Essays in Macroeconomics

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Gea Hyun Shin

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Dissertation Advisor: *Author:*
Professor Benjamin Friedman **Gea Hyun Shin**

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Abstract

This dissertation consists of three essays in macroeconomics. The first essay studies the relationship between firm liquidity and new product introduction during the 2007-2008 financial crisis. Using public firms' product announcement data, we find that cash-constrained firms increased launching of new products more than cash-abundant firms during the crisis. In contrast, we find no evidence of a difference in introduction of new product varieties as measured by trademarks. These findings suggest that liquidity constrained firms may have tried to generate more cash flows through sales of new products within existing product lines. Next, we turn to patent applications as a measure of the development of new technologies, which eventually lead to new products. We find that constrained firms reduced potentially radical patent applications by more, while we do not find a difference in likely typical patent applications. This is consistent with the view that liquidity constrained firms have lower risk tolerance.

The second essay, co-authored with Seunghyup Lee, investigates the relationship between employment protection and firm R&D investment. By increasing operating leverage, employment protection reduces the ability of financially constrained firms to undertake R&D projects. We use the adoption of wrongful-discharge protections by state courts across the U.S. as a source of exogenous variation in the cost of adjusting labor downwards. We show that these protections increase the operating leverage of firms in these states. Among financially constrained firms, these court decisions reduce R&D investment and amplify its procyclicality. Capital expenditures, however, are not affected regardless of the level of financial constraints. To show that wrongful discharge laws impact investment decisions by

increasing operating leverage, we construct an industry layoff elasticity measure as a proxy for the exposure to the shock, and compare the operating leverage and investment responses of the firms with different levels of exposure. Last, we show that high R&D firms hoard cash and issue more equities in response to the court decisions. We provide a corporate investment model with costly external finance and liquidity constraints that predicts these patterns.

The third essay studies the welfare consequences of severance payments in an incomplete market setting when workers face private borrowing rates that are higher than the equilibrium interest rates. Given prices, the ex-ante benefit of severance payments is shown to be increasing in worker borrowing costs, in a finite period model. Steady-state numerical analysis reveals that severance payments are welfare-enhancing in an economy with high worker borrowing costs. These results provide an additional explanation of the generosity of severance payments in low per capita income countries.

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To my parents

Chapter 1

Product Introduction during the Financial Crisis

1.1 Introduction

Firms responded by reducing employment and investment when they were faced with significant disruptions in the financial market during the crisis of 2007-2008, which began in mid-2007 and culminated in the fall of Lehman Brothers in late 2008. On the employment side, Chodorow-Reich (2014) shows that firms, who had borrowed from banks that got into trouble following the Lehman crisis, lowered employment more than those whose banks were relatively healthier during the crisis. On the investment side, Duchin *et al.* (2010) and Almeida *et al.* (2012) document that firms, who before the crisis had a lower cash-ratio or a higher proportion of soon-to-mature long-term debt, reduced their investment more during the crisis. Furthermore, firms who had low cash-ratios before the crisis raised the prices of their products after mid-2008 while firms with high liquidity lowered theirs instead, which has important implications for inflation-output dynamics (Gilchrist *et al.*, 2017).[1]

[1] If products are imperfect substitutes and consumption depends on the past consumption habit, borrowing constrained firms in a high borrowing cost state (financial crisis) raise prices following the demand shock. Depending on the composition of constrained firms in the economy, the economy can end up with lower output and higher inflation than what the model without financial constraint would predict.

In contrast to the breath and depth of evidence on the general production activity during the 2007-2008 financial crisis, the evidence on the extensive margin of new production, in other words product introduction, is scarce. There is some anecdotal evidence suggesting potential for a response on this margin. For instance, more than half of the CFOs surveyed reported that they had to either cancel or postpone their planned investments and bypass attractive opportunities (Campello *et al.*, 2010). This study is an attempt at providing more direct evidence of firms' responses in the product introduction margin in the wake of the financial crisis. Using the product launch announcement data from Capital IQ Key Developments, we document that firms with low pre-crisis liquidity, measured by cash-ratio, increased product launches more than other firms with high liquidity during the 2007-2008 crisis.

Standard investment models with financing constraints predict that firms facing tight external financing constraints would decrease overall investment if they do not have enough internal capital (Holmstrom and Tirole, 1997; Stein, 2003), which is consistent with existing empirical findings. However, firms facing financing constraints also make decisions on other margins. In particular, introducing new products can be beneficial to firms without enough internal capital during times of expensive external capital. Firms improve their profitability and are valued higher in the market following new product introductions (Chaney *et al.*, 1991; Chaney and Devinney, 1992; Bayus *et al.*, 2003). If new products generate the much-needed cash flows, product introductions can relax the funding constraints that firms face. Product introduction also affects firm price flexibility. The importance of product substitutions in firm price flexibility, especially among durable goods producers, has been discussed in the literature (Moulton *et al.*, 1997; Nakamura and Steinsson, 2008, 2012). Thus, in light of the evidence documented by Gilchrist *et al.* (2017), who show that firms with low liquidity raised prices on their products, introducing new products may temporarily increase the price flexibility and assist firms in setting new prices. However, premature introduction of products can be costly for firms as well. Product launch timing of a firm is optimally determined given the joint estimates of demand for its existing products and expected demand for its new products, which depends on the level of improvements in the new products and their similarity to its existing products. Early introduction of products under binding financing constraints would imply a deviation from the unconstrained optimal timing and could potentially incur costs in the form of higher production costs if the production technology was not fully matured. It could also result in lower demand for the new products if they were not sufficiently different from the existing ones. If the unconstrained rivals who can wait longer introduced better products with more improvements, the demand for the firm's new products would be short-lived. Furthermore, premature new product introduction could lead to greater cannibalization of the demand for existing products if the demand was still high. The contradicting economic incentives underlying the product introduction decisions by liquidity constrained firms stress the need for empirical evidence on how firms respond during times of costly external financing.

The main proxy for firm product introductions in our study comes from Capital IQ Key Developments (CIKD) data. The dataset contains press releases on various subjects such as earnings announcements, product-related announcements, executive changes, and SEC filing delays by more than 200,000 companies worldwide. Their sources include popular news providers, such as Reuters, Dow Jones, Comtex, and CNN, in addition to company regulatory filings and investor presentations. Under the product-related announcement category, we sample only the announcements about product introductions by searching for words such as "introduce", "launch", "ships", and "unveil" from the headlines of the announcements. Then, we count the number of new product announcements by each quarter and merge them to the COMPUSTAT/CRSP dataset on unique GVKEY. CIKD screens out duplicate press releases with identical contents so we treat each announcement as a unique product announcement. Not all companies announce introductions of their new products on the venues covered by CIKD so we limit the sample to those companies who have announcement data in CIKD during the sample period. This reduces our sample to a little over 2000 firms during the financial crisis. The results are robust to expanding the analysis to the entire sample.

The empirical strategy used in this study is borrowed from Duchin *et al.* (2010) and Gilchrist *et al.* (2017). The core identification assumption is that ex-ante indicators of firm liquidity are not correlated with changes in unobserved product launch opportunities before and after the beginning of the crisis. Then, we rely on the intuition that firms with low pre-crisis liquidity would exhibit behaviors consistent with liquidity constrained firms with hardship of financing during the crisis. Accordingly, in our baseline regression using quarterly data from 2006:Q3 to 2008:Q2, we look at how the product introduction announcements before and after the July of 2007 differed between the firms who are expected to have a high exposure to the supply shock in the external capital market and those expected to have a low exposure. Almeida *et al.* (2012) propose using the ratio of long-term debt maturing within a year to total long-term debt at the end of 2007 as a proxy for the degree of exposure to the capital market crisis. However, implementation of their method requires reducing the sample to a few firms with sizable long-term debt (Duchin *et al.*, 2010). Since we additionally require firms to have their announcement data on CIKD, this further limits our sample of interest. Thus, we take an approach similar to the identification strategy of Duchin *et al.* (2010) and Gilchrist *et al.* (2017) which allows analysis on a more representative set of firms in the COMPUSTAT/CRSP universe. The identification method of Chodorow-Reich (2014) overcomes the capital structure endogeneity problems hampering other papers in the literature. Unfortunately, his design is not suitable for investigating the responses of the firms before the fall of Lehman. Moreover, because our outcome variable of interest, press releases about product launches, is mostly only available for public firms and because we can retain a broader set of public firms using the liquidity ratio approach, we do not apply his empirical design in this study.

Our analysis using quarterly data suggests that product announcements per quarter increase by 5.2% after the second quarter of 2007 for pre-crisis zero-cash firms. But the increase is 2.3 percentage points smaller for firms with a one standard deviation higher pre-crisis cash ratio. The effect of pre-crisis cash-ratio becomes more significant once we include the third quarter of 2008. When we use pre-crisis net short-term debt ratio instead of cash-ratio, the result is similar. This suggests that short-term liquidity was an important channel through which credit market disruption affected product launch decisions. The results are robust to the inclusion of controls, industry and quarter fixed effects, and the use of cluster-robust standard errors at the firm level. Our findings suggest that firms more aggressively increase launches of new products when faced with a negative credit supply shock. It implies that, for cash-constrained firms, the benefits of immediate cash flows outweigh the costs associated with early product introductions. We can think of new products simply as quality improvements over existing products or broadly as realizations of increased productivity. Launching products prematurely would then imply the possibility of forgoing full productivity improvements. This rational short-termism would prevent the output from falling too much in the short-run but would result in lower potential productivity in the long-run.

Firms with low cash ratio or high net short-term debt may be the ones who have used up internal resources or borrowed extensively in order to launch more products in the near future. They may also have expected better prospects for introducing new products, and resulting cash flows, such that they carried less cash ex-ante and eventually launched more products during the crisis. If any of these were true, we should observe the same general patterns in other time periods. Therefore, we run placebo tests for the 2002-2004, 2003-2005, 2004-2006, and 2005-2007 periods by treating the latter half of the periods as pseudo-financial crises and find that the magnitude of the estimates are small with no significance and the sign of the estimates is inconsistent. This indicates that there is no clear general pattern existing between cash-ratio and changes in the volume of product launches outside the financial crisis. To strengthen our argument that the credit supply shock affected firm product introduction decision, we estimate heterogeneous effects of pre-crisis cash-ratio by categorizing firms using their Whited-Wu index (Whited and Wu, 2006), asset size, and bond credit rating. We find that the liquidity ratio was only important for the group with high Whited-Wu index, small asset size, or no bond access who were expected to face tighter financial constraints.

CIKD announcement data do not include information on product characteristics. In order to address this limitation, we turn to patents and test if firms' volume and choice of invention has changed. Patents reflect the underlying technologies being applied to firms' products. Thus, any changes in the volume and nature of patent applications can be interpreted as changes in future product characteristics if not current. We find that cash constrained firms lowered patent applications by more and experienced greater reduction in 3-year patent citations. To examine the changes in the nature of patent applications, we look at radical inventions. Radical inventions that lead to technological breakthrough are risky to pursue as they have lower probability of success (Ahuja and Morris Lampert, 2001; Fleming, 2001; Eggers and Kaul, 2018). When firms face a binding liquidity constraint, pursuing radical invention can be too risky. Using the measure of patent radicalness developed by Eggers and Kaul (2018), we divide patents into two categories: potentially radical and typical patents. We find that firms with low pre-crisis liquidity ratio had a larger reduction in potentially radical patents. We do not find significant differences for typical patents.

In addition to documenting the general activities around product introduction, we also explore the product variety margin using the trademark data by the U.S. Patent and Trademark Office (USPTO). This study is not the first one to proxy for product variety using these data. For example, Gao and Hitt (2012) use the trademark data for 116 Fortune 1000 manufacturing firms to study the relationship between the information technology stock such as software and product variety. Unlike product announcement, we do not find that pre-crisis liquidity ratio is associated with changes in a firm's use of trademarks or its filings of intent-to-use trademarks.[2] It implies that larger increase in product introductions by constrained firms did not come in the form of more product variety measurable through trademarks but happened within the existing line of products.

In section 1.2, we provide a simple model to illustrate the relationship between cash reserves and product introduction under credit crunch. In section 1.3, we describe our data. In particular, we introduce the measures of product introductions and patent radicalness used

[2] Intent-to-use legal basis was established on November 16, 1989. Since then, potential users of new trademarks have applied for trademark registration with the intent to use in the future.

in this study. Section 1.4 discusses the difference-in-difference empirical design that we employ and presents our results. Section 1.5 concludes.

1.2 Theoretical Motivation

1.2.1 Simple model

A firm is initially endowed with a cash reserve of x_0 and operates for two periods. It produces a single product and its profits from production follow an AR(1) process, $y_t = \phi y_{t-1} + \epsilon_t$, with $0 < \phi < 1$. ϵ_t is a random variable which equals $-\gamma$ with probability p and $\left(\frac{p}{1-p}\right)\gamma$ with probability $1-p$ for some $0 < \gamma < 1$ and $0 < p < 1$. y_0 is assumed to be 1. And as long as the firm operates, it incurs a fixed operating cost of η. At the end of each period, the demand shock, ϵ_t, and operating profits, $\pi_t = y_t - \eta$, are realized. In Period 1, if negative operating profits cannot be covered by cash reserves ($\pi_1 + x_0 < 0$), the firm can issue risk-free debt, b_1, at interest rates of $r + \alpha$ to continue operating.[3] But it faces a borrowing constraint $b_1 \leq \frac{\pi_2^* | \epsilon_2 = -\gamma, l_1}{(1+r+\alpha)}$ where $\alpha \geq 0$ captures potential credit crunch and l_1 is a new product launch variable introduced below. If the firm is unable to cover losses in Period 1 through debt issuance, it stops operating. As a result, borrowing is possible only if the firm can continue operation upon issuing debt. Debts are repaid at the end of Period 2.

Before the beginning of each period, the firm can commercialize a new technology that it has been developing as a new product. If it commercializes a new product in Period 1 ($l_1 = 1$), it introduces a "bad" product with $y_1^B = 1 + \epsilon_1$ and it loses an opportunity to further develop the technology and launch a better product in Period 2. If it waits until the beginning of Period 2, it can launch a better and distinct product ("good" product) with $y_2^G = 1 + \beta + \epsilon_2$ for some $0 < \beta < 1$. Even if the firm has already introduced a new product in Period 1, however, it can still launch a new product with $y_2^B = 1 + \epsilon_2$ applying some technology it has developed in the meantime.

[3] Instead of imposing a fixed operating cost to generate negative total profits, we can have some positive debt b_0 maturing at the end of Period 1.

We make some assumptions on the model parameters. First, operating profit is always non-negative when a new product is introduced regardless of the realized state; $(1-\gamma)-\eta \geq 0$. Without this condition, borrowing in Period 1 is not feasible in any state given any l_1 due to the borrowing constraint. Second, optimal operating profit is non-negative in the good state in Period 1 even if the new product is not introduced. This assumption is not required for our results below but we impose it to reflect that a firm can still have non-negative profit in a good state of the world even if it does not introduce a new product. Third, we require that γ, ϕ, and β satisfy $\gamma \leq \phi$, $\phi(1+\frac{p}{1-p}\gamma) \leq 1$,and $(1+r)(1-\phi) < \beta < \frac{(1-\phi)(1+r)-p(\eta-1)}{1-p}$. The first inequality reflects that profit from production is non-negative without the operating cost. This would naturally hold if we had explicitly modeled the production and demand processes. The second inequality makes it beneficial to introduce a new product for contemporaneous profit. This may not hold in reality and it is not necessary for our results but it makes our exposition simple. Finally, the last inequality ensures that in the absence of a borrowing constraint and credit crunch, the firm prefers to introduce a better product in Period 2. And it also ensures that the new product premium in Period 2 is not "large" enough for the firm to take the risk of closing down in Period 1.

