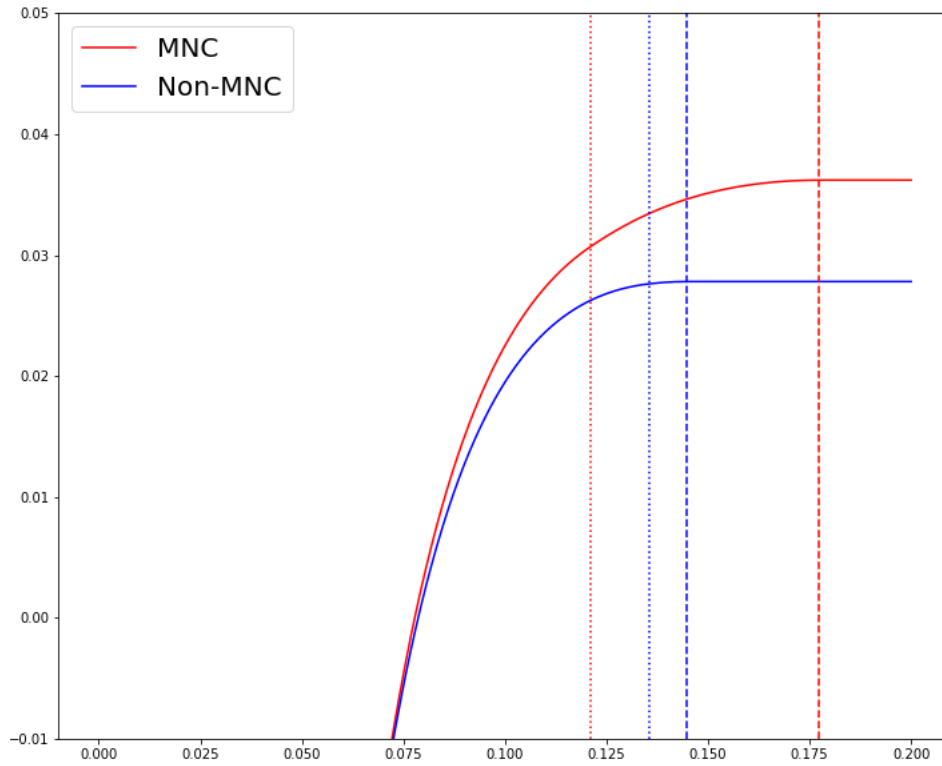
Notes: This figure plots the sales shares accounted for by the top 10% firms in multinational firms and non-multinational firms, respectively. The blue line plots the sales shares of top 10% for multinational firms, and the orange line tracks that ratio for non-multinational firms.

Figure 8: Value Functions for Multinationals and Non-Multinationals



Notes: This figure plots the solution for the multinationals and non-multinationals, as well as their risky investment and payout policies. The blue line is the solution for non-multinationals and the red line, multinationals.

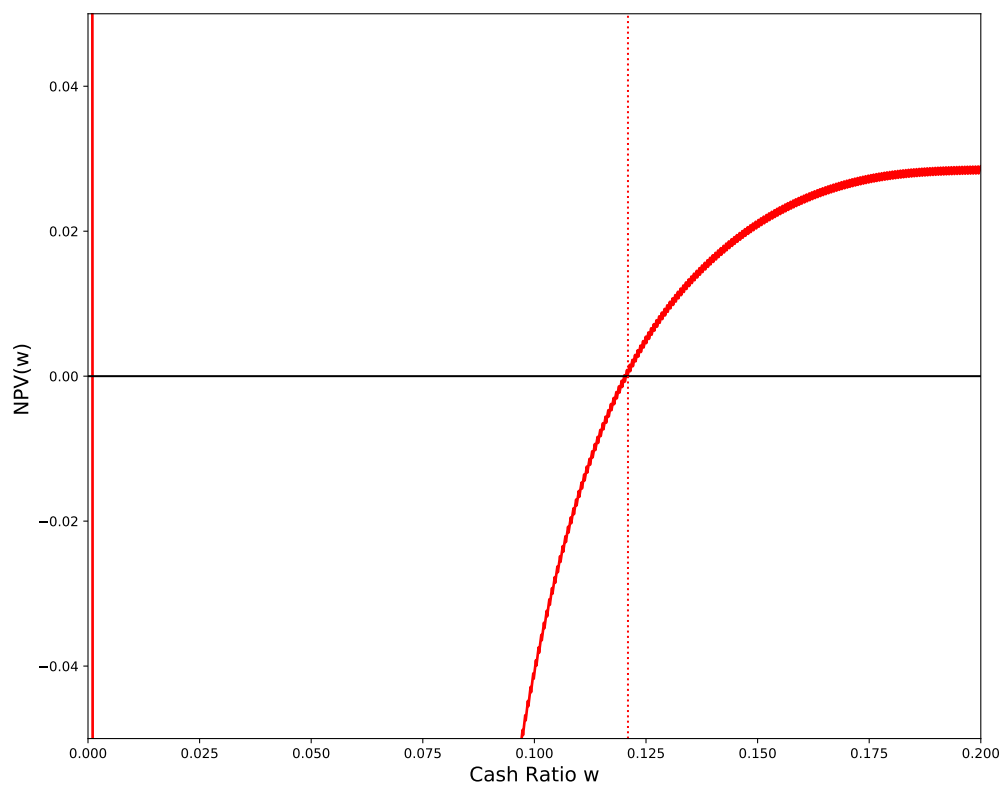
Figure 9: Risky Investment and Payout Policy for Multinationals and Non-Multinationals