We solve for the firm's optimal choices through backward induction. The firm's problem in the beginning of Period 2 is

$$\max_{l_2 \in \{0,1\}} \mathbb{E}_2[\Pi_2 | l_2, l_1, y_1, b_1] = \max_{l_2} \mathbb{E}_2[\big(l_2(1+\beta \mathbb{I}_{l_1=0}+\epsilon_2)+(1-l_2)(\phi\kappa_1+\epsilon_2)\big)-\eta \\ -(1+r+\alpha)b_1].$$

Given our assumption that $\phi(1+\frac{p}{1-p}\gamma) \leq 1$, the firm would always choose to launch a new product in Period 2 regardless of its launch choice in Period 1. Thus,

$$\mathbb{E}_2[\Pi_2^* | l_1, b_1] = \mathbb{E}_2[(1+\beta \mathbb{I}_{l_1=0}+\epsilon_2)-\eta-(1+r+\alpha)b_1].$$

Next, the firm's problem in the beginning of Period 1 is

$$
\begin{aligned}
&\max_{l_1\in\{0,1\}} \mathbb{E}_1[\ \max_{0\le b_1} \Pi_1|l_1,x_0] \\
&= \max_{l_1\in\{0,1\}} \mathbb{E}_1\Big[\ \max_{0\le b_1} \Big(\big(l_1(1+\epsilon_1)+(1-l_1)(\phi+\epsilon_1)\big)-\eta+x_0 \\
&\qquad + \Big(b_1+\frac{1}{1+r}\mathbb{E}_2\left[\Pi_2^*|l_1,b_1\right]\Big)\mathbb{I}_{b_1\ge-(\pi_1+x_0)}\Big)|l_1,x_0\Big] \\
&\text{subject to} \qquad b_1 \le \frac{\pi_2^*|\epsilon_2=-\gamma,l_1}{(1+r+\alpha)} \text{ (borrowing constraint).}
\end{aligned}
$$

When $\alpha=0$, it is costless to issue debt. Thus, given that $\mathbb{E}_1(\pi_2^*)>0$, it is always optimal to issue debt to continue operating if $\alpha=0$ and $\pi_1+x_0<0$. In fact, when $\alpha=0$, any non-negative b_1 that satisfies the borrowing constraint is optimal as long as it enables the continuation of operation. However, if $\alpha>0$, the cost of issuing debt today is $\frac{\alpha}{1+r}$ per dollar. In this case, b_1^* can be characterized as following:

$$
b_1^* = \begin{cases} 0, & \text{if } \pi_1+x_0\ge 0 \\ -(\pi_1+x_0), & \text{if } \pi_1+x_0<0, \mathbb{E}_1[\pi_2^*|l_1] > -\alpha(\pi_1+x_0), \text{ and } \frac{\pi_2^*|\epsilon_2=-\gamma,l_1}{(1+r+\alpha)} \ge -(\pi_1+x_0) \\ 0 & \text{otherwise.} \end{cases}
$$

Given our assumption that operating profit is always non-negative when a new product is introduced, $b_1^*=0$ when $l_1=1$. But when $l_0=0$, b_1^* depends on whether there is a loss in Period 1 in the bad state, whether the loss can be covered by issuing debt, and whether it is beneficial to continue to operate through debt issuance. Let $b_1^*|\,(l_1=0,x_0,\epsilon_1=-\gamma)=b_{1,\phi,B}^*$ and $\pi_1^*|\,(l_1=0,\epsilon_1=-\gamma)=\pi_{1,\phi,B}^*$. Total optimal firm profits conditioning on launch decision are

$$
\begin{aligned}
&\mathbb{E}_1[\Pi_1^*|l_1=1,x_0] = \mathbb{E}_1\big[(1+\epsilon_1)-\eta\big]+x_0+\frac{1}{1+r}\mathbb{E}_2\left[\Pi_2^*|l_1=1,b_1=0\right] \text{ and} \\
&\mathbb{E}_1[\Pi_1^*|l_1=0,x_0] = p\Big((\phi-\gamma)-\eta\Big)+(1-p)\Big((\phi+\frac{p}{1-p}\gamma)-\eta\Big)+x_0 \\
&\qquad + p\left(b_{1,\phi,B}^*+\frac{1}{1+r}\mathbb{E}_2\left[\Pi_2^*|l_1=0,b_{1,\phi,B}^*\right]\right)\mathbb{I}_{b_{1,\phi,B}^*\ge-(\pi_{1,\phi,B}+x_0)} \\
&\qquad + (1-p)\frac{1}{1+r}\mathbb{E}_2\left[\Pi_2^*|l_1=0,b_1=0\right].
\end{aligned}
$$

The firm would choose to prematurely launch a new product in Period 1 if $\mathbb{E}_1[\Pi_1^*|l_1 = 1, x_0] > \mathbb{E}_1[\Pi_1^*|l_1 = 0, x_0]$ and would optimally launch it in Period 2 if $\mathbb{E}_1[\Pi_1^*|l_1 = 1, x_0] \leq \mathbb{E}_1[\Pi_1^*|l_1 = 0, x_0]$.

Case 1: There is no credit crunch and operating profit is always non-negative: $\alpha = 0$ and $\phi - \gamma \geq \eta$.

In this case, it is straightforward to show that the firm waits until the product matures and launches the new product in Period 2 independent of x_0. In other words, $\mathbb{E}_1[\Pi_1^*|l_1 = 0, x_0] \geq \mathbb{E}_1[\Pi_1^*|l_1 = 1, x_0]$ as $\beta \geq (1 - \phi)(1 + r)$.

Case 2: There is no credit crunch but operating profit in Period 1 is negative in the bad state when $l_1 = 0$: $\alpha = 0$ and $\phi - \gamma < \eta$.

Because there is no discounted cost of issuing debt when $\alpha = 0$, as long as the borrowing constraint does not bind, the firm's optimal choice is to launch its new product in Period 2 and issue debt to continue the operation when total profits in Period 1 are negative. We verify that the borrowing constraint never binds even if $x_0 = 0$ and $l_1 = 0$ given our assumptions. First, $\beta \geq (1 - \phi)(1 + r)$ which reflects that the additional profit from waiting, β, is high enough for waiting to be attractive. Second, because operating profit is always non-negative when $l_t = 1$, $1 \geq \gamma + \eta$. Then, we can show that $-(\phi - \gamma - \eta) \leq \frac{1+\beta-\gamma-\eta}{1+r}$. In other words, $-\pi_{1,\phi,B} = b^*_{1,\phi,B} \leq \frac{\pi_2^*|\epsilon_2=-\gamma, l_1=0}{(1+r+\alpha)}$.

The above analysis illustrates that, in the absence of credit crunch, or a financial crisis, a firm in our model always launches its new product in Period 2 in order to realize the full benefit of new product introduction. This is independent of initial cash reserves x_0. Now, we introduce $\alpha > 0$ and show that a firm without cash reserves prematurely launches its new product in Period 1.

Case 3: Borrowing is expensive and operating profit is always non-negative ($\alpha > 0$ and $\phi - \gamma \geq \eta$).

Because the firm does not need to borrow in any state, the equilibrium is identical to Case 1. Thus, the firm optimally launches its new product in Period 2 instead of Period 1.

Case 4: Borrowing is expensive and operating profit in Period 1 in the absence of new product launch is negative in the bad state. ($\alpha > 0$ and $\phi - \gamma < \eta$).

With the introduction of positive α, we get both the tighter borrowing constraint and positive discounted implicit borrowing costs. Suppose that $x_0 = 0$. In this case, the firm's launch decision in Period 1 depends on the level of credit crunch, α.

Suppose that $l_1 = 0$ and $\epsilon_1 = -\gamma$. Then, issuing debt to continue operation is beneficial only if $\mathbb{E}_1[\pi_2^*|l_1 = 0] > -\alpha(\pi_{1,\phi,B})$. This condition can be rewritten as the following:

$$\alpha \leq \frac{1+\beta-\eta}{\gamma+\eta-\phi}.$$

It is straightforward to show that this is automatically satisfied when the borrowing constraint holds. The new borrowing constraint during the financial crisis is

$$-(\phi-\gamma-\eta) = b^*_{1,\phi,B} \leq \frac{\pi_2^*|\epsilon_2 = -\gamma, l_1 = 0}{(1+r+\alpha)} = \frac{1+\beta-\gamma-\eta}{1+r+\alpha}.$$

Rearranging it yields

$$\alpha \leq \frac{1+\beta-\eta}{\gamma+\eta-\phi} - \frac{\gamma}{\gamma+\eta-\phi} - (1+r) < \frac{1+\beta-\eta}{\gamma+\eta-\phi}.$$

Thus, as long as the borrowing constraint holds, it is beneficial to issue debt and continue operating when $l_1 = 0$ and $\epsilon_1 = -\gamma$.

Now, suppose that issuing debt to continue operation is optimal conditional on $l_1 = 0$ and $\epsilon_1 = -\gamma$.[4] Then, we can show that $\mathbb{E}_1[\Pi_1^*|l_1 = 0, x_0 = 0] \geq \mathbb{E}_1[\Pi_1^*|l_1 = 1, x_0 = 0]$ only if the following holds:

$$\alpha \leq \frac{p^{-1}(\beta-(1-\phi)(1+r))}{\gamma+\eta-\phi} = \frac{(\beta-(1-\phi)(1+r)) + \frac{1-p}{p}(\beta-(1-\phi)(1+r))}{\gamma+\eta-\phi}.$$

But because issuing debt is constrained by the borrowing constraint, α also needs to satisfy the borrowing constraint:

$$\alpha \leq \frac{1+\beta-\gamma-\eta}{\gamma+\eta-\phi} - (1+r) = \frac{(\beta-(1-\phi)(1+r)) + (r+2)(1-(\gamma+\eta))}{\gamma+\eta-\phi}.$$

[4]By our parameter restriction on β, if closing down the operation is optimal in the bad state when $l_1 = 0$, the firm would ex-ante choose to prematurely launch the product to avoid the situation.

If α satisfies both inequalities, the firm waits to launch its new product in Period 2 and in the bad state, it issues debt to continue the operation. If credit crunch is severe (α is "high") such that any of the inequalities above is violated, the firm finds it optimal to prematurely launch the product in Period 1 in order to avoid the need for the expensive borrowing or the risk of closing down. Additionally, the first inequality becomes sufficient if $\frac{1-p}{p}(\beta - (1-\phi)(1+r)) < (r+2)(1-(\gamma+\eta))$ and the second inequality becomes sufficient otherwise.

If there is positive cash $x_0 > 0$, the inequalities above become:

$$\alpha \leq \frac{p^{-1}(\beta - (1-\phi)(1+r))}{\gamma + \eta - \phi - x_0},$$
$$\alpha \leq \frac{1+\beta-\gamma-\eta}{\gamma+\eta-\phi-x_0} - (1+r).$$

It is evident that $\frac{\delta \text{RHS}}{\delta x_0} > 0$ for both inequalities. Thus, a cash reserve relaxes the borrowing constraint and reduces the discounted borrowing costs. Furthermore, if x_0 is large enough such that $\phi - \gamma - \eta + x_0 > 0$, the firm will always choose to introduce its better product in Period 2 as debt issuance becomes unnecessary. This motivates our first regression setting where we use firm cash-ratio as a measure of exposure to the credit supply shock.

α may vary across firms as well. Let $\alpha_i = \rho_i \alpha^C + \alpha_i^I$ where α^C is the common degree of borrowing constraint applied to all firms and α_i^I is the individual component of the borrowing constraint such as firm size. As we have seen in the earlier discussion, if $\alpha_i = 0$, cash reserves become irrelevant for the new product introduction decision. Thus, in our empirical section, we divide the sample into two groups of firms: those who face a tight external financing constraint, and those who do not, using the Whited-Wu index, firm size, and bond rating. Based on our model, we expect the role of cash to be greater among firms facing a tight external financing constraint.

1.2.2 Discussion

We made a few assumptions on the parameters of the model for our exposition. Restrictions on the parameters are not essential to our results except the one on β. If β is too small, the reward from delaying product launch is so small that a firm in our model prefers to introduce a product in every period regardless of the degree of financing constraint. However, if β is too large, the reward from waiting is large enough to overcome tightening financing constraints and larger borrowing costs. In this case, the firm would prefer to introduce new products in later periods even during a financial crisis. Thus, for our exposition in the previous section to represent an average firm's behavior during the crisis, β of an average firm would need to satisfy $(1+r)(1-\phi) < \beta < \frac{(1-\phi)(1+r)-p(\eta-1)}{1-p}$.

Introduction of a new product generates new demand but also replaces part of the demand for the old product due to Arrow's replacement effect (Tirole, 1988, p.392). If a firm does not introduce a new product in Period 1 and waits until Period 2, average y_2 becomes higher because the new "good" product is more technologically advanced with abundant features and it is distinct enough from the old one, implying a smaller Arrow's replacement effect. We can emphasize the superior quality of the "good" product by extending the model to include Period 3 in which no more new products are introduced but the demand for "good" product depreciates less ($\phi^B < \phi^G$).

Our current model implicitly represents falling demand for the firm's product over time which can be recovered by introducing new products. We can instead make the profit process be unit root and let new product introduction increase profit further either through an increase in demand or an increase in productivity. Concerning the financing constraint, we can have a different form of borrowing constraint such as costly verification instead of an auxiliary α. We could also impose an equity financing constraint instead of a debt financing constraint by introducing an equity issuance cost which becomes higher during the financial crisis. The results would be similar in both cases.

We abstract away from R&D investment in our model. But if we add an R&D investment to it and link it to the level of the average y_t, a cash-constrained firm would lower R&D more compared to a cash-rich firm and would end up with an even worse quality new product in Period 2.

1.3 Data and Sample Properties

1.3.1 Data

The main dataset we use is constructed by merging firm accounting information from COMPUSTAT, stock returns from CRSP, product introduction announcements from Capital IQ Key Developments, and trademark and patent filing data from the U.S. Patent and Trademark Office (USPTO). To the best of my knowledge, readily available firm level data on the numbers of new products and services being introduced do not exist. There are product level data that can be matched to firms but they exist only for specific industries or categories of products. For instance, there are drug and medical device approval data from the U.S. Food and Drug Administration (FDA) and retail sector product data from Nielsen Retail Scanner for those products with UPC barcodes distributed through retail chains.[5] However, using the former data as a proxy for new product launches would result in missing the activity in all other industries, and using the latter data would require omitting product and service launches for non-retail products, many durable goods, and business-to-business products. Thus, for this study, we use product launch announcement data from Capital IQ Key Developments (CIKD) as a proxy for new product introduction. We also use trademark usage and filings information from USPTO to proxy for new product variety.

CIKD contains a variety of press release information on topics such as earnings announcements, product-related news, M&A, and executive changes which are collected from company regulatory filings, investor presentations, and news providers including Reuters, Bloomberg, Dow Jones, Comtex, and CNN. Product-related announcements for firms that can be matched to COMPUSTAT with general coverage are available from 2002. Under this product-related announcement category, we sample only the announcements about product introductions by searching for the following words in the headlines: "launch", "introduce", "release", "ships", "shipping", "shipment", "unveil", "new", and "debut". In order to filter

[5] Phillips and Sertsios (2016) match FDA approved medical device data to firm financing record from S&P Capital IQ and Thomson Reuters DealScan to study the effect of Medicare reimbursement approval on firm financing decision. And Jaravel (2017) and Kim (2017) each match UPC barcodes from Nielsen to manufacturer identifiers from GS1 to create a firm level retail product data.

out announcements about patent applications and grants, technology introduction including concept car showcase, and launch delays and cancellations, we exclude announcements containing the following words: “patent”, “technology”, “concept”, “delay”, “cancel”, and “postpone”.[6] CIKD screens out duplicate press releases with identical contents. Thus, we treat each sampled announcement event as unique, indicating an introduction of new products. We aggregate the number of new product announcements for each quarter for each firm and merge them to COMPUSTAT/CRSP dataset on unique COMPUSTAT company identifier (GVKEY).

There are some limitations to using product announcements as a proxy for new product introduction. First, firms may have different predispositions concerning how many products to include in a single announcement. Second, some firms may not make announcements about their new products. We address this by limiting the sample to those firms who have product announcement information for our analysis on new product introduction. Finally, unlike patent citation, there is no quality measure for product announcement. We address this limitation by using USPTO patent applications as proxy for indirect product quality.

We use three imperfect measures of product qualities: R&D expenses, all patent applications, and patent applications categorized by the degree of radicalness. R&D expenses affect both the qualities and breadth of future product offerings. New patent applications by a firm reflect technologies underlying its future new product offerings if not current.[7] Neither of these measures, however, provides information on the kinds of technologies that a firm is developing for its new products. In particular, we do not know how radical or discontinuous the technologies being developed by a firm are. Radical inventions, as opposed to incremental inventions, are risky and less likely to succeed, but successful ones have high economic value and lead to technological breakthrough (Ahuja and Morris Lampert, 2001;

[6]Companies sometimes add the word “patented” in front of their product names in their announcements. Thus, we add those announcements back in to the sample after filtering out announcements about patenting activities.

[7]We merge USPTO patents and citations data to the COMPUSTAT/CRSP dataset following the steps similar to the trademark merging steps.

Fleming, 2001; Eggers and Kaul, 2018). Thus, we use an index of patent potential radicalness developed by Eggers and Kaul (2018) to categorize patents into potentially radical and typical patents. Radical inventions are often based on existing knowledge and are results of combining knowledge from unfamiliar technological domains (Schoenmakers and Duysters, 2010). The index we use captures this idea. Simply put, it measures how unusual the technology classes of patents that a patent is citing are, given the past citation patterns of all patents in the focal patent's technology class. It is important to note that since we are interested in a firm's current technology development effort, we use an index based on patent applications instead of patent grants which can come many years after the successful technology development.

We now introduce the construction of patent potential radicalness index developed by Eggers and Kaul (2018). USPTO categorizes patents according to their technological features using a patent classification system. Until 2012, United States Patent Classification (USPC) system was used, after which it was replaced by Cooperative Patent Classification (CPC) in 2013. To construct the index we need, we use the three-digit classes of the USPC system. For example, both 711 and 707 are three-digit classes and refer to "Electrical computers and digital processing systems: memory" and "Data processing: database and file management or data structures", respectively.[8] Each patent can fall into multiple classes. In this case, we use the primary class, which is the class listed first. Some definitions are needed for the index construction. Let i and j be patent primary classes. Also, let $C_{i,t}$ be total citations made by patents in class i in application year t and $C_{i,j,t}$ be total citations made by patents in class i to class j in application year t. Following Eggers and Kaul (2018), we define $L_{i,j,t}$ ("Link") as:

$$L_{i,j,t} = \frac{\sum_{k=t-5}^{t-1} C_{i,j,k}}{\sum_{k=t-5}^{t-1} C_{i,k}}.$$

For a given tuple (i, j, t), a high $L_{i,j,t}$ score indicates that for the past 5 years, class i patents have been citing class j patents relatively more than patents in other classes. Additionally,

[8]There are more than 400 classes in the USPC system.

We define D_p ("Distant") as:

$$D_p = 1 - \min_{j(p) \in J(p)} (L_{i(p),j(p),t(p)}),$$

where p refers to a patent, $i(p)$ is the class of patent p, $j(p)$ is the class of a patent cited by patent p, $J(p)$ is the set of classes of patents cited by patent p, and $t(p)$ is the application year of patent p. Note that D_p can be equivalently expressed as $D_{p,i(p),t(p)}$ and that $0 \leq D_p \leq 1$ for any p. The distant score captures whether a patent in class i is making an unusual technology link through cross-class citations. Let $P(i,t)$ be a collection of class i patents being filed in year t. And let p^1 and p^2 be two patents in $P(i,t)$. If $D_{p^1} > D_{p^2}$, p^1 is considered to be making a cross-class technology connection that is more unusual than what p^2 is making. An extreme example would be a case when a patent p cites class j that no patent in class $i(p)$ has cited in the past 5 years. In this case, the link score would be 0 and the distant score D_p would be 1. The distant scores are meaningful to compare potential radicalness of patents in the same technology class but they are not suitable for comparing patents in different technology classes. Thus, we normalize $D_{p,i(p),t(p)}$ by the average distant score of last period's patents in the same class, $P(i(p), t(p)-1)$. We define this as AD_p ("Adjusted Distant"):

$$AD_p = AD_{p,i(p),t(p)} = D_p - \sum_{p' \in P(i(p),t(p)-1)} D_{p'} \,/\, \left| P(i(p), t(p)-1) \right|.$$

Given t, the higher the AD_p index is, the more extreme the unusual technological connection the patent p is making. Hence, in every year t, we designate patents that fall into the top 30% of the AD distribution as potentially radical patents and regard the rest of the patents as potentially typical patents.[9] For patents applied between 2002 and 2012, the unconditional sample average of normalized 3-year citations is larger for potentially radical patents than potentially typical patents while the sample variance of normalized 3-year citations is also higher for potentially radical patents.