Notes:

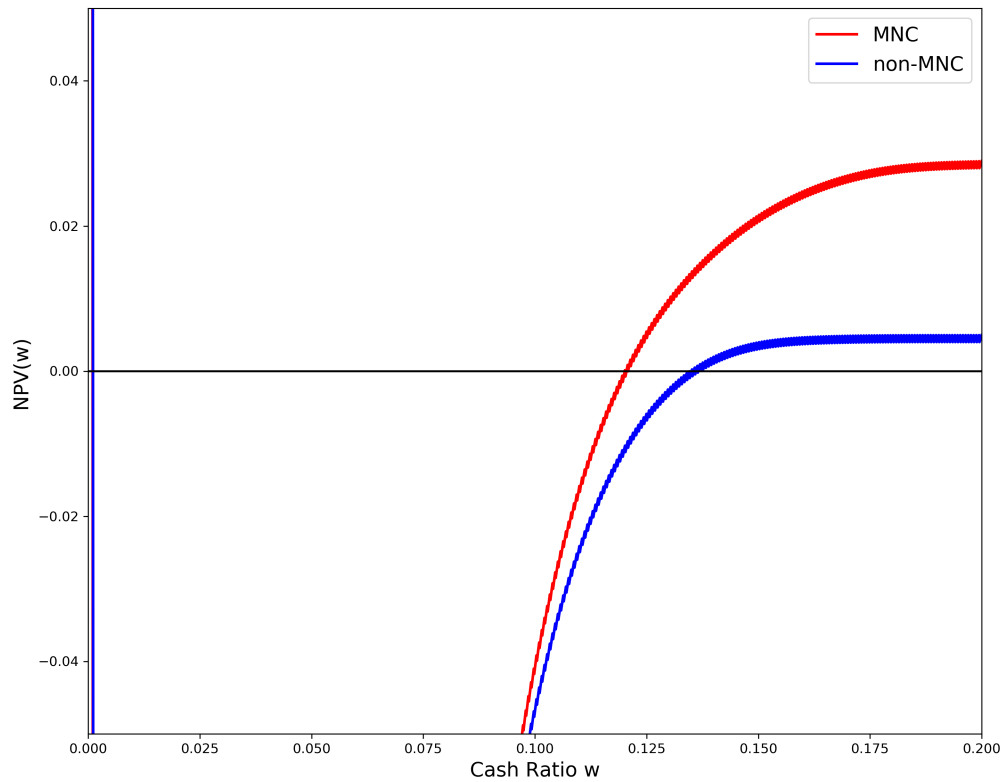
This figure plots the risk-less investment policy for the multinationals and non-multinationals, as well as their risky investment and payout boundaries (dotted line and dashed line). The blue line is the solution for non-multinationals and the red line, multinationals.

Figure 10: Net Present Value (NPV) of Risky Projects



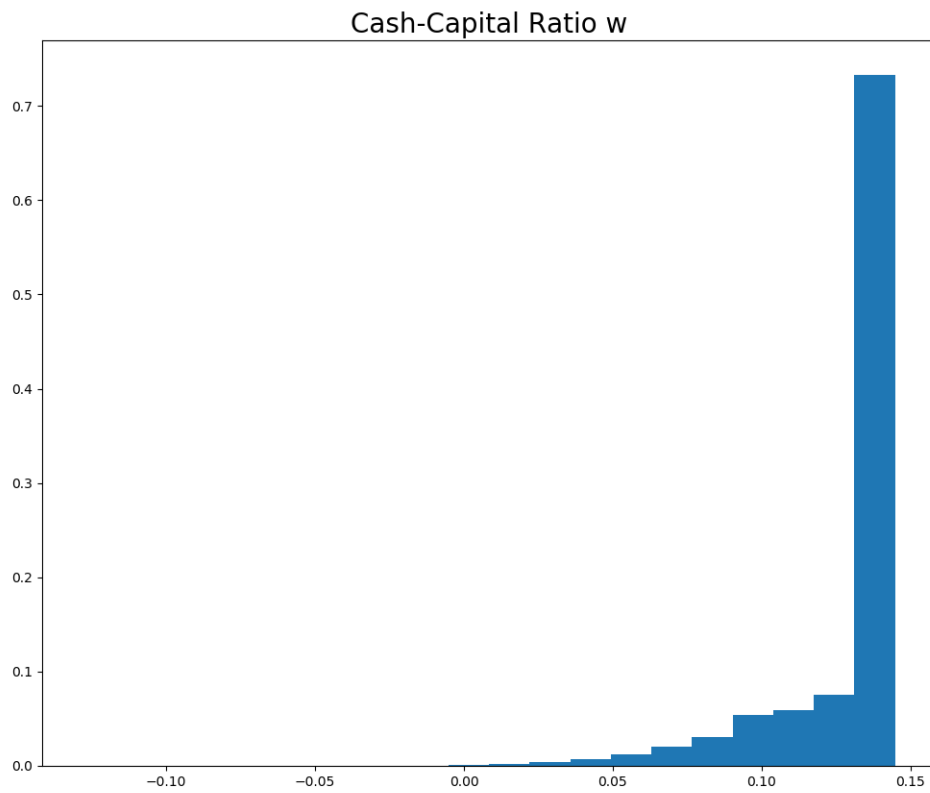
Notes: This figure plots net present value of risky projects. A firm only invests in risky projects if its net present value is positive.

Figure 11: Net Present Value (NPV) of Risky Projects: multinationals vs non-multinationals



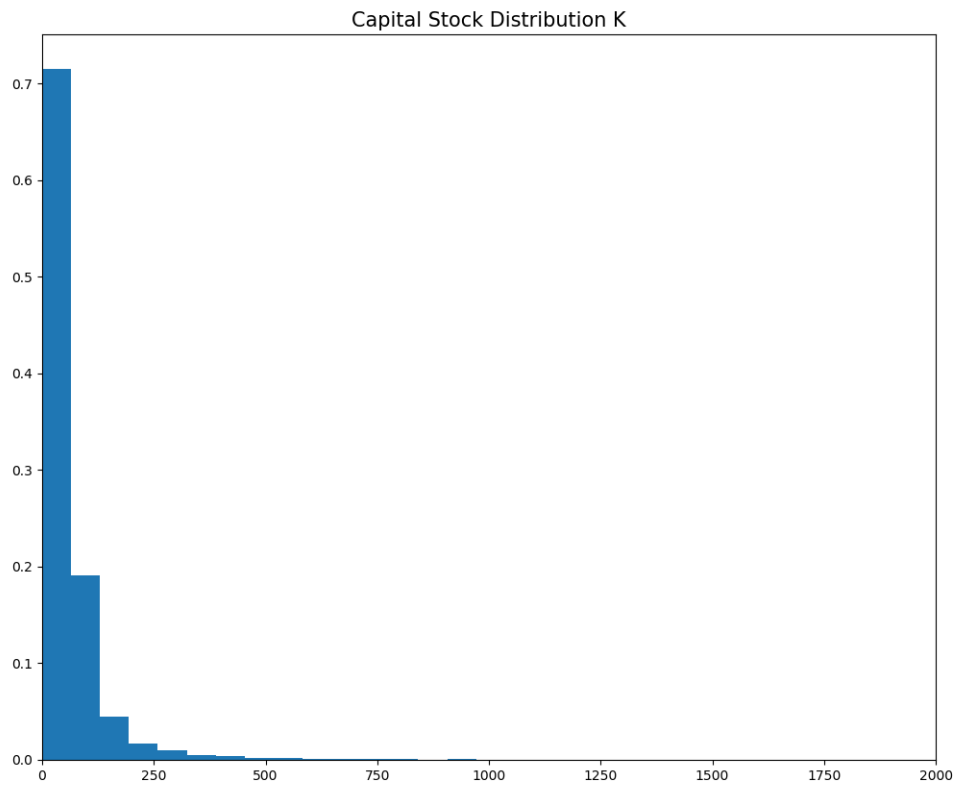
Notes: This figure plots net present value of risky projects for multinationals and non-multinationals. The multinationals (MNCs) and non-multinationals (non-MNCs) are identical other than the tax rate on their return on cash. A firm only invests in risky projects if its net present value is positive.