[9]The cutoff point of top 30% is an arbitrary choice. We also tried top 25%, top 20%, and even top 15% cutoffs like Eggers and Kaul (2018) did in their paper and found qualitatively similar results.

To measure the product variety margin, we use trademark filings data from USPTO. USPTO website defines trademark as "any word, name, symbol, device, or any combination, used or intended to be used to identify and distinguish the goods/services of one seller or provider from those of others."[10] Firms with a wide range of distinct products utilize trademarks to help consumers distinguish offerings among their own product portfolios and to let consumers distinguish their offerings from others' portfolios (Miaoulis and d'Amato, 1978; Landes and Posner, 1987). For instance, Apple's iPhone and iTunes are both registered trademarks. Trademarks are protected under the Trademark Act of 1946 which gives companies an incentive to not only use distinctive words or design for product identification but also actively seek registration of them with USPTO for legal protection. And trademark registration is relatively inexpensive. Trademark application fees per each class range from $225 to $400.[11] For large IT manufacturing firms Gao and Hitt (2012) interviewed, the estimated total costs of registering a trademark are less than $4,000.

Trademark registration takes several steps. First, an applicant decides on a distinctive mark to be used on its goods and/or services and files an application. The applicant must clearly identify goods and/or services on which the mark will be used and choose proper classes and filing basis. USPTO uses Nice Classification system to classify goods and services for the purpose of trademark registration. According to the classification system, for example, musical instruments fall under Class 15 while beverages fall under Class 32. One mark can be applied to multiple goods and services with different Nice classes. In this case, an applicant needs to specify to which class each good and/or service belongs. In terms of the basis for filling, there are two choices: "use-in-commerce" and "intent-to-use". The former applies to a case where the mark is already being used on goods which are "sold or transported in commerce" or on services that "are rendered in commerce" by the filing

[10] `https://www.uspto.gov/trademarks-getting-started/trademark-basics` (retrieved on March 14th, 2018.)

[11] https://www.uspto.gov/trademark/fees-payment-information/overview-trademark-fees (retrieved on March 14th, 2018)

date.[12] The latter refers to a case where an applicant has an intent to use the mark in commerce in the future. Once the application is filed, an USPTO examiner reviews the file to verify that it complies with applicable regulations and to make sure that the mark being claimed is not confusingly similar to other trademarks in the database. Upon the approval of the examiner, USPTO publishes the mark on Trademark Official Gazette (TMOG) for opposition; from the day of publication, others have 30 days to oppose the mark from being assigned. If no one opposes the assignment or if the applicant successfully overcomes all the oppositions, the trademark is registered for an "use-in-commerce" application. For an "intent-to-use" application, a Notice of Allowance (NOA) is issued and the applicant has 6 months until she actually uses the mark in commerce and proves the use to USPTO for successful registration.[13] For non-problematic "use-in-commerce" and "intent-to-use" applications, application to registration takes about 7 months and application to the issue of NOA takes about 6 months, respectively.[14] The use of registered trademarks needs to be reaffirmed within 6 years of registration and the trademarks need to be renewed every 10 years.

A trademark cannot be registered unless it actually gets used in commerce and continued use is required to maintain the registration. This makes trademarks a useful measure of product variety as each trademark is associated with a different set of goods and services. Furthermore, trademark attorneys, corporate trademark officers, and USPTO officers interviewed by Gao and Hitt (2012) testify that firms apply for new trademarks to differentiate their new products from the existing portfolio of products and that there is a strong association between trademark applications and new product development. There is additional suggestive evidence that trademarks are a good measure of product variety.

[12] The Trademark Act of 1946, 15 U.S.C. §1127

[13] Trademark applicants under "intent-to-use" basis can ask for the use extension if they cannot use the mark within six months of the NOA issue date. Additionally, they can start using their trademarks even before the publication date and change the filing basis to "use-in-commerce" instead.

[14] https://www.uspto.gov/trademark/trademark-timelines/section-1a-timeline-application-based-use-commerce
https://www.uspto.gov/trademark/trademark-timelines/section-1b-timeline-application-based-intent-use
(retrieved on March 14th, 2018.)

Using Form 10-K product descriptions, Hoberg and Phillips (2010) find that firms with similar product languages are more likely to merge. Hsu *et al.* (2017) document similar results using trademark data. They find that firms are more likely to merge when they share similar trademark portfolios in terms of their trademark distribution over Nice classes. Trademark, however, is fundamentally distinct from product announcements. Firms make announcements about new products that are upgraded versions of their old ones. But if these upgrades fall into the same product variety, firms mark them with the old trademarks that they already own. For instance, the first version of MacBook Air got released in January 2008 with a new trademark of the same name. But newer versions of it have been released using the same trademark.[15] As the example illustrates, general new product launches cannot be measured using trademark activity; in many cases, only the first releases of product lines would be captured through observing the trademark activity. As a result, we use product announcements as the main proxy for new product introduction while we use trademark usage and applications as a proxy for new product variety introduction.

To construct trademark counts for each firm, we first standardized company names in both the CRSP historical header file, which contains the historical company names, and the USPTO trademark owner files using the Stata routines written by Bessen (2010). Then, we computed distances between the standardized names and assigned scores using Python FuzzyWuzzy package.[16] In order to minimize false matches, we sampled matches with distance scores above 97. We made the choice of using the CRSP historical header file at the expense of sample reduction because the COMPUSTAT file only reflects the most recent company names.[17] USPTO collects and maintains each registered trademark's first date of use in commerce and its application filing date. Using this information, we construct

[15] But in some cases, trademark captures new features that are added to the upgrades. For example, a new macOS High Sierra is a registered trademark in addition to Super Retina and Facetime. Face ID and Animoji are pending registration.

[16] https://github.com/seatgeek/fuzzywuzzy. The package measures distance between two strings using Levenshtein distance.

[17] Chava and Roberts (2008) match company names from DealScan to company names from CRSP historical header file as well.

the quarterly number of trademarks used for the first time and the number of intent-to-use trademark applications for each matched CRSP firm. The former measures the total number of new product varieties being introduced currently. For more than 90% of the sample, the first use date of an intent-to-use application comes after the filing date. Thus, we treat the total number of intent-to-use applications as the number of new product varieties the firm is planning to introduce in the near future.

1.3.2 Sampling procedure

Sampling of our main quarterly dataset starts with the firm-quarter observations from the merged COMPUSTAT/CRSP dataset for the period 2001:Q3 to 2009:Q2. We merge the product and patent measures described in section 1.3.1 to the observations. Our sample begins from 2001:Q3 due to the limited data on CIKD product announcements. We only include firms with product launch announcements in the CIKD database. For firms that change their fiscal year and have duplicate records in the same fiscal quarter, we keep the records that follow the recent customs. From the observations, we exclude firms in regulated and financial industries (SIC codes 4900-4999 and 6000-6999). Then, for the period 2006:Q3 to 2008:Q2, we exclude firms from the sample according to the following criteria. To begin with, we drop firms with missing or negative assets (*atq*), cash reserves (*cheq*), or sales (*saleq*). Additionally, we drop firms for which cash reserves are greater than assets. Following Almeida *et al.* (2004), we exclude firms that experienced asset or sales growth greater than 100% per quarter including missing quarters. This step is taken to screen out firms involved in mergers and acquisitions. Also, similar to Duchin *et al.* (2010), we drop firms with asset values of less than $50 million before 2006:Q3. Inconsistent quarterly observations such as negative short-term debts are set as missing and all accounting variables are deflated to 2009 US dollars. In addition to the product and patent measures, a few additional variables are constructed to be used as controls in our regressions. ROA is constructed as operating income before depreciation (*oibdpq*) over lagged total assets. Tobin's Q is defined as the market value of assets ($atq - (ceqq + txditcq) + prccq \times cshoq$) over their book value. We also construct the Whited-Wu index (Whited and Wu, 2006) for our subsample analysis. Finally, two measures of exposure to the credit supply shock, cash-ratio and net short-term debt-ratio, are constructed. Cash-ratio is defined as cash reserves over assets and net short-term debt-ratio is defined as short-term debt net of cash ($dlcq - cheq$) over assets. All variables are winsorized at the top and bottom 0.5 percentile. Table 1.1 reports the descriptive statistics of the constructed variables.

1.3.3 Sample properties of product measures

Through the following simple exercises, we provide some evidence that our measures of product introduction have sample properties that are consistent with what proper proxies for new product introductions should exhibit. We expect that new product introductions lead to higher future profits and that innovative firms introduce more new products. Thus, good proxies for new product introductions should reflect these characteristics. Using CRSP daily stock returns from 2002 to 2014, we show that CIKD new product launch announcements and trademark first uses both predict positive daily excess returns. Also, using the annual COMPUSTAT observations from 2002 to 2014 and USPTO patents applied in the same periods, we show that patenting volume and quality-adjusted patenting volume both positively predict our measures of new product introduction.

In Figure 1.1, we present the share turnover and daily excess returns around the CIKD new product launch announcement dates. The first one plots daily share turnover 3 days around the announcement dates. Share turnover l is the ratio of daily volume (vol) to shares outstanding ($shrout$). The median daily share turnover in our sample is 0.52%. The points in the plot are the coefficients β_k estimated from the following regression with standard errors clustered by year:

$$l_{i,t} = \alpha + \sum_{k=-3}^{3} \beta_k \mathbb{I}^{AN}_{i,t+k} + \gamma'_{\mathrm{F}} \mathbf{F}_{i,y} + \gamma'_{\mathrm{D}} \mathbf{D}_d + \epsilon_{i,t}, \tag{1.1}$$

where $\mathbb{I}^{AN}_{i,t+k}$ is an indicator variable that takes value 1 if a firm i made a new product introduction announcement on day $t+k$, $\mathbf{F}_{i,y}$ are firm-year fixed effects, and $\mathbf{D}_d$ are day

Table 1.1: *Descriptive Statistics*

The following table shows the descriptive statistics of quarterly product introduction measures, patent measures, control variables, and liquidity ratios that we use in the analyses of product introduction during the 2007-2009 financial crisis. Sample period is from 2006:Q3 to 2009:Q2. The sample only includes the firms who have product introduction announcement records present in CIKD during the sample period. Patents refer to the total number of patent applications by each firm. (Potentially) radical and (potentially) typical patents are applied patents classified using the index developed by Eggers and Kaul (2018). Tobin's Q is the market value of assets ($atq - (ceqq + txditcq) + prccq \times cshoq$) over their book value (atq). ROA is operating income before depreciation (oibdp) over lagged total assets (atq_{t-1}). Size is the natural logarithm of total firm assets (atq). Pre-crisis Cash, Net Short-term Debt, and Whited-Wu Index are all observed once in the sample and are averages of quarterly observations from 2005:Q3 to 2006:Q2. Quarterly Cash is cash reserves (cheq) over total assets (atq). Net Short-term Debt is net short-term debts ($dlcq - cheq$) over total assets (atq), and Whited-Wu Index is constructed using the structurally estimated equation from Whited and Wu (2006).

Statistic	N	Mean	St. Dev.	Min	Median	Max
ln(1 + Product Launch Announcements)	16,695	0.469	0.663	0.000	0.000	4.220
R&D Investment / Asset	11,134	0.025	0.029	−0.005	0.019	0.749
ln(1 + Patents)	16,695	0.449	1.000	0.000	0.000	6.683
ln(1 + Radical Patents)	16,695	0.242	0.687	0.000	0.000	5.656
ln(1 + Typical Patents)	16,695	0.365	0.885	0.000	0.000	6.579
ln(1 + Number of Trademarks First Used)	16,695	0.194	0.529	0.000	0.000	5.106
ROA_{t-1}	15,636	0.024	0.043	−0.490	0.028	0.383
Q	15,669	1.946	1.240	0.380	1.587	10.040
Size	16,688	6.923	2.012	2.512	6.672	12.044
Cash (pre-FC)	1,413	0.253	0.220	0.000	0.192	0.903
Net Short-term Debt (pre-FC)	1,404	−0.224	0.238	−0.897	−0.167	0.330
Whited-Wu Index (pre-FC)	778	−0.322	0.102	−0.635	−0.301	−0.154

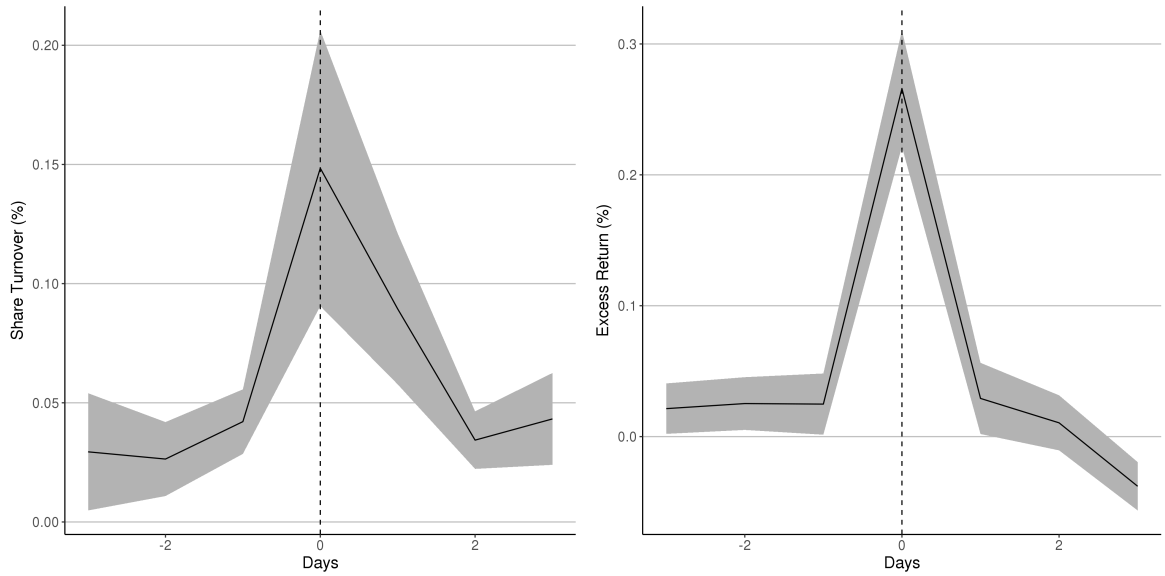


Figure 1.1: *Share Turnover and Excess Returns around Product Launch Announcement Days*

of the week fixed effects. We also plot 90% confidence intervals around the coefficient estimates. Similarly, the second figure plots daily excess return defined as firm daily return minus the market return ($ret - vwretd$) 3 days around the announcement dates. These plots indicate that there are more trades around the announcement dates and the market reacts positively to the news of new product introduction. New product launch announcements lead to additional average excess daily returns of about 26 basis points, which is consistent with what Chaney *et al.* (1991) find. In Figure 1.2, we also present the share turnover and daily excess returns around the trademark first use-in-commerce dates. Even though the magnitudes are smaller and estimates are less precise, they confirm that there are more trades and markets react favorably on the trademark first use dates. The magnitude is smaller for trademarks because the first use date can be locally imprecise in the sense that products may not be revealed on the first trademark use date. For instance, interstate shipping of products to retailers in advance of a sale is considered “use in commerce” in which case the products are revealed to the public a few weeks after the first trademark use date.

Next, we regress our product introduction measures on various firm characteristics to

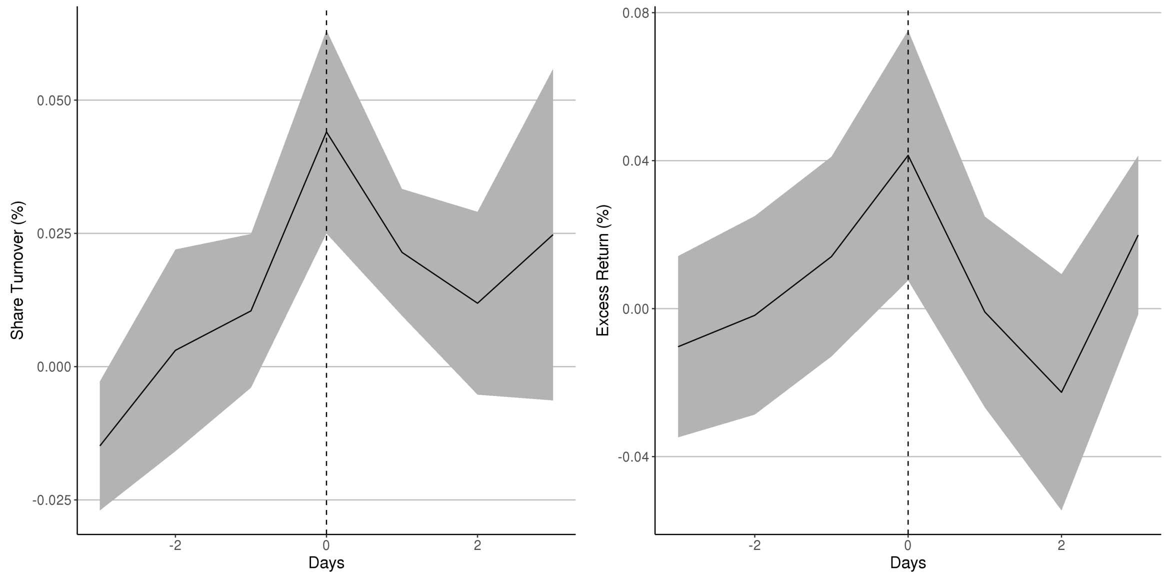


Figure 1.2: *Share Turnover and Excess Returns around Trademark First Use Dates*

examine the relationships between them. The firm characteristics include lagged return on asset (ROA), Tobin's Q, firm size (measured as natural logarithm of assets), capital investment intensity, and measures of innovation. Innovation measures include R&D investment intensity, the natural logarithm of patent applications, and the natural logarithm of normalized 3-year citations eventually received by the applied patents. We normalized 3-year citations of each granted patent by the average number of 3-year citations received by a granted patent in the same patent technology class in the same year. We would like to point out that the citation count of applied patents is not free of problems even after the normalization because grant years of the patents applied in the same year can differ from each other. The sample covers firm-year observations from 2002 to 2014 and it only includes the firms with product announcements covered in CIKD during the period. We use an annual sample to include as many firm R&D observations as possible. Also, we do not use years beyond 2014 to minimize patent and trademark truncation biases. Finally, regressions with patent citations only use observations up to year 2012 in order to take patent grant lag into consideration.