Figure 12: Stationary Distributions before Tax Regulation



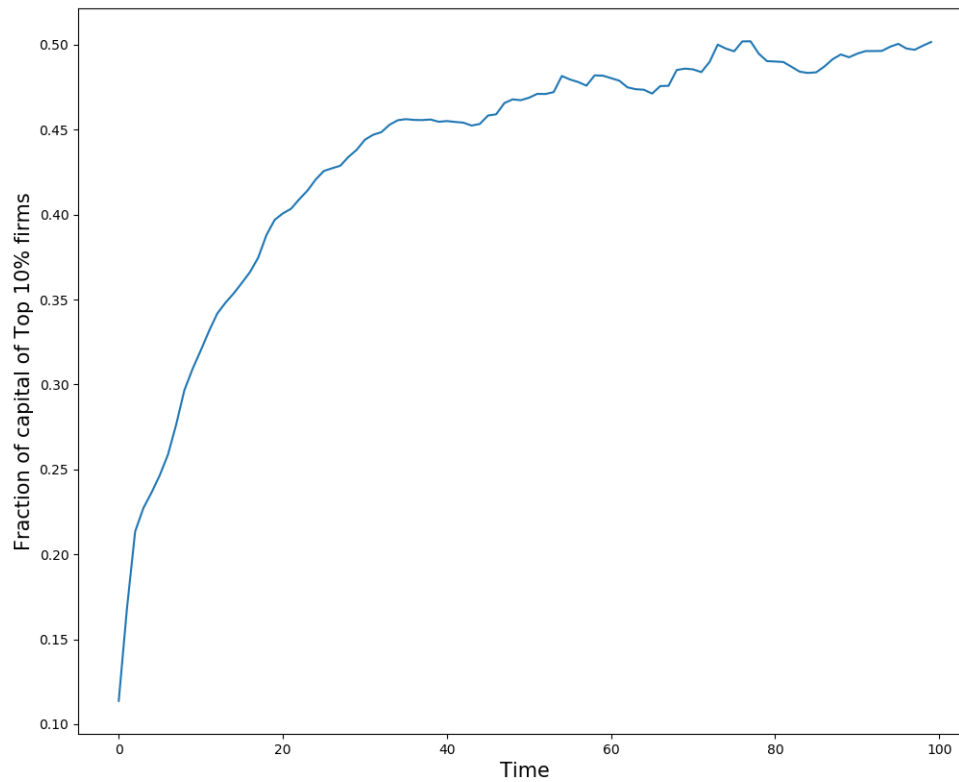
Notes: This figure plots stationary distribution of cash-to-capital ratio w when multinationals and non-multinationals have the same tax rate.

Figure 13: Stationary Distributions of Firm Size



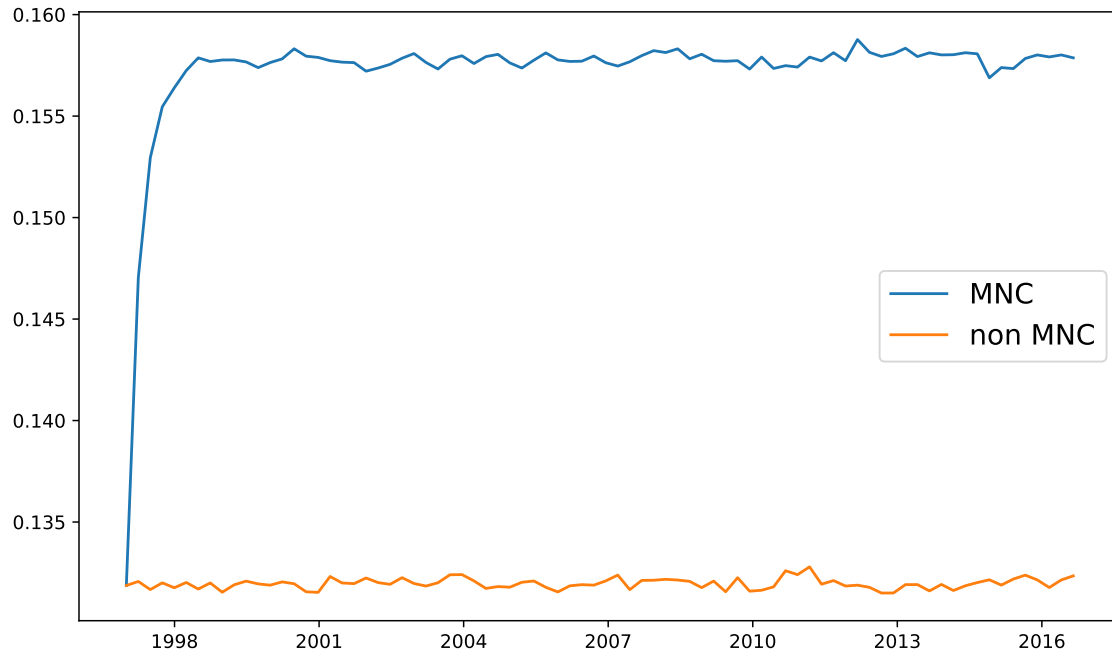
Notes: This figure plots stationary distribution of firm's capital stock k when multinationals and non-multinationals have the same tax rate.

Figure 14: Path of Concentration



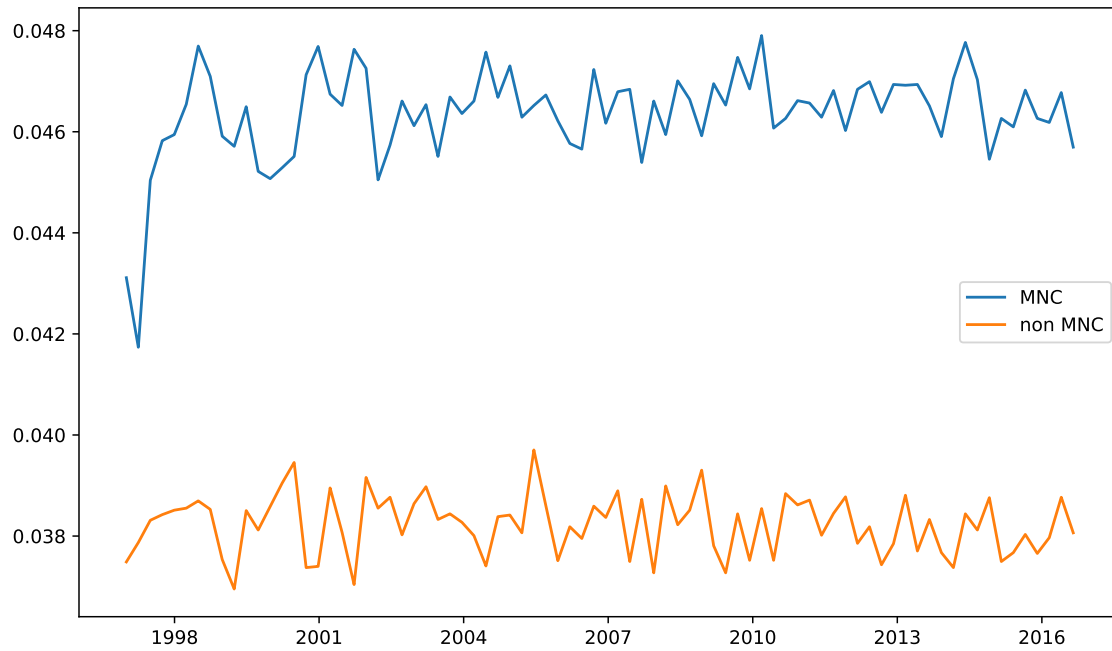
Notes: This figure plots the path of sales share accounted for by the top 10% in the economy, when multinationals and non-multinationals have the same tax rate. The x -axis is the time period, and the y -axis is the top sale share. In period 0, every firm has the same amount of capital, so that the top 10% account for 10% of sales share.

Figure 15: Cash-to-Capital Ratio after the Tax Regulation



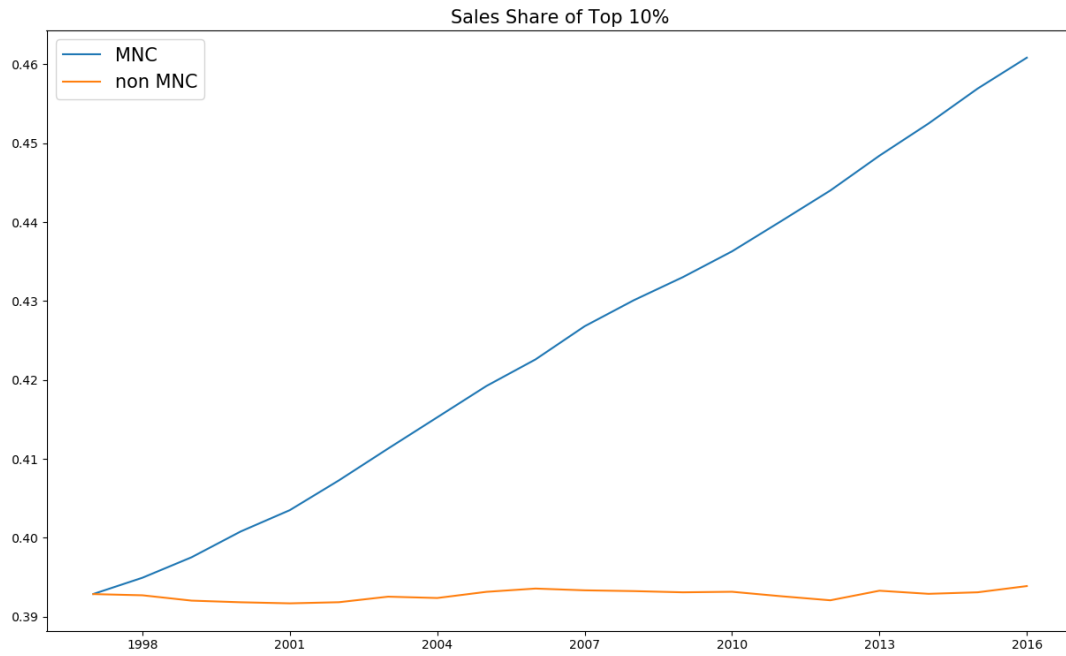
Notes: This figure plots the path of simulated cash-to-capital ratio after the tax regulation in 1997. The orange line tracks the non-multinationals and the blue line, multinationals. In the simulation, the tax rate is reduced for multinationals in 1997.