From Table 1.2, we observe that firm size, recent firm profitability, and measures of innova-

Table 1.2: *New Product Launch Announcement and Firm Characteristics*

Sample period is 2002 to 2014 for regressions without patent citations and it is 2002 to 2012 for regressions with patent citations. ROA is operating income before depreciation (oibdp) over lagged total assets. Patents refer to the annual total number of patent applications by each firm. 3-Year Citations are the number of citations eventually received by the applied patents for three years following their grants. 3-year citations of each granted patent are normalized by the average number of 3-year citations received by a granted patent in the same patent technology class in the same year. Construction of other variables is self-explanatory. Standard errors are clustered at the firm level and given in parentheses.

	Dependent variable:					
	ln(1 + Product launch announcements)					
	(1)	(2)	(3)	(4)	(5)	(6)
ROA_{t-1}	−0.083	−0.218***	−0.224***	−0.048	−0.069	−0.063
	(0.069)	(0.055)	(0.058)	(0.059)	(0.044)	(0.045)
Q	0.014	0.013**	0.014*	0.006	0.004**	0.003
	(0.012)	(0.007)	(0.008)	(0.006)	(0.002)	(0.002)
ln(Asset)	0.253***	0.151***	0.154***	0.116***	0.087***	0.070***
	(0.016)	(0.013)	(0.013)	(0.023)	(0.017)	(0.019)
Capital Investment / Asset	−0.739**	−0.194	−0.242	−0.058	0.057	0.070
	(0.363)	(0.243)	(0.252)	(0.230)	(0.152)	(0.160)
R&D Investment / Asset	1.046***			0.152*		
	(0.177)			(0.092)		
ln(1 + Patents)		0.161***			0.026**	
		(0.015)			(0.013)	
ln(1 + 3-Year Citations)			0.159***			0.019*
			(0.015)			(0.011)
Firm FE	No	No	No	Yes	Yes	Yes
Industry x Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	14,678	20,699	17,841	14,678	20,699	17,841
R^2	0.451	0.445	0.446	0.786	0.775	0.787

Note: *p<0.1; **p<0.05; ***p<0.01

tion are associated with product introduction announcements. Not surprisingly, larger firms have more new product launch announcements. And looking at the estimates without firm fixed effects, we observe that a firm's past profitability, measured with lagged ROA, is associated with fewer new products. This can be explained either by a firm's desire to improve profitability through new product introductions when the profitability is low or by its desire to avoid cannibalizing the demand for its existing products when the profitability is still high. Finally, R&D investment, patent applications, and quality-adjusted patent applications are all significantly positively associated with product introduction announcements.

Table 1.3 shows the estimates from the firm characteristic regression using a product variety measure (new trademark) as the dependent variable instead. We observe that larger firms also have more new product varieties. Unlike general new product launches, however, a new trademark is positively associated with a firm's recent profitability. Recall that trademarks capture product variety and not necessarily general products or upgrades of existing products. If introducing new product varieties is riskier than introducing upgrades of existing products, the positive correlation may be capturing a firm's willingness to take risks and expand its offerings only when the firm's profitability has been high. Similar to new product launch announcements, new trademarks are positively associated with patenting activities.

1.4 Results

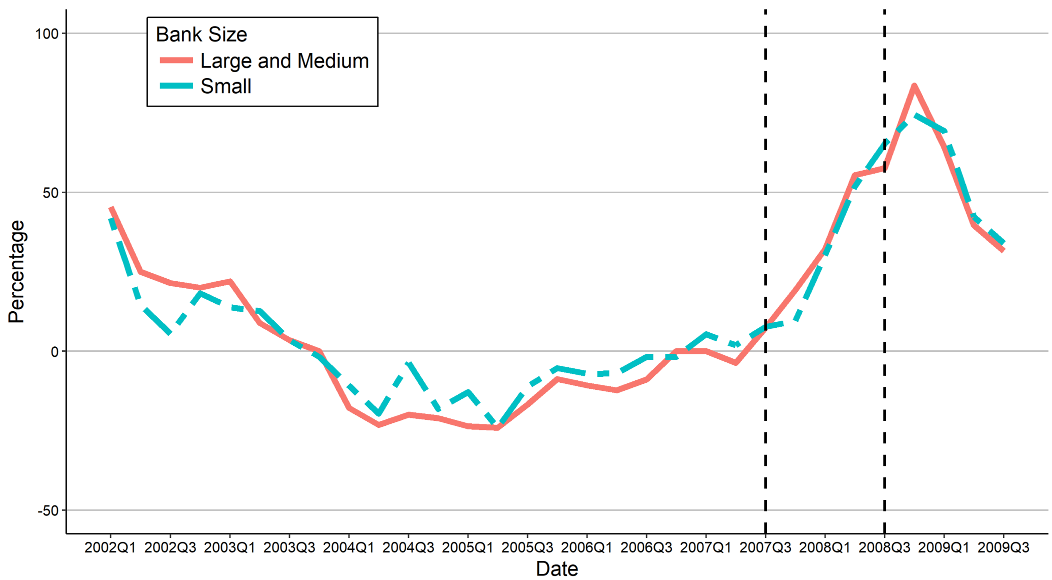
The total amount and number of loans issued decreased drastically after the second quarter of 2007 across all types of loans (Ivashina and Scharfstein, 2010). As shown in Figures 1.3 and 1.4, banks tightened their standards on commercial and industrial loans and increased loan rates relative to their costs of funds from mid-2007. In addition, both the spread between 3-month LIBOR and 3-month T-bill (TED spread) and the spread between 3-month LIBOR and 3-month overnight indexed swap (LIBOR-OIS spread) sharply widened up since the late July of 2007 (Greenlaw *et al.*, 2008). These indicators all show the severity of capital market disruptions that began to appear from the third quarter of 2007. We would like

Table 1.3: *Number of Trademarks First Used and Firm Characteristics*

Sample period is 2002 to 2014 for regressions without patent citations and it is 2002 to 2012 for regressions with patent citations. ROA is operating income before depreciation (oibdp) over lagged total assets. Patents refer to the annual total number of patent applications by each firm. 3-Year Citations are number of citations eventually received by the applied patents for three years following their grants. 3-year citations of each granted patent are normalized by the average number of 3-year citations received by a granted patent in the same patent technology class in the same year. Construction of other variables is self-explanatory. Standard errors are clustered at the firm level and given in parentheses.

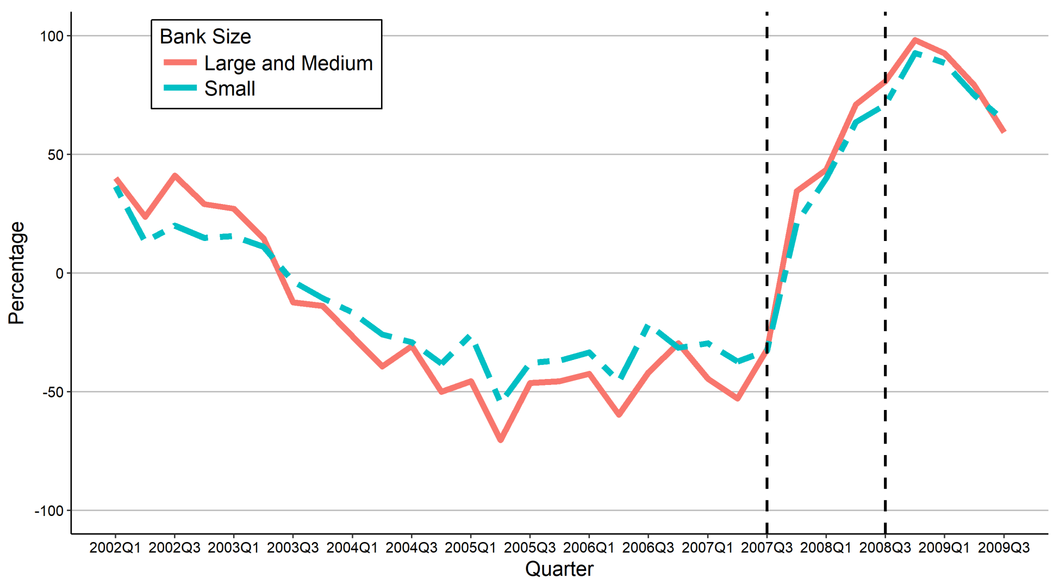
	Dependent variable:					
	ln(1 + Number of Trademarks First Used)					
	(1)	(2)	(3)	(4)	(5)	(6)
ROA_{t-1}	0.033	0.162***	0.179***	0.028	0.048	0.038
	(0.070)	(0.055)	(0.060)	(0.062)	(0.048)	(0.049)
Q	0.036***	0.007	0.008	0.003	0.001	−0.0001
	(0.010)	(0.005)	(0.005)	(0.006)	(0.002)	(0.002)
ln(Asset)	0.174***	0.058***	0.070***	0.066***	0.040**	0.060***
	(0.020)	(0.012)	(0.013)	(0.021)	(0.017)	(0.019)
Capital Investment / Asset	0.322	−0.136	−0.141	0.428	0.221	0.214
	(0.362)	(0.231)	(0.250)	(0.272)	(0.160)	(0.168)
R&D Investment / Asset	0.072			0.071		
	(0.136)			(0.117)		
ln(1 + Patents)		0.257***			0.090***	
		(0.015)			(0.019)	
ln(1 + 3-Year Citations)			0.236***			0.055***
			(0.015)			(0.015)
Firm FE	No	No	No	Yes	Yes	Yes
Industry x Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	14,678	20,699	17,841	14,678	20,699	17,841
R^2	0.263	0.330	0.313	0.750	0.736	0.745

Note: $^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$



Source: Senior Loan Officer Opinion Survey by the Federal Reserve Board

Figure 1.3: *Net Percentage of U.S. Banks Tightening Standards for Commercial and Industrial Loans*



Source: Senior Loan Officer Opinion Survey by the Federal Reserve Board

Figure 1.4: *Net Percentage of U.S. Banks Increasing Spreads of Loan Rates over Banks' Cost of Funds*

to estimate the effect of this historic disruption in credit supply on firms' product launch decisions. First, based on the above observations, we designate the periods starting from the third-quarter of 2007 as the financial crisis period. Next, similar to Duchin *et al.* (2010) and Gilchrist *et al.* (2017), we take the stance that firms with low liquidity buffer before the financial crisis were more exposed to the shock in credit supply and would therefore have exhibited behaviors of liquidity constrained firms with hardship of financing. In fact, firm cash-ratios decreased significantly from mid-2007 implying that firms used up their cash reserves at the face of the tightening capital market (Duchin *et al.*, 2010). In order to minimize the concern of capital structure endogeneity, we use the average of quarterly cash-ratio from 2005:Q3 to 2006:Q2, a year before the beginning of the crisis, as a measure of the pre-crisis liquidity buffer. Then, we take a difference-in-difference approach and test how the product introduction announcements before and after the July of 2007 differed between the firms who are expected to have had a high exposure to the supply shock in the external capital market and those expected to have had a low exposure. The following is the baseline model that we estimate:

$$AN_{i,t} = \alpha + \beta_1 FC + \beta_2 FC \times \text{Cash}_{i,2006} + \gamma_{\text{F}}' \mathbf{F}_i + \epsilon_{i,t}, \quad (1.2)$$

where $AN_{i,t}$ is the natural logarithm of one plus number of product launch announcements, FC is a dummy variable which equals to 1 from the third quarter of 2007 onward, and $\mathbf{F}_i$ are firm fixed effects. The core identification assumption is that the ex-ante indicators of firm liquidity are not correlated with changes in unobserved product launch opportunities before and after the beginning of the crisis. We estimate the above model for three sample periods: 2006:Q3 to 2008:Q2, 2006:Q3 to 2008:Q4, and 2006:Q3 to 2009:Q2. The first sample period ends before the onset of Lehman's fall. We are testing if the shock in credit supply that occurred before Lehman's fall had a differential effect on changes in firm product launch announcements, depending on the firms' level of exposure to the shock. During the onset of the Lehman crisis, firms drew down their credit lines to ensure that they had access to liquidity (Campello *et al.*, 2011; Ivashina and Scharfstein, 2010) and self-reported liquidity constrained firms noticeably changed their plans on capital expenditure, technology expenditure, cash holdings, and employment (Campello *et al.*, 2010). These indicate that there was extra pressure on firms to secure liquidity after the fall of Lehman. Thus, we extend the sample to include the third and fourth quarters of 2008, immediately after the fall of Lehman, and re-estimate the above model. Finally, we further extend the sample until 2009:Q2 in order to include the entire recession period and minimize the influence of seasonality on the estimates.

Firms voluntarily release the news about their product introductions. Thus, firms could differ in how they make announcements about their new products. For instance, some firms may make announcements about every new product while others only selectively announce their new products. We include firm fixed effects in every regression to control for these kinds of unobserved time-invariant firm-level differences in the volume of launch announcements. Also, we include industry-quarter fixed-effects to account for seasonality in product launches in each SIC 2-digit industry. In addition, we include three additional variables as controls. Firms may not want to introduce new products if the production of existing products is still profitable. Therefore, we control for recent firm operating profitability using last quarter's return on assets (ROA) in the regression. ROA is operating income before depreciation over lagged total assets. We also include Tobin's Q in the regression to control for any unobservable opportunities for product introduction. Larger firms may introduce more products on average. Thus, we control for firm size using the natural logarithm of total assets in 2009 dollars.

1.4.1 Firm liquidity and product introduction

Table 1.4 reports the estimates from the baseline regression (1.2) over the three sample periods: 2006:Q3 to 2008:Q2, 2006:Q3 to 2008:Q4, and 2006:Q3 to 2009:Q2. Our sample only includes the firms who have at least one record of new product launch announcements in CIKD in the first sample period. Column (1) presents the estimates from the specifications without any controls for the base period (2006:Q3 to 2008:Q2). It shows the core result of this paper. Zero-cash firms made 5.3% more new product announcements per quarter during the crisis. But the increase was smaller for firms who had high internal liquidity a year before the crisis. In particular, product launch announcements of firms with one standard deviation larger cash reserves grew 2 percentage points less per quarter after the onset of the crisis. The estimates of the coefficients on the financial crisis dummy and the interaction term are both statistically significant at 5% level. Column (4) shows that the estimates are robust to the inclusion of various controls and industry-quarter fixed effects at the SIC 2-digit level to account for firm product introduction opportunities and industry specific seasonality, respectively [18,19]. In fact, the coefficient estimate of the interaction term becomes larger and more significant when firm product introduction opportunities are controlled for and industry-quarter fixed effects are included. The estimates suggest that the growth of product launch announcements was 2.3 percentage points lower per quarter for firms with one standard deviation larger cash reserves. And on average, there was no change in product launch announcements for firms with a cash ratio of 49%. The similar results are found when net short-term debt ratio is used as in Duchin *et al.* (2010) instead of the cash ratio and they are reported in Table A.3. These results indicate that firms who were low on liquidity during the financial crisis increased product launches more than other firms with abundant cash reserves. In the light of the findings that firms improve profitability temporarily following new product introductions (Chaney *et al.*, 1991; Bayus *et al.*, 2003), early introduction of products may alleviate the liquidity constraints that the firms face. Consequently, firms that are short on liquidity during the financial crisis have greater incentive to secure cash flows through prematurely introducing new products that they have been developing.

Banks tightened their lending standards further and increased loan rates after the fall of

[18] When we classify the industries using 3-digit SIC codes instead, the results are both quantitatively and qualitatively similar. They are reported in Table A.1.

[19] We also try interacting ex-ante (before 2006:Q3) average level of controls with the financial crisis dummy to additionally control for any effect that the ex-ante levels of control variables have on the changes in the volume of product launch announcements before and after the onset of the financial crisis. The results are reported in Table A.2.

Table 1.4: *Product Introduction and Cash during the Financial Crisis*

The following table reports the coefficient estimates and their standard errors from the baseline regression (1.2) described in section 1.4. The sample only includes the firms who have product introduction announcement records present in CIKD from 2006:Q3 to 2008:Q2. Each sample period begins in 2006:Q3 and ends in the quarter reported in each column. The dependent variable is the natural logarithm of one plus the number of product launch announcements. FC is a dummy variable equal to 1 from 2007:Q3. Cash is the quarterly average of cash reserves (cheq) over total assets (atq) from 2005:Q3 to 2006:Q2. ROA is operating income before depreciation (oibdp) over lagged total assets (atq_{t-1}). Q is Tobin's Q computed as the market value of assets over their book value. Size is the natural logarithm of total assets. Standard errors are clustered at the firm level.

	Dependent variable:					
	ln(1 + Product launch announcements)					
	(1)	(2)	(3)	(4)	(5)	(6)
FC	0.052***	0.045***	0.046***	0.051***	0.053***	0.047***
	(0.013)	(0.012)	(0.012)	(0.014)	(0.013)	(0.013)
FC x Cash	−0.088**	−0.106***	−0.106***	−0.105**	−0.108***	−0.106***
	(0.040)	(0.036)	(0.035)	(0.043)	(0.040)	(0.038)
ROA_{t-1}				0.313	0.069	0.009
				(0.305)	(0.245)	(0.202)
Q				−0.004	0.001	0.004
				(0.010)	(0.009)	(0.008)
Size				0.104**	0.081***	0.096***
				(0.040)	(0.029)	(0.024)
End Quarter	2008:Q2	2008:Q4	2009:Q2	2008:Q2	2008:Q4	2009:Q2
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Industry x Quarter FE	No	No	No	Yes	Yes	Yes
Observations	10,697	13,130	15,465	9,596	11,798	13,902
R^2	0.654	0.649	0.646	0.667	0.660	0.657

Note: *p<0.1; **p<0.05; ***p<0.01

Lehman Brothers (See Figures 1.3 and 1.4). Thus, firms' internal liquidity might have become more important at the onset of the Lehman crisis. To check this, we re-estimate the baseline regression (1.2) by extending the sample period to include the third and fourth quarters of 2008. Columns (2) and (5) of Table 1.4 report estimates for this extended sample period. We then extend the sample period to the end of the NBER defined recession (2009:Q2). This also helps balancing the quarters in our sample. Columns (3) and (6) present the estimates for this fully extended sample period. Once we include the periods following the onset of the Lehman crisis, the estimate of the interaction coefficient without controls becomes larger in magnitude and statistically more significant.[20] As shown in column (2), for firms with a one standard deviation higher cash ratio, product launch announcements grew by 2.4 percentage points less per quarter following the onset of the financial crisis. With controls, extending the sample periods does not make the estimate become larger in magnitude but it does make the estimate statistically more significant. The coefficients estimates from the fully extended sample are similar in magnitude and are equally statistically significant at 1% level.

Not all public firms who launched new products made new product announcements on the venues covered by CIKD during the sample period. Thus, we include only the firms who have product announcement data in CIKD between 2006:Q3 and 2008:Q2 for the estimates in Table 1.4. But some firms do have product launch announcement records in CIKD in other times. We check if the results change qualitatively once we include all firms who have at least one product launch announcement record present in the CIKD database regardless of the announcement date. Table 1.5 reports the estimates from the baseline regression (1.2) for this case.

Columns (1) and (4) of Table 1.5 report the estimates over the sample period 2006:Q3-2008:Q2. Column (1) shows that zero-cash firms increase new product launch announcements per quarter by 3% but the growth of the announcements per quarter is one percentage point smaller for firms with one standard deviation higher cash reserves. This interaction estimate

[20]We do not find, however, that the difference in the estimates is statistically significant.

Table 1.5: *Product Introduction and Cash during the Financial Crisis (Full Sample)*

The following table reports the coefficient estimates and their standard errors from the baseline regression (1.2) *described in section 1.4. The sample begins in 2006:Q3 and it includes all firms who have any product introduction announcement record in CIKD. The dependent variable is the natural logarithm of one plus the number of product launch announcements. FC is a dummy variable equal to 1 from 2007:Q3. Cash is the quarterly average of cash reserves (cheq) over total assets (atq) from 2005:Q3 to 2006:Q2. ROA is operating income before depreciation (oibdp) over lagged total assets (atq_{t-1}). Q is Tobin's Q computed as the market value of assets over their book value. Size is the natural logarithm of total assets. Standard errors are clustered at the firm level.*

	Dependent variable:					
	ln(1 + Product launch announcements)					
	(1)	(2)	(3)	(4)	(5)	(6)
FC	0.031***	0.033***	0.035***	0.030***	0.036***	0.034***
	(0.008)	(0.007)	(0.007)	(0.009)	(0.008)	(0.008)
FC x Cash	−0.050*	−0.069***	−0.069***	−0.061**	−0.072**	−0.073***
	(0.028)	(0.026)	(0.025)	(0.031)	(0.029)	(0.027)
ROA_{t-1}				0.214	0.059	0.002
				(0.184)	(0.154)	(0.110)
Q				−0.004	−0.004	−0.002
				(0.007)	(0.006)	(0.006)
Size				0.070**	0.054***	0.060***
				(0.028)	(0.021)	(0.017)
End Quarter	2008:Q2	2008:Q4	2009:Q2	2008:Q2	2008:Q4	2009:Q2
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Industry x Quarter FE	No	No	No	Yes	Yes	Yes
Observations	15,890	19,511	23,007	14,346	17,633	20,803
R^2	0.703	0.693	0.687	0.720	0.707	0.701

Note: $^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$

is weakly statistically significant. As shown in column (4), the estimate of the coefficient on the interaction term becomes larger and statistically significant at 5% level when product introduction opportunities, firm size, and industry specific seasonality are controlled for. The rest of the columns in Table 1.5 present the results for the extended sample periods. Overall, the results are qualitatively similar to the ones presented in Table 1.4 even though the magnitude of the estimates becomes smaller and the estimates become less precise. Excluding firms without any new product launch announcements during the sample period removes the biases and noise introduced by firms who launched new products but did not make new product announcements on the venues covered by CIKD and by firms with zero probability of launching products regardless of the severity of the financial crisis. Thus, for all the following analyses, we continue to use this restricted sample.

In section 1.2.1, we modeled the firm's decision as a binary choice of whether to introduce any new products or not. Given that firms may differ in how many new products to launch at once and how many new products to include in a single launch announcement, changes in the volume of new product launch announcements may not tell us much about the magnitude of the changes in the number of underlying new products being launched. For instance, the same 5% increase in the number of new product launch announcements might imply different magnitudes of increase in the number of new products being launched for two distinct firms. Thus, it makes sense to also look at the changes in the likelihood of making a new product launch announcement. Accordingly, we recode the dependent variable as a binary variable and estimate the effect of liquidity ratio on changes in the likelihood of launching new products before and after the onset of the financial crisis. The sample includes all firms who have product launch announcement records present in CIKD during each sample period and the estimation is done through logistic regression.

Table 1.6 reports the marginal coefficients computed from the estimated coefficients of logistic regression. Columns (1) and (4) present the estimates without and with controls, respectively, for the sample period 2006:Q3-2008:Q2. In both specification, we find a negative and statistically significant effect of cash ratio on the change in the likelihood of launching

Table 1.6: *Likelihood of New Product Introduction and Cash during the Financial Crisis*

The following table reports the marginal coefficient estimates and their standard errors from the logistic regression described in section 1.4. The sample begins in 2006:Q3 and it includes firms who have product introduction announcement records present in CIKD during each sample period. The binary variable used in the estimation is an indicator variable that takes value one when a firm makes any new product launch announcement in a given quarter and takes value zero otherwise. FC is a dummy variable equal to 1 from 2007:Q3. Cash is the quarterly average of cash reserves (cheq) over total assets (atq) from 2005:Q3 to 2006:Q2. ROA is operating income before depreciation (oibdp) over lagged total assets (atq_{t-1}). Q is Tobin's Q computed as the market value of assets over their book value. Size is the natural logarithm of total assets. Standard errors are clustered at the firm level.

	Binary variable used:					
	$\mathbb{I}$(# of product launch announcement > 0)					
	(1)	(2)	(3)	(4)	(5)	(6)
FC	0.043^{***}	0.044^{***}	0.044^{***}	0.049^{***}	0.056^{***}	0.050^{***}
	(0.014)	(0.012)	(0.011)	(0.016)	(0.014)	(0.013)
FC x Cash	-0.089^{**}	-0.108^{***}	-0.104^{***}	-0.113^{**}	-0.126^{***}	-0.115^{***}
	(0.041)	(0.035)	(0.033)	(0.046)	(0.040)	(0.037)
ROA_{t-1}				0.127	−0.087	−0.083
				(0.322)	(0.252)	(0.204)
Q				0.004	0.003	0.003
				(0.011)	(0.009)	(0.007)
Size				0.076^{*}	0.071^{**}	0.061^{**}
				(0.044)	(0.031)	(0.025)
End Quarter	2008:Q2	2008:Q4	2009:Q2	2008:Q2	2008:Q4	2009:Q2
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Industry x Quarter FE	No	No	No	Yes	Yes	Yes
Observations	9,587	12,670	15,581	8,322	11,130	13,701
Note:						$^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$

new products. From column (1), we observe that, for zero-cash firms, the likelihood of introducing new products increases by 4.3 percentage points after the onset of the financial crisis. But the likelihood of making a new product launch announcement actually falls by 2 percentage points for firms with a 1 standard deviation greater cash ratio. The estimates imply that the likelihood would not change at all for firms whose cash ratio is at the 80th percentile.

The marginal coefficient estimates become larger and more significant both when controls and fixed effects are included and when the sample period is extended to include post-Lehman crisis quarters. Column (5) reports the estimates from the specification with controls and industry-quarter fixed effects over the sample period 2006:Q3-2008:Q4. The estimates suggest that the effect of cash ratio stays significant when the Lehman crisis period is included in the sample. The likelihood of making new product launch announcements increases by 5.6 percentage points for zero-cash firms. But a 1 standard deviation increase in firm cash ratio implies a 2.5 percentage point decrease in the likelihood of a new product launch announcement. These results indicate that cash constrained firms were more likely to make product launch announcements than before compared to firms with enough liquidity buffer.

We interpret the results above as evidence that the shock to the external capital market leads to a larger increase in product launches among liquidity constrained firms relative to firms with abundant liquidity. But this interpretation can be problematic if the constrained firms strategically increased the announcement coverage of their new products to increase their market values without actually launching more new products than before. We cannot formally rule out this possibility but the evidence found in the literature suggest that increasing announcement coverage alone is unlikely to help the constrained firms. Using the CIKD data, Cohn *et al.* (2018) find that the market's response to a new product announcement is less positive if the managers have incentives to focus on short-term market performances. This implies that the market pays attention to the content of and motivations behind announcements and would discount mere increase in product announcement coverage.

There is further evidence of the market's attention to the details of product announcements. Using the product announcements that appeared on Wall Street Journal from 1975 to 1984, Chaney *et al.* (1991) document that announcement returns were higher when an announcement contained news about multiple new products as opposed to a single new product. Also, stock returns were lower if an announcement was about an update of existing products than if it was about introduction of a distinct new product.

1.4.2 Robustness

The results presented in the previous section suggest that firms short on liquidity increased product launches more than other firms with abundant liquidity did. This can be explained by the firms' willingness to secure additional funding sources through new product launches in the face of tightening liquidity constraints during the crisis. In order to attribute the observed differences in firm product launch decisions to the credit supply shock, we rely on two assumptions. The first one is relatively non-controversial. We assume that the sudden disruption in credit market supply of the realized magnitude was largely unexpected. Due to the endogeneity of capital structure, it is expected that firms with higher probability of binding liquidity constraint in the future would carry larger cash reserves relative to their size (Almeida *et al.*, 2004). But we take the view that the actual realized negative shock in the capital market was larger in magnitude than what the firms had expected such that the firms who carried more liquid assets had extra benefits from them. The empirical evidence from Duchin *et al.* (2010) and Gilchrist *et al.* (2017) supports this view. Second, we also need an assumption that the pre-crisis level of firm liquidity is not negatively correlated with unobserved changes in product introduction opportunities before and after the onset of the crisis. For instance, our interpretation of the results found above would be incorrect if firms had accumulated liquidity buffer ex-ante in expectation of ex-post firm-specific lower new product demand, worse condition for introducing new products in general, or higher profitability from delaying product launches. From our model framework, the assumption we make is equivalent to $x_{i,0} \not\propto \mathbb{E}_0[y^B_{i,1}]^{-1}$ and $x_{i,0} \not\propto \beta_i$. There is no direct test of the second assumption. Instead, following Duchin *et al.* (2010), we re-estimate equation (1.2) for other sample periods as placebo tests. Specifically, for sample periods 2002:Q3-2004:Q2, 2003:Q3-2005:Q2, 2004:Q3-2006:Q2, and 2005:Q3-2007:Q2, we designate the latter half of the periods as pseudo financial crises. And we measure liquidity ratio for each firm as the four-quarter average cash ratio before the beginning of each sample period. Then, we re-estimate the baseline regression for the four sample periods. If the pattern observed during the actual financial crisis is found to be prevalent in these placebo periods as well, then we cannot argue that the credit market disruption during the financial crisis was responsible for the observed differences in firm launch decisions. The results of these placebo tests are shown in Table 1.7.

The estimates of the coefficients on the pseudo financial crisis dummy are inconsistent and are generally insignificant. Furthermore, for every placebo period, the estimate of the coefficient on the interaction term is statistically insignificant. And the estimates are either close to 0 or positive. This indicates that the general association existing between ex-ante cash-ratio and changes in the volume of product introductions would bias us against finding the strong negative association that we found for the actual crisis period. The results of the placebo tests are consistent with our second identification assumption. Thus, it supports our interpretation that the tightening liquidity constraints during the financial crisis were responsible for the observed differences in product launch increases between firms with low liquidity and others with enough liquidity.

The simple model presented in section 1.2.1 suggests that x_0, or liquidity, is important for product launch decisions in the case of a high enough α, or the degree of financing constraints. Average α increases during the financial crisis but the increase may still be irrelevant for firms with ex-ante low α's. To put it another way, firm internal liquidity may only matter for firms with an ex-ante worse access to the capital market. To test this, we split our sample into two groups, financially constrained and unconstrained groups, using three different measures of ex-ante α's and estimate a heterogeneous treatment effects model. The first measure we use is the fitted shadow value of external finance constructed using

Table 1.7: *Product Introduction and Cash during the Placebo Financial Crises*

The following table shows the results of several placebo tests. We designate the latter half of the periods 2002:Q3-2004:Q2, 2003:Q3-2005:Q2, 2004:Q3-2006:Q2, and 2005:Q3-2007:Q2 as pseudo financial crises. Each sample only includes the firms who have product introduction announcement records in CIKD in the corresponding sample period. The dependent variable is the natural logarithm of one plus the number of product launch announcements. FC is a dummy variable which is equal to 1 from the middle of each placebo period. Cash is the four-quarter average of cash reserves (cheq) over total assets (atq) before the beginning of each sample period. ROA is operating income before depreciation (oibdp) over lagged total assets (atq_{t-1}). Q is Tobin's Q computed as the market value of assets over their book value. Size is the natural logarithm of total assets. Standard errors are clustered at the firm level.

	Dependent variable:			
	ln(1 + Product launch announcements)			
	2002:Q3-2004:Q2	2003:Q3-2005:Q2	2004:Q3-2006:Q2	2005:Q3-2007:Q2
	(1)	(2)	(3)	(4)
FC	0.017	0.077^{***}	−0.011	0.010
	(0.014)	(0.015)	(0.015)	(0.014)
FC x Cash	0.032	−0.009	0.061	−0.011
	(0.043)	(0.047)	(0.044)	(0.044)
ROA_{t-1}	0.080	−0.260	0.197^{**}	0.174
	(0.182)	(0.219)	(0.097)	(0.107)
Q	−0.009	0.007	0.003	0.008
	(0.008)	(0.009)	(0.010)	(0.011)
Size	0.081^{**}	0.064^{*}	0.032	0.010
	(0.032)	(0.034)	(0.039)	(0.042)
Firm FE	Yes	Yes	Yes	Yes
Ind x Qtr FE	Yes	Yes	Yes	Yes
Observations	9,483	9,623	9,732	9,419
R^2	0.566	0.598	0.633	0.659
Note:				*p<0.1; **p<0.05; ***p<0.01

the structurally estimated equation from Whited and Wu (2006) (Whited-Wu index). High value of the Whited-Wu index indicates high marginal value of external finance. Thus, we expect the effect of liquidity on product launches to be greater in the group with a high Whited-Wu index. The next measure we use is simply the firm total asset size. Small firms might have limited access to the credit market. Then, internal liquidity would be more important for product launch decisions of small firms during the financial crisis. Both measures are observed once before the beginning of our sample period (2006:Q3) and each one is computed as an average of quarterly values from 2005:Q3 to 2006:Q2. We then cut our sample into two at the median of each measure to create two subgroups. To sum up, the financially constrained group contains firms with an above median Whited-Wu index when the index is used to split the sample, while it contains firms with a median or below median total asset size when asset size is used to form the groups. The last measure we use to group firms is Standard & Poor's corporate bond rating. Firms that can issue corporate bonds are considered less financially constrained ex-ante than firms without access to a bond market. Thus, we treat firms with bond rating information between 2005:Q3 and 2006:Q2 as financially unconstrained whereas we treat other firms as financially constrained. We then estimate the following heterogeneous treatment effects model:

$$
\begin{aligned}
AN_{i,t} = \alpha &+ \beta_1 FC \times \mathbb{I}^{Con}_{i,2006} + \beta_2 FC \times \text{Cash}_{i,2006} \times \mathbb{I}^{Con}_{i,2006} \\
&+ \beta_3 FC \times \mathbb{I}^{Uncon}_{i,2006} + \beta_4 FC \times \text{Cash}_{i,2006} \times \mathbb{I}^{Uncon}_{i,2006} + \gamma_{\text{F}}' \mathbf{F}_i + \gamma_{\text{X}}' \mathbf{X}_{i,t} + \epsilon_{i,t}, \quad (1.3)
\end{aligned}
$$

where $\mathbb{I}^{Con}_{i,2006}$ is an indicator variable that takes value 1 if firm i is in a financially constrained group before 2006:Q3. Table 1.8 reports the estimates from this regression for different measures of ex-ante α's.