Figure 16: Risky Investment Ratio After Tax Regulation



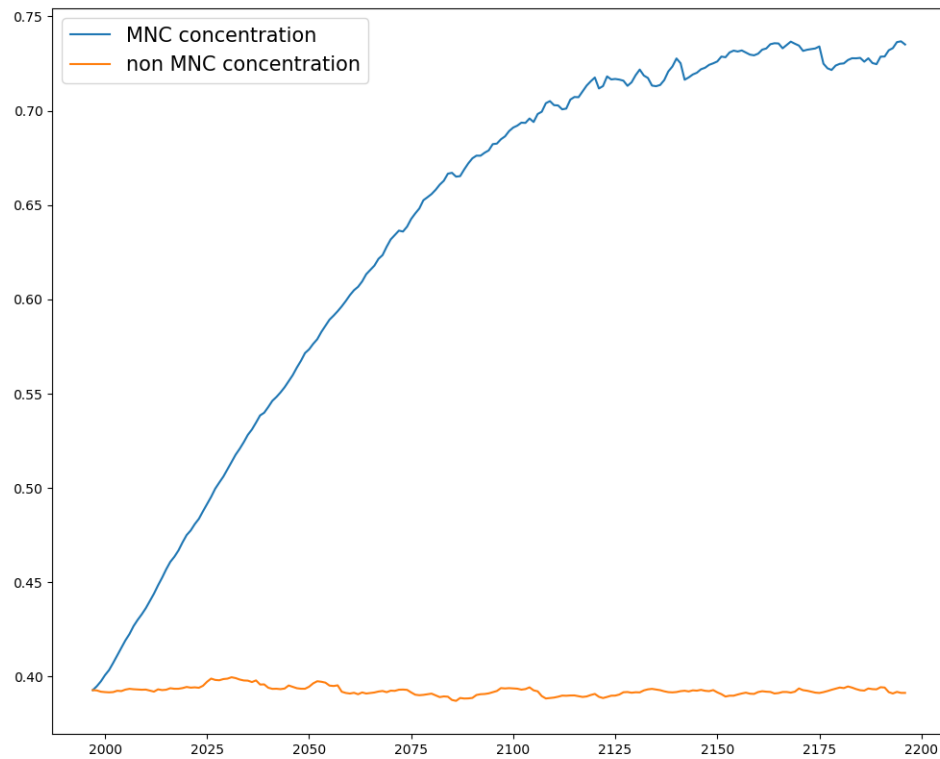
Notes: This figure plots the path of simulated risky investment-to-capital ratio after the tax regulation in 1997. The orange line tracks the non-multinationals and the blue line, multinationals. In the simulation, the tax rate is reduced for multinationals in 1997.

Figure 17: Within Group Concentration Level: Multinationals and Non-multinationals



Notes: This figure plots the path of sales share accounted for by the top 10% firms in multinationals and non-multinationals, respectively. The blue line first calculate the total sales for top 10% in multinationals, and then divide it by the total sales for all multinationals. The orange line keep tracks of that ratio for non-multinationals.

Figure 18: Within Group Concentration Level (Convergence Path): Multinationals and Non-multinationals



Notes: This figure plots the path of sales share accounted for by the top 10% firms in multinationals and non-multinationals, respectively. It extends figure 17 up to 200 years. The blue line first calculate the total sales for top 10% in multinationals, and then divide it by the total sales for all multinationals. The orange line keep tracks of that ratio for non-multinationals.

A Appendices

A.1 The Kolmogorov Forward Equation of Capital Stock

It is helpful to show the argument that the stationary distribution of capital stock in the simple model is Pareto. In doing so, it illustrates a basic version of Kolmogorov forward equation, which is used later in describing the evolution of capital stock and cash holding in the full model.

In this basic version, the dynamics of the capital stock is:

$$dK = (I - \delta K)dt + \xi \pi K dN_t \mathbf{1}_{risky} \quad (21)$$

where it subjects to Poisson reset with positive rate γ . Then the logarithm of capital stock follows the following dynamics:

$$dx = (i - \delta)dt + \pi \log(1 + \xi) dN_t \quad (22)$$

I can write down the *infinitesimal generator* of this process, defined by

$$\mathcal{A}f = (i - \delta)x \frac{\partial f}{\partial x} + \lambda [f((1 + \xi)x) - f(x)] \quad (23)$$