Columns (1)-(3) show that cash reserves play a statistically significant role in product launch decisions only among the group of firms with a high Whited-Wu index, small asset size, or no bond market access. When Whited-Wu index is used to form subgroups, zero-cash firms in the constrained group increase product launch announcements by 5.5%. But the growth of product launch announcements is 3.4 percentage points lower per quarter for

Table 1.8: *Product Introduction, Cash, and Financial Constraints during the Financial Crisis*

The following table reports the coefficient estimates from the heterogeneous effect regressions (1.3) described in section 1.4. Con is a dummy variable equal to 1 for the potentially financially constrained group while Uncon is a dummy variable equal to 1 for the financially unconstrained group. Each column reports the estimates when the variable used to form the groups is Whited-Wu index, firm asset size, or bond access, respectively. When Whited-Wu index or firm asset size is used, financially constrained and unconstrained groups are formed by splitting the sample at the median of the respective variable before 2006:Q3. Firms with a high Whited-Wu index are designated as financially constrained as they are expected to face tighter external financing constraints. Similarly, firms with a small asset size are designated as constrained. Additionally, we designate firms without bond access before 2006:Q3 as constrained and those with bond access before 2006:Q3 as unconstrained. The dependent variable is the natural logarithm of one plus the number of product launch announcements. FC is a dummy variable equal to 1 from 2007:Q3. Cash is the quarterly average of cash reserves (cheq) over total assets (atq) from 2005:Q3 to 2006:Q2. ROA is operating income before depreciation (oibdp) over lagged total assets (atq_{t-1}). Q is Tobin's Q computed as the market value of asset over their book value. Standard errors are clustered at the firm level and the sample period is 2006:Q3-2008:Q2.

	Dependent variable:		
	ln(1 + Product launch announcements)		
	Whited-Wu Index	Asset Size	Bond Access
	(1)	(2)	(3)
FC x Con	0.054*	0.052**	0.051**
	(0.028)	(0.021)	(0.020)
FC x Cash x Con	−0.143**	−0.116**	−0.101**
	(0.069)	(0.053)	(0.051)
FC x Uncon	0.061**	0.054***	0.055**
	(0.025)	(0.019)	(0.022)
FC x Cash x Uncon	−0.067	−0.041	−0.045
	(0.130)	(0.092)	(0.150)
ROA_{t-1}	0.510	0.384	0.411
	(0.422)	(0.306)	(0.309)
Q	−0.005	−0.009	−0.009
	(0.016)	(0.010)	(0.010)
Firm FE	Yes	Yes	Yes
Ind x Qtr FE	Yes	Yes	Yes
Observations	5,436	9,596	9,435
R^2	0.675	0.667	0.665
Note:			*p<0.1; **p<0.05; ***p<0.01

firms with one standard deviation larger cash reserves. The results are generally similar when the groups are formed using other measures. However, the estimated coefficient for the cash interaction term is smaller and statistically insignificant among financially unconstrained groups (small Whited-Wu index, large asset size, or access to bond market), which is consistent with our model prediction.

1.4.3 Product characteristics and varieties

Looking at the differences in changes in the volume of product launch announcements gives us information on the differential changes in the number of products being introduced. But it does not tell us anything about changes in the characteristics of the new products or changes in the underlying technology being reflected on the new products. To examine if there is any differential change in the level of technology being applied to new products, we turn to R&D investment and patent applications. The importance of credit market access in corporate investment as well as the dependence of corporate investment on internal resources have been well documented (Hoshi *et al.*, 1991; Lamont, 1997; Rauh, 2006). Access to credit is especially crucial for long-term investment like R&D investment which is found to be procyclical in countries with low levels of financial development (Aghion *et al.*, 2010). Thus, we expect the R&D investment of low liquidity firms to suffer more during the financial crisis. Similarly, we expect the total patent application volume, which depends on R&D investment, to shrink more for firms with low liquidity during the financial crisis. Replacing the dependent variable in the baseline regression (1.2) with these measures of innovation, we test if there are differential changes in the level of innovation between firms with low liquidity and firms with high liquidity. Columns (1)-(3) of Table 1.9 report the results of these tests.

Column (1) replicates the finding of Duchin *et al.* (2010) who show that R&D investment intensity fell more for firms with low liquidity. R&D investment to total assets fell by 0.1 for zero-cash firms. But firms with median liquidity barely decreased their R&D investment intensity. As shown in column (2), there is weak evidence that patent applications of firms

Table 1.9: *Innovation and Cash during the Financial Crisis*

This table presents estimates from regressions with various innovation measures as dependent variables. The sample period is from 2006:Q3 to 2008:Q2 and the sample is identical to the one used in product announcement analyses. Patents refer to the total number of patent applications by each firm. 3Y Cites is the number of citations received by the applied patents for three years following their grants. 3-year citations are normalized by the average number of 3-year citations received by granted patents in the same patent technology class in the same year. (Potentially) radical and (potentially) typical patents are applied patents classified using the index developed by Eggers and Kaul (2018). FC is a dummy variable equal to 1 from 2007:Q3. Cash is the quarterly average of cash reserves (cheq) over total assets (atq) from 2005:Q3 to 2006:Q2. Cash Flow is the contemporaneous operating income before depreciation (oibdp) over total assets (atq). ROA is operating income before depreciation (oibdp) over lagged total assets (atq_{t-1}). Q is Tobin's Q computed as the market value of assets over their book value. Size is the natural logarithm of total assets. Standard errors are clustered at the firm level.

	Dependent variable:				
	R&D / Asset	ln(1 + Patents)	ln(1 + 3Y Cites)	ln(1 + Radical Pat.)	ln(1 + Typical Pat.)
	(1)	(2)	(3)	(4)	(5)
FC	-0.001^{**}	-0.027^{***}	-0.040^{***}	-0.026^{***}	-0.021^{**}
	(0.001)	(0.010)	(0.012)	(0.009)	(0.010)
FC x Cash	0.005^{**}	0.074^{*}	0.111^{**}	0.101^{***}	0.020
	(0.002)	(0.040)	(0.053)	(0.034)	(0.038)
Cash Flow	-0.133^{***}				
	(0.024)				
ROA_{t-1}		0.277	0.184	0.086	0.423^{**}
		(0.223)	(0.287)	(0.182)	(0.205)
Q	0.002^{***}	0.025^{**}	0.031^{***}	0.019^{**}	0.018^{**}
	(0.0004)	(0.010)	(0.012)	(0.009)	(0.009)
Size		0.083^{**}	0.056	0.035	0.077^{**}
		(0.037)	(0.043)	(0.028)	(0.033)
Firm FE	Yes	Yes	Yes	Yes	Yes
Ind x Qtr FE	Yes	Yes	Yes	Yes	Yes
Observations	6,458	9,596	9,596	9,596	9,596
R^2	0.818	0.931	0.885	0.888	0.917
Note:					*p<0.1; **p<0.05; ***p<0.01

with lower liquidity declined more than those of other firms. Patent applications decrease by 2.7% for zero-cash firms but the decrease was 1.6 percentage points smaller for firms with one standard deviation higher cash reserves. In fact, a cash ratio of 35.7% would imply no change in the volume of patent applications during the financial crisis. Column (3) shows that total normalized 3-year citations fell more for liquidity constrained firms as well. Changes in a firm's R&D investment level as well as the level and quality of its patenting activity imply changes in the current or future level of its technology which can be applied to its new products or production processes. Thus, the findings of columns (1)-(3) suggest that technology development of firms with low liquidity suffered more during the financial crisis.

In addition to the volume of technology development, the kind of technology being developed by a firm could also change during the financial crisis. When firms expect their liquidity constraints to bind for a while, investment in the future cash flow with high volatility becomes riskier than before. Thus, firms with low liquidity may decrease investment in risky technology more compared to firms with abundant liquidity. We test this hypothesis using the different categories of patents: potentially radical patents and typical patents. The categorization procedure was described in section 1.3.1. It is important to recall that potentially radical patent applications are defined cross-sectionally. We are making the strong assumption that 30% of patents every year are considered potentially radical.[21] Also, because of this definition, the total volume of potentially radical patents completely tracks the total volume of all patent applications. Columns (4) and (5) of Table 1.9 report the estimates from regression (1.2) using patent applications in each category as the dependent variable. The estimates in column (4) suggest that there is a statistically significant difference between the changes in the volume of radical patent applications of low and high liquidity firms. Patents designated as potentially radical declined by 2.5% for zero cash firms. But the decline completely disappears for a firm with mean level of cash ratio. Unlike radical patents, we cannot reject the null of no impact of liquidity for typical patents as shown in

[21] We tried more conservative cutoffs like 25%, 20%, and 15% and still found similar results.

column (5). We find that the changes in the volume of radical technology differed between firms with low and high liquidity. This finding supports the view that firms short on liquidity reduce investments in risky development projects more compared to other firms during the credit supply crisis. The technologies being developed by a firm can be either for improving the product qualities themselves or for improving the production process. Thus, we do not know for sure if the observed differences in the changes of radical patents would be manifested in the new products themselves or in the production process. But as long as the technologies are not all developed for better production process, we can conclude that the new products being introduced or developed by liquidity constrained firms would reflect technologies that are less radical than before compared to those being introduced by unconstrained firms.

Products being introduced can fall into the existing lines of products or new lines of products. Broadening product varieties helps capture wider consumer demands but may increase production costs significantly. Marketing literature does not have a consensus on which effects dominate in general (Kekre and Srinivasan, 1990; Bayus and Putsis Jr, 1999; Randall and Ulrich, 2001; Hui, 2004; Berger *et al.*, 2007). In the context of our setting, for firms with low liquidity during the financial crisis, it is not clear whether speeding up the launch of products in new varieties offers higher net profits than accelerating the product launches within the same existing varieties. Launching of new product varieties may relieve the binding liquidity constraints by expanding the consumer demands that the firm is facing. But adjusting production facilities all of a sudden for new product varieties may incur high fixed-costs in the short-run. Furthermore, the demand for them can be uncertain, especially when they are being launched prematurely. We test if low liquidity firms also reacted differently in product variety margin measured using new trademark usages and applications. The construction of trademark measures was described in section 1.3.1. Table 1.10 and Table 1.11 report the estimates from the baseline regressions (1.2) using the number of new trademarks first used and the number of new intent to use trademark applications as dependent variables, respectively.

Table 1.10: *New Trademark and Cash during the Financial Crisis*

The following table reports the coefficient estimates and their standard errors from the baseline regression described in section 1.4. The sample only includes the firms who have product introduction announcement records present in CIKD from 2006:Q3 to 2008:Q2. Each sample period begins in 2006:Q3 and ends in the quarter reported in each column. The dependent variable is the natural logarithm of one plus the number of new trademarks first used. FC is a dummy variable equal to 1 from 2007:Q3. Cash is the quarterly average of cash reserves (cheq) over total assets (atq) from 2005:Q3 to 2006:Q2. ROA is operating income before depreciation (oibdp) over lagged total assets (atq_{t-1}). Q is Tobin's Q computed as the market value of assets over their book value. Size is the natural logarithm of total assets. Standard errors are clustered at the firm level.

	Dependent variable:		
	ln(1 + Number of Trademarks First Used)		
	(1)	(2)	(3)
FC	−0.009	−0.003	−0.008
	(0.010)	(0.009)	(0.009)
FC x Cash	0.016	0.002	0.012
	(0.030)	(0.027)	(0.026)
ROA_{t-1}	0.082	0.022	0.022
	(0.214)	(0.181)	(0.128)
Q	0.013	0.001	−0.0004
	(0.009)	(0.007)	(0.007)
Size	0.081***	0.036*	0.045***
	(0.028)	(0.020)	(0.016)
End Quarter	2008:Q2	2008:Q4	2009:Q2
Firm FE	Yes	Yes	Yes
Ind x Qtr FE	Yes	Yes	Yes
Observations	9,596	12,478	15,195
R^2	0.687	0.673	0.661
Note:			*p<0.1; **p<0.05; ***p<0.01

Table 1.11: *Intent to Use Trademark Applications and Cash during the Financial Crisis*

The following table reports the coefficient estimates and their standard errors from the baseline regression described in section 1.4. The sample only includes the firms who have product introduction announcement records present in CIKD from 2006:Q3 to 2008:Q2. Each sample period begins in 2006:Q3 and ends in the quarter reported in each column. The dependent variable is the natural logarithm of one plus the number of intent-to-use trademark applications. FC is a dummy variable equal to 1 from 2007:Q3. Cash is the quarterly average of cash reserves (cheq) over total assets (atq) from 2005:Q3 to 2006:Q2. ROA is operating income before depreciation (oibdp) over lagged total assets (atq_{t-1}). Q is Tobin's Q computed as the market value of assets over their book value. Size is the natural logarithm of total assets. Standard errors are clustered at the firm level.

	Dependent variable:		
	ln(1 + Number of Intent to Use Trademark Applications)		
	(1)	(2)	(3)
FC	0.001	0.004	−0.002
	(0.014)	(0.013)	(0.011)
FC x Cash	0.003	−0.004	0.013
	(0.043)	(0.038)	(0.035)
ROA_{t-1}	−0.100	−0.032	−0.027
	(0.249)	(0.201)	(0.143)
Q	0.024*	0.018*	0.021**
	(0.013)	(0.010)	(0.009)
Size	0.114***	0.100***	0.083***
	(0.039)	(0.025)	(0.018)
End Quarter	2008:Q2	2008:Q4	2009:Q2
Firm FE	Yes	Yes	Yes
Ind x Qtr FE	Yes	Yes	Yes
Observations	9,596	12,478	15,195
R^2	0.719	0.700	0.689
Note:			*p<0.1; **p<0.05; ***p<0.01

In all three sample periods, we do not observe differential changes in the number of new trademarks first used between firms with low liquidity and high liquidity. Furthermore, changes in future plans to use new trademarks do not seem to depend on the level of pre-crisis liquidity ratio either.[22] Combined with the results found on product launch announcements, this suggests that firms with a low liquidity ratio increased the number of new products more than other firms within the existing lines of products, or at the very least, they did not differentially expand product varieties that can be measured through trademark usage and filings.

1.5 Conclusion

This paper studies the role of liquidity in firm product launch decisions during the 2007-2008 financial crisis. Using the product launch announcement data from Capital IQ Key Developments (CIKD), we document that firms with low liquidity increased product launch announcements more than firms with abundant liquidity after the beginning of the financial crisis in mid-2007. Product announcements per quarter increases by 5.2% after June of 2007 for pre-crisis zero-cash firms. But the increase is 2.3 percentage points smaller for firms with a one standard deviation higher pre-crisis cash ratio. We show that these estimates become more significant once the quarters around the Lehman crisis are included in the sample. The estimates are robust to the inclusion of industry-quarter fixed effects, various controls, and the use of cluster-robust standard errors at the firm level. This finding suggests that firms more aggressively launch new products when faced with a negative credit supply shock and that for cash-constrained firms, the benefit of immediate boosts in cash flows outweigh the costs associated with early product introductions. We illustrate this intuition in a simple model framework.

We run placebo tests in other sample periods and verify that the pattern observed during

[22]This may be due to the low cost of trademark applications. Firms can first claim trademarks through intent to use applications with small costs and then abandon the trademarks if they end up not launching the associated products. Furthermore, firms can delay the actual use of trademarks up to 3 years from the issuance date of NOA.

the actual financial crisis cannot be found in other periods. As an additional robustness check, we estimate a heterogeneous treatment effects model which shows that the liquidity ratio was only important for the group with high expected exposure to the credit supply shock.

We provide a few additional findings that are complementary to the results on new product introductions. We find that R&D investment intensity and patenting activities decreased more for firms with low liquidity during the financial crisis. In particular, radical patent applications decreased more for low cash firms than others but we cannot find significant differences in patterns of typical patent applications. Combining our findings suggest that product launches increase more for firms with low liquidity, but the decrease in the radicalness of technology, which would be reflected on the products being developed for the future, is more severe for those firms as well. Finally, we show that the differential changes in product launches did not happen in the product variety margin, suggesting that the within-variety margin was critical.

Chapter 2

Employment Protection, Financial Uncertainty, and Corporate Investment in Innovation [1]

2.1 Introduction

The appropriate degree of employment protection has been an important policy question in many developed countries. Economic literature has documented ample evidence that employment protection is associated with lower job turnover and higher unemployment. Recent researches also examine its implications for corporate investment.[2] In particular, as productivity growth through innovation is believed to be the primary driving source of economic growth, the impact of employment protection on innovation has been gaining the attention of policy makers and firm managers. Despite the growing literature documenting various channels through which corporate R&D investment reacts to employment protection,

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[1] Co-authored with Seunghyup Lee

[2] Empirical works on the impact of employment protection on corporate investment and capital deepening include Autor *et al.* (2007), Bassanini *et al.* (2009), Calcagnini *et al.* (2009), Cingano *et al.* (2010, 2016), Janiak and Wasmer (2014). Some recent papers also consider corporate R&D investment implications. Griffith and Macartney (2014) show how employment protection affects the types of innovation in which firms invest, and Bradley *et al.* (2016) examine the relationship between unionization and corporate investment in innovation.

there is little understanding of how this real friction in the labor market interacts with frictions in the financial market and affects corporate R&D investment decisions.

This paper investigates the role of employment protection in corporate R&D investment decisions, with a focus on the financial frictions that firms face. Employment protection laws reduce firms' flexibility to adjust labor cost, thereby increasing their operating leverage. Firms that have easy access to external capital markets may still support profitable investment projects, regardless of the availability of internal resources. However, financially constrained firms may be unable to implement some profitable investment opportunities. These firms rely more heavily on internal resources, which have now become more volatile, to fund investment. In the meantime, high adjustment costs of R&D investment, combined with uncertainty in timing and duration of R&D projects, imply that R&D investment requires stable financing. Based on these observations, we test three hypotheses. First, employment protection reduces R&D investment of financially constrained firms. Second, R&D investment of these firms become more procyclical. Third, as a partial offset, R&D intensive firms accumulate more cash that would act as a buffer against their more volatile operating cash flow.