Let $p(x, t)$ denote the probability density function of the logarithm of the capital stock at time t . According to [Gabaix et al. \(2016\)](#), I can calculate its *adjoint* and its dynamics can be written as

$$\frac{\partial p(k, t)}{\partial t} = -(i - \delta) \frac{\partial}{\partial k} [p(k, t)k] + \lambda \pi \left[\frac{p(\frac{k}{1+\xi}, t)}{1+\xi} - p(k, t) \right] - \gamma p(k, t) + \gamma p(k_0, t)$$

The first term on the right hand side is the outflow associated with the drift of the dynamic. If the drift is positive $i - \delta$, then the net outflow is positive since the firm deterministically grows. The second term has to do with the success of risky investments. The density function receives the injection at a size k coming from a size $\frac{k}{1+\xi}$, at the same time, there is a outflow from k , and both have density $\lambda \pi$. The last two terms correspond to the death and the reinjection at k_0 .

KFE for the Full Model In the full model, the dynamics of capital and cash holdings follow:

$$dK_t = (I_t - \delta K_t)dt + \xi K_t dN_t \mathbf{1}_{invest \& success} \quad (24)$$

$$dW_t = K_t dA_t - I_t dt - G(I, K)dt - fK dN_t \mathbf{1}_{invest} + r(1 - \tau)W_t \quad (25)$$

Let $g(K, W, t)$ denote the probability density function over W and K . According to Chapter 8 in [Oksendal \(1992\)](#), multi-dimensional case is similar to the one-dimensional case, so I can calculate the adjoint in R^n and write down

the kolmogorov forward equation as:

$$\begin{aligned} \frac{dg_t(W, K)}{dt} = & -\frac{\partial}{\partial K}[\mu_K(W, K)g(W, K)] - \frac{\partial}{\partial W}[\mu_{W,t}(W, K)g(W, K)] + \frac{1}{2}\frac{\partial^2}{\partial W^2}[\sigma^2 K_t^2 g(W, K)] \\ & + \lambda \mathbf{1}_{\text{Invest}}(W - fK, \frac{K}{1+\xi})\pi P(W - fK, \frac{K}{1+\xi}) - \lambda \mathbf{1}_{\text{Invest}}(W, K)P(W, K) \\ & + \mathbf{1}_{\text{Invest}}(W + fK, K)(1 - \pi)P(W + fK, K) - \gamma g_t(W, K) + \gamma g_0(W_0, K_0) \end{aligned} \quad (26)$$

where $\mathbf{1}_{\text{invest}}(W, K)$ is the indicator function of whether to invest in the risky project for a firm with W and K , and

$$\mu_K(W, K) = I(W, K) - \delta K \quad (27)$$

$$\mu_W(W, K) = (r - \lambda)W + \mu K - I(W, K) - G(I, K) \quad (28)$$

The first term on the right hand side captures the outflow of distribution g due to the drift of capital stock. The second and third terms captures the effect of drift, diffusion of cash holdings, respectively. The fourth, fifth, and sixth terms captures the change of distribution due to the risky investments: the fourth term captures the density inflow from state $(W - fK, \frac{K}{1+\xi})$ if risky investments are made and succeeded at that state, which occurs at frequency $\lambda\pi$. The fifth term captures the density outflow if firms invest in (W, K) , which occurs with frequency λ . The sixth terms captures the density inflow from state $(W + fK, K)$ if investments are made and failed at that state, which comes with probability $\lambda(1 - \pi)$. The last two terms captures the entry and exit.

A.2 Calibration

I use annual data from COMPUSTAT to calculate the moments of the R&D-capital ratio for model calibration. The sample is from 1990-1997 and excludes utilities (Standard Industrial Classification (SIC) codes 4900-4999) and financial firms (SIC codes 6000-6999). The sample range is below 1997 since I attribute the difference between MNCs and Non-MNCs after 1997 as the impact of tax regulations, rather than the fundamental difference between these two groups of firms. I require firms to be incorporated in the United States and have positive assets.

Risky investment is measured using Research and Development expenditure (XRD). The cash holdings are measured using cash and short-term investments (CHE). The capital stock is measured using total assets (AT). So the R&D-capital ratio is $\frac{XRD}{AT}$ and the cash-capital ratio is $\frac{CHE}{AT}$. I first compute the moments for cash-capital ratio and the R&D-capital ratio at the firm level, for multinationals and non-multinationals, respectively. And then calibrate the model parameters to match the moments of the median across firms.

A.3 Recent Tax Regulation: Tax Cuts and Jobs Act

On December 22, 2017, the Tax Cuts and Jobs Act (TCJA) was passed by US government, which is considered to be one of the largest tax cut in American history. The TCJA took effect on January, 1, 2018, and it mainly consists of

two key elements: (1) a reduction in the corporate tax rate from 35 percent to 21 percent, and (2) a one-time tax holiday that cuts the tax on cash repatriation from foreign subsidiaries from 35 percent to 15.5 percent. Moreover, the US corporate system also changed from a worldwide tax system to a territorial system in which benefits of delayed repatriation are removed. Overall, the TCJA substantially reduced firms' repatriation costs, as well as the tax incentive for firms to hold cash abroad.