We use the adoption of wrongful discharge laws by state courts across the U.S. between 1971 and 1999 as a source of exogenous variation in the degree of employment protection. We compare pre- and post-adoption R&D investment of firms facing different degrees of financial constraints. Wrongful discharge laws provide protection for workers by limiting firms' ability to freely fire them, a right formerly guaranteed under the traditional employment-at-will doctrine. Once state courts adopted these laws, firms in these states faced large potential financial losses stemming from wrongful termination litigation. To avoid potential legal actions, firms refrained from terminating workers, raised the compensation level for severance packages, and spent more on administration or personnel in preparation for the threat of litigation on the grounds of wrongful discharge (Dertouzos *et al.*, 1988; Dertouzos and Karoly, 1992). This increase in firing costs induced employment to respond less to the business cycle, and raised the proportion of fixed costs in labor compensation. Therefore, the affected firm's operating cash flow became more sensitive to the contemporaneous revenue. We start by confirming that the courts' recognition of the good-faith exception, one type of wrongful discharge laws, acted as an exogenous shock to a firm's operating leverage. Because operating leverage is defined as how revenue growth translates into earnings growth, it captures the elasticity of operating profits to sales. The estimated elasticity increases immediately after the adoption by 0.2 to 0.3 from a pre-adoption level of around 1.5.

We then show that after the adoption of the good-faith exception R&D investment falls for financially constrained firms. R&D investment becomes more procyclical among these firms. These effects are particularly strong among the highly innovative industries, such as chemical, electronics, business service, and industry machinery, in which information and agency problems are more substantial due to a high degree of technical uncertainty.

We observe that, in response to the recognition of the good-faith exception, firms actively change their capital structure by accumulating more cash, mostly by increasing the amount of equity issuance. Such cash hoarding is only found among firms in R&D-intensive industries.

We argue that these findings are consistent with R&D investment being impacted by operating leverage. To isolate the operating leverage channel, we compare the effects of the adoption on R&D investment between firms that would experience a larger increase in firing costs for ordinary workers upon the adoption and those that would not. We group firms by industry and sort them according to their industry layoff elasticity to industry business cycles. Because firms are less likely to adjust layoff rates for R&D workers throughout the business cycle, the elasticity captures each industry's tendency to dismiss ordinary workers in industry recessions. Firms that dismiss more workers have higher chances to encounter wrongful discharge lawsuits, and therefore may expect larger increase in expected firing costs. Therefore, layoff elasticity is a proxy for the increase in firing costs for ordinary workers in each industry. We find that the increase in operating leverage is only significant among the firms in the industries with high layoff elasticity. We also show that the observed negative association between the level of financial constraints and post-adoption R&D investment are significant only in these industries. This confirms that the adoption affects R&D investment of financially constrained firms by increasing their operating leverage.

Using the adoption of wrongful discharge laws by the U.S. states as a source of exogenous variation in labor rigidity is not new in the macroeconomics or labor literature. Previous studies primarily focused on the relationship between employment protection and employment flows, wages, and firm productivity (Dertouzos and Karoly, 1992, 1993; Morriss, 1994; Miles, 2000; Autor *et al.*, 2006, 2007).[3] Some recent research in the finance literature has examined the impact of these laws, including on R&D labor productivity (Acharya *et al.*, 2014) and capital structure (Serfling, 2016). Our research differs from the existing literature in our discovery of the operating leverage channel through which employment protection affects corporate R&D investment in an incomplete financial market.

This paper also contributes to an extensive literature on the relationship between employment protection and corporate innovation. One perspective is that efficiency wages encourage workers to build firm-specific human capital and more actively participate in innovation (Akerlof, 1982; Shapiro and Stiglitz, 1984; Acemoglu, 1997; Belot *et al.*, 2007). The empirical evidence supporting this argument includes Wasmer (2006), Tang (2012), and Acharya *et al.* (2014). In a similar vein, it has also been documented that corporate innovation increases when managers are more protected due to the firm ownership structure (Lerner *et al.*, 2011; Aghion *et al.*, 2013). Others, however, have pointed out that higher adjustment costs induced by stricter employment protections may lead to underinvestment in innovation, especially in advanced technology industries (Saint-Paul, 1997, 2002; Samaniego, 2006; Cuñat and Melitz, 2010). Other studies show that firms concentrate on incremental innovations rather than radical innovations under stricter employment protection (Griffith and Macartney, 2014), and that firms invest less in innovation under stronger employment

[3] Autor *et al.* (2006) report that the employment rate declines under the implied-contract exceptions, but there is no evidence of wage changes. Autor *et al.* (2007) use establishment-level data to show reduced employment flows, capital deepening, decline in total factor productivity, and increase in labor productivity after the adoption of the good-faith exception.

protection, especially when protection measures target temporary workers who are typically used to respond to shifts in product demand more freely (Murphy *et al.*, 2012). This paper uses a sample of public firms across the U.S., avoiding the difficulty of making reliable inferences from cross-country samples that would contain a high level of heterogeneity.[4]

This paper is related to a broader corporate finance literature. Since the seminal work by Fazzari *et al.* (1988), the literature has extensively studied a contemporaneous relationship between firms' internal funds availability and discretionary investment (Blanchard *et al.*, 1994; Hoshi *et al.*, 1991; Kaplan and Zingales, 1997; Lamont, 1997; Rauh, 2006). In this paper, our focus is on shocks that impact cash flow volatility rather than the level directly. We show that the associated volatility has an impact on corporate R&D investment.[5]

This paper proceeds as follows. Section 2.2 describes wrongful discharge laws. Section 2.3 develops the theoretical framework and derives the empirical hypotheses. Section 2.4 describes the data and discusses the construction of variables and controls. Section 2.5 examines the effect of the adoption of wrongful discharge laws on firm operating leverage, firm investment, and liquidity management. Section 2.6 provides policy remarks and concludes.

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[4] Appendix Table B.1 shows the result from the regression of each OECD country's GDP share of gross private R&D expenditure on the country's employment protection level. We find modest country-level evidence that employment protection tends to reduce R&D investment. However, not only does the regression fail to control for cross-country differences that might affect R&D investment other than fixed effects, but it also does not show how an individual firm behaves under stronger employment protection when it allocates investment resources between physical capital and R&D projects.

[5] There are only a few existing papers that empirically test the impact of cash flow volatility on corporate investment, and none of them uses exogenous variation in cash flow volatility. For example, Minton and Schrand (1999) document that higher cost of external financing is associated with higher sensitivity of investment to cash flow volatility. However, their approach is not free from the potential endogeneity problem and may produce spurious results, because cash-related variables may be also correlated with investment profitability in a different way for the firms with different external financing costs.

2.2 Wrongful Discharge Laws and Investment

2.2.1 Description of Wrongful Discharge Laws

This section presents the detailed description of wrongful discharge laws.[6] Prior to the 1970s, the employ-ment-at-will doctrine governed the employer-employee relationship across the United States.[7] However, between 1972 and 1992, most U.S. state courts adopted some form of exception to this doctrine that limited the employer's ability to freely terminate workers. Given that the employment-at-will doctrine was an accepted norm in the employment relationship prior to 1970s, it seems reasonable that possible costs to the employers, arising from potential wrongful discharge litigation stemming from the introduction of exceptions, were highly unpredictable. The legal profession categorizes these common-law exceptions to the doctrine as follows: the good-faith exception, the implied contact exception, and the public policy exception.

The good-faith exception protects employees from being discharged for 'bad cause,' the definition of which is not necessarily consistent across states and over time. It was originally understood as permitting employers to terminate workers only with 'good cause,' implying that firms were not allowed to discharge workers without a cause such as the firm's economic distress, or the workers' poor performance. However, most states have limited the application of the good-faith exception to cases in which employers deprive workers of promised benefits (e.g. an employer fires a salesperson before the commission is due, or an employer fires a worker just before the worker becomes eligible to receive pension benefits). This exception typically allows for awards based on both compensatory and punitive damages.

The second type of wrongful discharge law, the implied contract exception, provides

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[6] The descriptions of wrongful discharge laws presented here are largely based on Dertouzos *et al.* (1988), Dertouzos and Karoly (1992), Autor *et al.* (2006), and Autor *et al.* (2007).

[7] Employment law does not provide general protection from wrongful-cause discharge (such as some types of good-cause discharge clauses in union-negotiated collective bargaining agreements). In most states, the default principle is employment-at-will, where employers are allowed to freely terminate their employees for any reason [Anderson v. Douglas & Lomason Co., 540 N.W.2d 277, 282 (Iowa 1995)].

protection for workers based on implied or verbal contracts. In jurisdictions where the implied contract exception is adopted, an implicit agreement that an employer would not fire workers without good cause can be inferred from the various circumstances of employment, including statements made during the recruitment process, oral representations, comments from performance reviews, and past practices. However, employers can easily get around this exception simply by including the statement in employment contracts or personnel manuals that all employment contracts are at will.

Finally, the public policy exception protects the employments of those who abide by public policy. For example, workers cannot be fired because they refuse to violate laws or exercise legal rights stipulated by laws. Autor *et al.* (2007) argue that this exception is not believed to be a substantially binding constraint for employers, since courts generally do not acknowledge cases that involve violation of non-explicit public obligations.

Based on the above discussion, we expect that the good-faith exception would generate a material impact on corporate labor management but the implied-contract and public policy exceptions would not. Therefore, we use the good-faith exception as the primary source of an exogenous variation in the degree of employment protection we use for our analysis. In our empirical section, we confirm that the good faith exception is the only type of wrongful discharge laws the adoption status of which has significant impact on firm operating leverage, capital structure, and investment decisions.

The direct costs of wrongful termination litigations, including legal fees, liabilities, and settlement costs, tend to be substantial. Early literature has estimated that 75% of wrongful discharge suits that go to trial result in a verdict for the employees, the average award being $450,000. Even a successful defense is costly, with average spending between $100,000 and $200,000 (St. Antoine, 1994).

Given the high expected costs of wrongful discharge litigations and uncertainty of whether a termination would result in a litigation, firms may retain poor performers, use temporary workers in times of expansion, or implement stronger screening processes when hiring employees. Among equally poor performers, firms would discharge the ones without future benefits while retaining the ones anticipating promised benefits in the near future. The decision becomes harder when workers expecting promised benefits in the near future are the poor performers. Dertouzos and Karoly (1992) also point out that a firm's internal decision-making process intensifies the impact of wrongful discharge laws on labor rigidity. Because the benefits of correct firing decisions do not generally accrue to the termination decision-makers while they would be liable in potential litigations, they have incentives to promote preventive measures and refrain from firing workers to optimal levels. Furthermore, although most state courts make it clear that wrongful discharge laws are not applied to layoff cases that can be justified, a firm's willingness to lay off workers may be limited by fears of potential lawsuits following layoffs; many corporate employment decisions are in a gray area and even workers who are properly laid off might pursue legal action.

Economic literature has documented extensive evidence of the increase in labor rigidity after the adoption of wrongful discharge laws. For example, Miles (2000) and Autor (2003) document that employers in adopting states replace direct-hire workers with temporary (agency) workers to minimize litigation risks. Kugler and Saint-Paul (2004) find that the re-employment rate of the unemployed relative to employed workers drops because the adverse selection problem against the unemployed is worsened in the labor market after the adoption.

The popularity of employment practices liability insurance (EPLI) may jeopardize our assumption that the adoption of wrongful discharge laws works as an increase in downtime labor adjustment costs and may render our results spurious. However, EPLI generally does not provide full coverage of legal fees and compensation, and considering that more wrongful discharge disputes may result in higher premiums, firms still have incentives to reduce the possibility of potential wrongful termination litigation.

2.2.2 Potential Concerns

Despite its impact on expected firing costs and employment rigidity, to use the adoption of wrongful discharge laws as a source of exogenous variations in operating leverage, we have to verify that (1) the adoption is unrelated to other factors that may change operating leverage, and that (2) it is not predictable, so that the comparison between pre- and post-adoption periods is not spurious.

One potential concern is that the adoption of wrongful discharge laws in each state may be associated with the state's economic and political conditions. These can potentially affect employment rigidity and the operating leverage of the firms doing business in the state. Past research examined the list of economic variables that may influence court decisions to adopt wrongful discharge laws, and concluded that only the ones representing the attitude toward workers' rights determine the probability of the adoption.[8] However, because each state's political and social background that determines the overall level of labor protection tends to be persistent, it is unlikely that there would be a considerable change in other labor-related factors affecting firm operating leverage at the precise time when wrongful discharge laws are adopted. In Section 2.5.1 we document that there is a step function-like increase in operating leverage immediately after the good-faith exception is recognized by the court, and that there is no pre-trend of increasing operating leverage. Section 2.5.5 also shows that equity issuance, which turns out to be the main sources of the extra liquidity that firms accumulate as a response to increased operating leverage, evolves in a similar manner. These findings imply that the adoption of the good-faith exception induces an exogenous shock to the operating leverage.

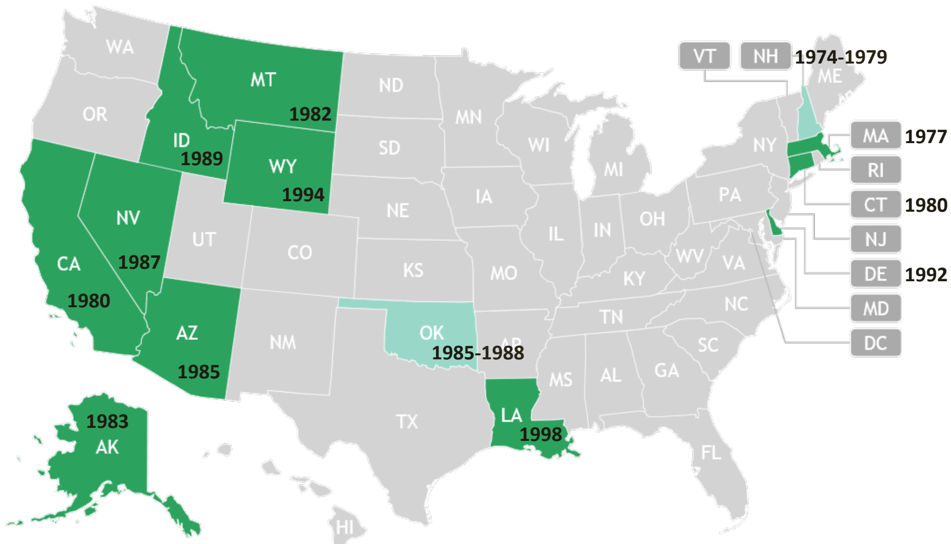
Another concern is that the states with wrongful discharge laws are geographically concentrated, so that the adoptions would be largely due to common factors reflecting their economic conditions. Figure 2.1 shows that, on the contrary, the states that have adopted the good-faith exception are spread out across the United States, and that there are only a few, geographically dispersed, states that have not adopted the implied contract and public policy exceptions. Therefore, it is unlikely that only the states that adopted the good-faith

[8]Dertouzos *et al.* (1988) document that recognition decisions are largely unsystematic and uncorrelated with state economic characteristics such as wage levels, population demographics, region, and state-level business cycles. Dertouzos and Karoly (1992) report that states with higher unionization rates, experiencing larger declines in the degree of unionization, and without right-to-work laws, are more likely to adopt at least one form of wrongful discharge laws.

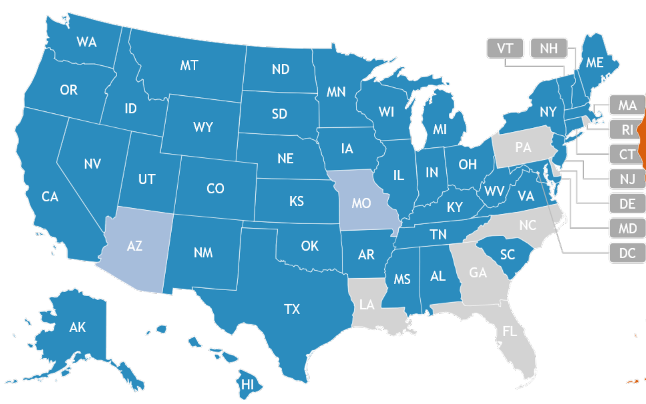
exception also happen to be simultaneously under the influence of some common regional economic factors. In the empirical analysis section, we show that our results do not change even after controlling for the region-specific variations in operating leverage and R&D investment.

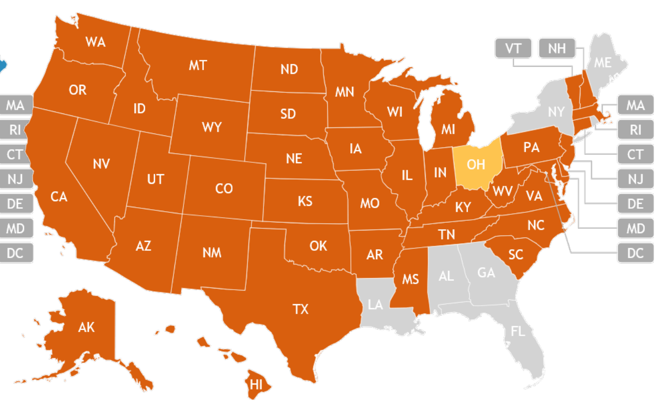
One might be also worried that the adoption decisions may be highly predictable so that the shock might not be fully exogenous. Most legislation on employment protection is largely influenced by macroeconomic conditions and political situations known to all economic agents. Furthermore, the legislation process is highly observable, and whether the proposed law may pass the legislature is also predictable based on legislative composition and political circumstances. On the contrary, the recognition of wrongful discharge laws is a court decision for a specific case arrived at the court, and the ruling is exclusively based on the legal considerations about the contractual nature between the discharged workers and the defendant firms. It is also unlikely for firms to predict at which court a potential wrongful discharge claim would be filed and what the disposition of the judges in the ruling court would be at time of the suit. In short, unlike ordinary employment protection legislation, the rulings to recognize the wrongful discharge principles are highly unforeseeable.