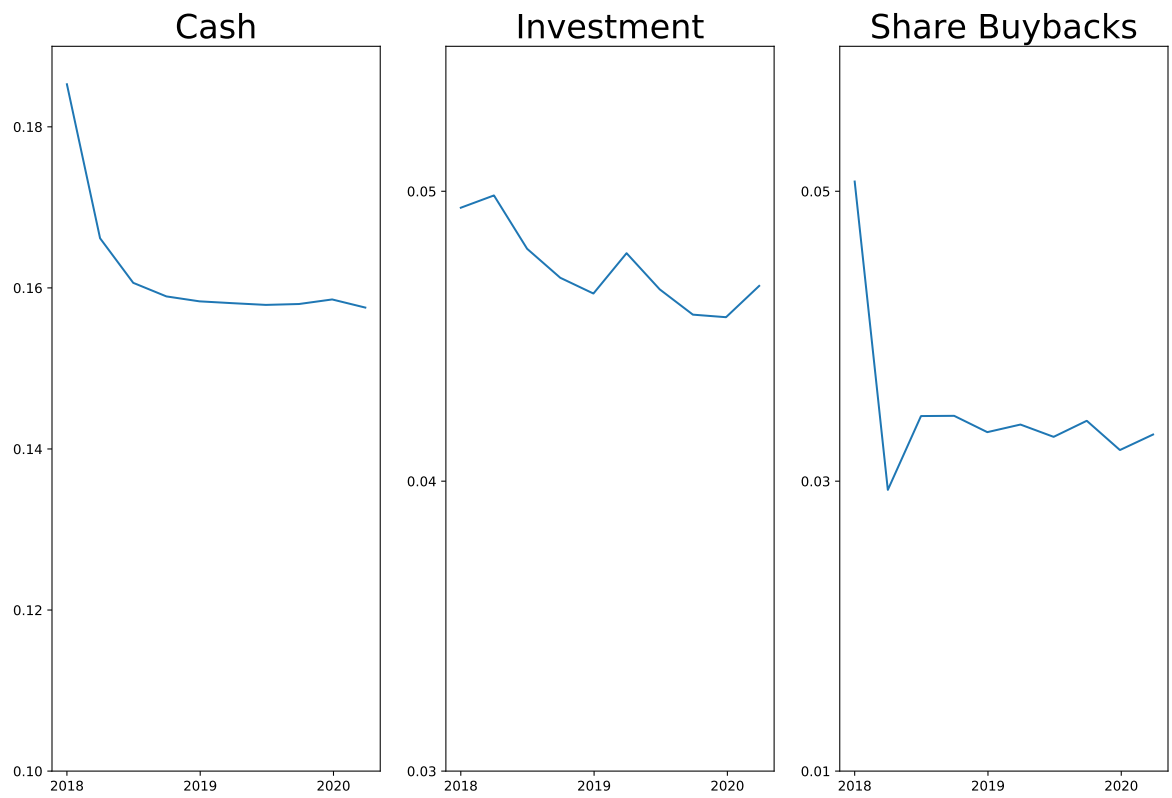
The intent of the TCJA, as suggested by the name of the act, is to stimulate corporate investment and employment. In fact, U.S. Treasury Secretary Steven Mnuchin noted, *"The Tax Cuts and Jobs Act creates a historic opportunity for American companies to bring capital home from overseas to invest in our domestic economy and create jobs for hardworking Americans."*

However, the evidence so far does not match the expectation. Critics of the act, including those in the financial media, have claimed that its effects was mostly to enable US firms to repurchase stock and that firms did not invest more. This surprising effects raise the question: when forming the expectation that firms will invest more, which part goes wrong?

To study this tax change in our model, I consider an unexpected positive shock to the cash holding of multinational firms while they are on the transitional path to the new steady state. I then study the impulse response of those multinational firms.

Figure 19 plots the impulse response for cash holdings, investment ratio and dividend payouts. The cash holdings fall sharply following the shock, and it is mostly coming from the dividend payout (share buybacks). The investment only increases modestly, which is consistent with the empirical evidence so far. The reason is that firms have already managed their liquidity positions so that their investment policy is not responsive to additional liquidity. As a result, additional cash windfall will not be used to invest more, but rather it boost the dividend payout. Put differently, the US firms have already internalize the impact of financial constraints by having accumulated a considerable amount of cash. And under such scenario, additional liquidity will not be effectively in boosting investment.

Figure 19: Cash Holdings, Investment and Payout After The Tax Cuts and Jobs Act



Notes: This figure plots the path of cash holdings, investment ratio and payout following the TCJA shock.