It is also possible that the rulings may represent a secular legal trend in labor disputes, enabling firms and workers to expect the adoption of wrongful discharge laws. Figure 2.2 shows that the recognition events of the implied contract and public policy exceptions by state courts may be contagious; a large number of adoptions occurred between mid-1970s and late-1980s, and these laws are rarely adopted after 1990. This may imply that there were general changes in the view of the state courts on employment-at-will doctrine in a relatively short period of time. However, the good-faith exception, which was recognized more slowly and less extensively than the other two types of wrongful discharge laws, is relatively free from this concern. Therefore, we may at least conclude that the adoption of the good-faith exception applies an exogenous shock to a degree of employment protection.



The Adoption Status of Good-Faith Exception (1999)

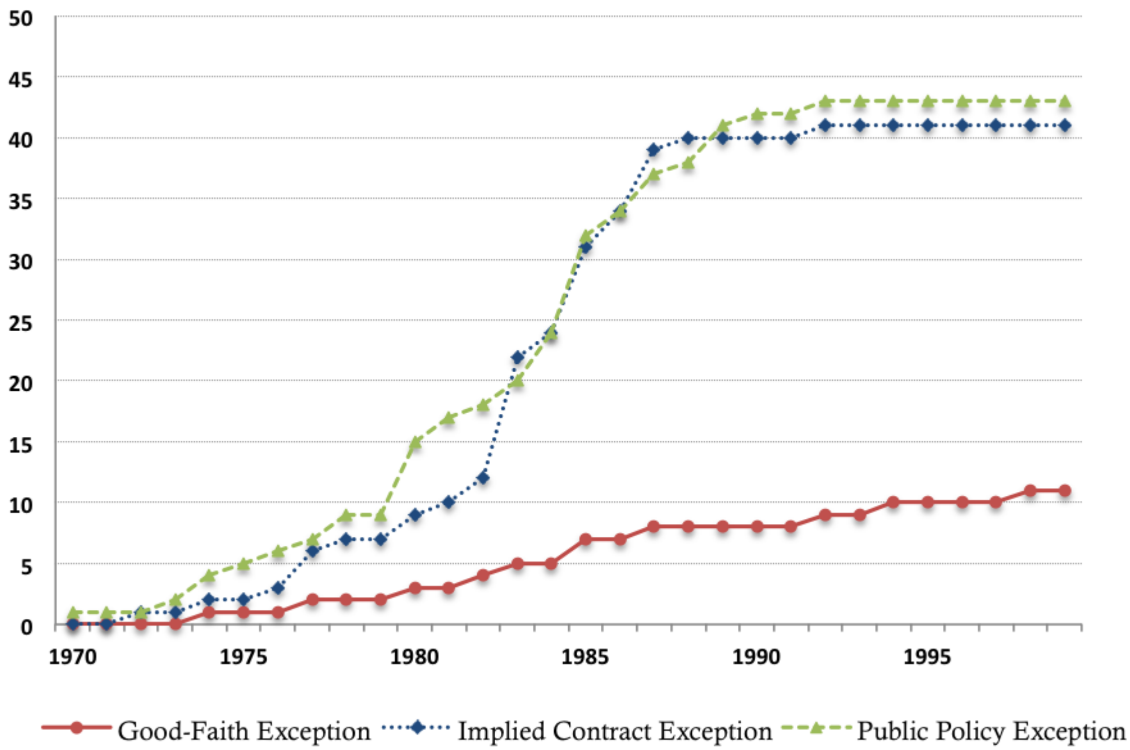




The Adoption Status of Impied Contract Exception (1999) *The Adoption Status of Public Policy Exception (1999)*

The above maps illustrate the adoption status of the good-faith, implied contract, and public policy exceptions across 50 states in the United States in the year 1999. The dark colors indicate that the adoption status has been unchanged since the first recognition of the exceptions by state courts, and the light colors imply that the exceptions have been originally accepted but later repealed. The first map also shows the recognition year of the good-faith exception in each state. Note that New Hampshire and Oklahoma repleaed the good-faith exception in 1979 and 1988, respectively.

Figure 2.1: *Map of the Adoption Status of Wrongful Discharge Laws*



This figure shows the number of U.S. states that have adopted and not repealed each category of wrongful discharge laws in each year.

Figure 2.2: *Number of U.S. States with Wrongful Discharge Laws*

2.3 Theoretical Considerations

In this section, we construct a simple model of corporate R&D investment with exogenous variation in firing costs where operating leverage and costly external financing play an important role in determining R&D investment. The theory builds on the liquidity shock model of Aghion *et al.* (2010), in which a successful R&D generates profits only when an entrepreneur implements the innovation by paying the implementation cost. We augment their model by introducing labor as a production factor and allowing costly external financing.

2.3.1 Model

Consider a firm that lives for three periods, Periods 0 to 2. The firm has two investment opportunities: one is conventional and the other is innovative. The conventional investment consists of the employment decision for production workers and the installation of production lines. The conventional production lines generate outputs in Period 2 using the production function $y = a\pi(k)s$, where k is the amount of installed physical capital, s is the level of employment, and a is the firm's productivity. a is realized at the beginning of Period 1. The firm also has an R&D project that consists of two stages. In the first stage, the project generates a blueprint with success probability $q(z)$, where z is the amount of R&D investment. Conditional on the success, the firm can proceed to the next stage where it has to pay the implementation cost to generate profits from the blueprint in hand. The value of the succefully developed and implemented R&D project is not related to the amount of the production factors the firm uses for the conventional production lines.

In Period 0, the firm is established with initial endowment w and makes a business plan. It commits the amount of R&D investment z_0 it will undertake in Period 1, and determines the number of production workers s_0 it will utilize in Period 1.[9] It may also raise equity e_0 from the external capital market. The cost of equity issuance $c(e_0)$ is given as a convex

[9] The subscripts indicate the periods in which the firm decisions are made or the outcomes are realized.

function of e_0, implying that the marginal cost is an increasing function of the amount of external finance. There is no interest on cash between Period 0 and Period 1.

In Period 1, productivity is realized. After observing the productivity, the firm determines the amount of physical capital investment k_1 and bond holdings b_1 with interest rate r. Because it already committed the amount of R&D investment z_0, the budget constraint is

$$k_1 + b_1 \leq w + [e_0 - c(e_0)] - z_0$$

Note that there is no borrowing contraints for physical capital. Physical capital serves as production lines and determines labor productivity $\pi(k_1)$, where $\pi' > 0, \pi'' < 0$. Demand for the firm's output is given by the isoelastic demand function

$$p = By^{\alpha-1}$$

with constant B and $0 < \alpha < 1$, so the revenue is By^{α}.

The firm commits employment s_0 in Period 0, but before production, it can reduce employment after paying a firing cost τ per worker. We assume that the firm cannot hire additional workers above the pre-committed level, and that workers do not initiate a separation. Given the wage level g, production lines generate profits

$$y_2^n = B[a\pi(k_1)s_0]^{\alpha} - gs_0 - (1+r)k_1$$

if the firm does not adjust employment, and

$$y_2^a = \max_{s_1} B[a\pi(k_1)s_1]^{\alpha} - gs_1 - \tau(s_0 - s_1) - (1+r)k_1$$

if it reduces employment. Revenue is generated in Period 2.

In the meantime, the firm conducts the first stage of the R&D project. The project produces a blueprint with success probability $q(z_0)$. The success probability function follows neoclassical assumptions: $q' > 0$, $q'' < 0$.

In Period 2, the firm has to pay the implementation cost m_2 in order to generate profits from the blueprint. The cost is randomly drawn from the cumulative distribution function F over

$\mathbb{R}^+$. The firm may use the cash generated from physical capital investment as well as from bond holdings. Therefore, its resources for implementation, x_2, is given by

$$x_2 = y_2 + (1+r)(w - z_0 + e_0 - c(e_0))$$

The firm can generate profits from the blueprint only when $m_2 \leq x_2$. For simplicity, we assume that the amount of revenue generated by the implemented blueprint is $v + m_2$, where v is the expected amount of net profits from the implemented blueprint. In other words, implementation cost does not change the profitability of the implemented blueprint. The blueprint that is not implemented does not generate any value.

Firm's problem in Period 0 is

$$\max_{s,z,e} \mathbb{E}_0[\max_{k,b} x_2 - (1+r)e_0 + vq(z_0)F(\max_{k,b} x_2)].$$

We assume that the probability density function of the implementation cost f is decreasing and convex for all possible productivity realizations and firm decisions. This assumption is plausible considering that the cost distribution tends to be right-skewed in many highly uncertain R&D projects. It guarantees that cash volatility reduces the probability of successful implmentation of the blueprint.

We solve this problem recursively. Because physical capital investment does not depend on R&D investment or equity issuance, we can solve for optimal k_1 as a function of s_0. If the firm does not adjust labor, the marginal revenue of k_1 is

$$A^n(k_1) = [\alpha B(as_0)^\alpha]\, \varepsilon(k_1) \frac{\pi(k_1)^\alpha}{k_1},$$

where $\varepsilon(k) = k\pi'(k)\pi(k)^{-1}$ denotes the elasticity of π. Next, the marginal revenue of k_1 when the firm decides to adjust labor is

$$A^a(k_1) = \left[\frac{\alpha B a^\alpha}{(g-\tau)^\alpha}\right]^{\frac{1}{1-\alpha}} \varepsilon(k_1) \frac{\pi(k_1)^{\frac{\alpha}{1-\alpha}}}{k_1}.$$

We assume

$$\alpha\varepsilon(k) + \alpha < 1$$

so that there exist proper solutions for the optimality conditions $A^n(k_1) = 1 + r$ and $A^a(k_1) = 1 + r$. Denote by k^* the unique value satisfying $A^n(k^*) = A^a(k^*)$. The optimal k_1 is then given by

$$\begin{aligned} A^n(k_1) &= 1 + r \qquad \text{for } A^n(k^*) = A^a(k^*) \geq 1 + r, \\ A^a(k_1) &= 1 + r \qquad \text{for } A^n(k^*) = A^a(k^*) < 1 + r. \end{aligned}$$

We now assume that the firm finds it optimal to adjust labor when $a < a^*$. We have $A^n(k^*) = A^a(k^*) = 1 + r$ when $a = a^*$. Therefore,

$$a^* = s_0^{\frac{1-\alpha}{\alpha}} \left(\frac{g - \tau}{\alpha B} \right)^{\frac{1}{\alpha}} \pi \left(\frac{s_0(g - \tau)\varepsilon(k^*)}{1 + r} \right)^{-1}.$$

Given that the elasticity of π is relatively stable, the above expression implies that the threshold point a^* is decreasing in the firing costs τ and increasing in the initial employment s_0.

We examine how profits from physical capital investment respond to the increase in firing costs. The net profits are

$$\begin{aligned} y_2^n &= (1 + r) \left[\frac{1}{\alpha\varepsilon(k_1)} - 1 \right] k_1 - g s_0, \\ y_2^a &= (1 + r) \left[\left(\frac{1}{\alpha} - 1 \right) \frac{1}{\varepsilon(k_1)} - 1 \right] k_1 - \tau s_0, \end{aligned}$$

respectively. When $a > a^*(\tau)$, firing costs do not affect physical capital investment and profits. Otherwise, the firm adjusts employment, and we have

$$\frac{\partial y_2^a}{\partial \tau} = \frac{1 + r}{\varepsilon(k_1)} \frac{1}{g - \tau} k_1 - s_0 < 0.$$

Therefore, given the same initial employment s_0, an increase in τ reduces the average profitability of the ordinary investment opportunity, and raises the variance of the profits it generates.

Hypothesis 1 (Firing Cost and Cash Flow Volatiltiy) An exogenous increase in firing costs raises the volatility of operating cash flow.

We now derive the optimality conditions for Period 0. The optimality condition for s_0 is

$$\mathbb{E}_0[\frac{\partial y_2}{\partial s_0}(1 + vq(z_0)f(x_2))] = 0. \tag{2.1}$$

Using the above optimality condition for s_0, we obtain the optimality conditions for z_0 and e_0 as follows.

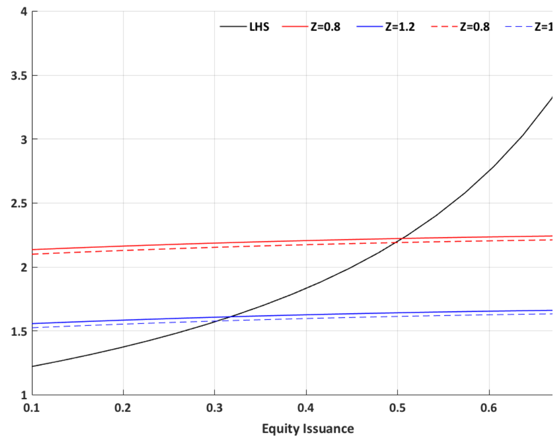
$$\frac{1+r}{1-c'(e_0)} = vq'(z_0)\mathbb{E}[F(x_2)] \tag{2.2}$$

$$c'(e_0) = vq(z_0)\mathbb{E}[f(x_2)](1 - c'(e_0)) \tag{2.3}$$

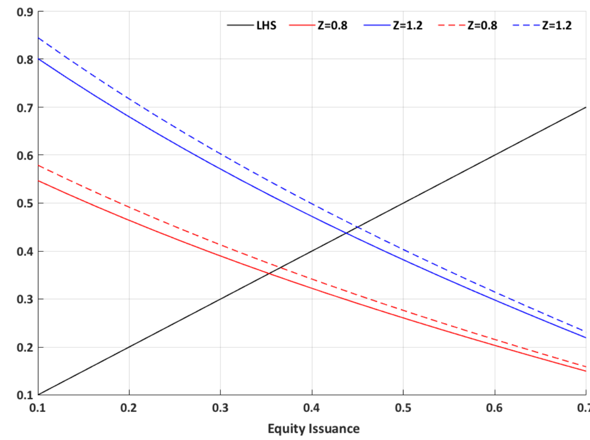
The above three equations jointly determine the optimal initial employment, R&D investment, and equity issuance. To solve the equilibrium, we use equation (2.1) to determine s_0 as a function of z_0 and e_0, and then find the equilibrium point where both equations (2.2) and (2.3) are satisfied. We present the results from the simulation of our model in Figures 2.3 and 2.4 in order to illustrate how the equilibrium changes in the cost of external finance and firing costs. We adjust labor productivity so that the average profitablity does not depend on firing costs, thereby isolating the impact of cash flow volatility on R&D investment.[10]
The LHS of equation (2.2) represents the marginal cost of R&D. It reflects the cost of equity issuance to compensate for the liquidity used for R&D investment. The RHS is the marginal R&D benefit, given that R&D investment is fully compensated by new equity and there is no change in available cash for the implementation stage. The marginal benefit of R&D investment is a decreasing function of itself for the given level of equity issuance. Therefore, as depicted in Panel A of Figure 2.3, this condition implies a negative relationship between R&D investment and equity issuance.

[10]The average profitability of the physical capital investment decreases in firing costs without such adjustment, and one might be worried that the simulated R&D response is not from the larger cash flow volatility, but from the reduction in available resources for the implementation stage. Productivity adjustment can be rationalized by the fact that higher firing costs induce firms to implement stronger screening processes when they hire employees, and incentivize workers to build firm-specific human capital that raises their productivity.

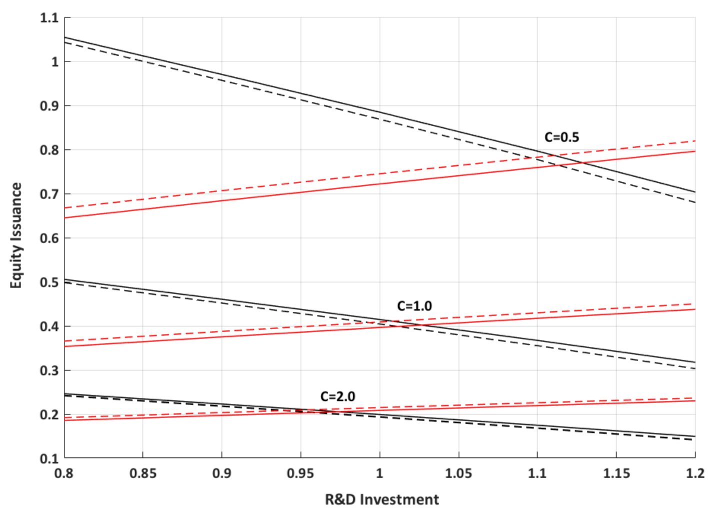
A. Optimal R&D Investment



B. Optimal Equity Issuance



C. Determination of Optimal R&D Investment and Equity Issuance



The above plots show the optimal R&D and equity issuance conditions presented in Section 2.3.1. Panel A depicts the marginal compensated benefit and cost of R&D investment, and Panel B shows the marginal benefit and cost of equity issuance, for the cases where the amount of R&D investment is small (red) and large (blue). The equity cost parameter is set to 1.0. The solid lines indicate the case where the firing cost parameter value is $\tau = 0.1$*, and the dashed lines are drawn with the parameter value* $\tau = 0.4$*. To isolate the impact of cash flow volatility, labor productivity is adjusted so that the average profitability of physical capital investment is not affected by the changes in firing costs. Panel C shows how two curves jointly determine the equilibrium values of R&D investment and equity issuance, when the equity cost parameter values are* $c = 0.5, 1.0,$ *and* 2.0.[11]

Figure 2.3: *Conditions for Optimal R&D Investment and Equity Issuance*

The LHS of equation (2.3) is the marginal cost of equity issuance. The RHS implies the marginal benefit, representing the contribution of extra one dollar of equity to the expected value of the R&D project by raising the probability of successful implementation. The marginal benefit of equity issuance grows as R&D investment becomes larger, since there is a higher chance that the raised equity can be used in the implementation stage. Therefore, we have a positive relationship between the two variables, as illustrated in Panel B of the same figure. Panel C shows that the equillibrium R&D investment and equity issuance are determined at the intersection of two curves in the z-e plane.

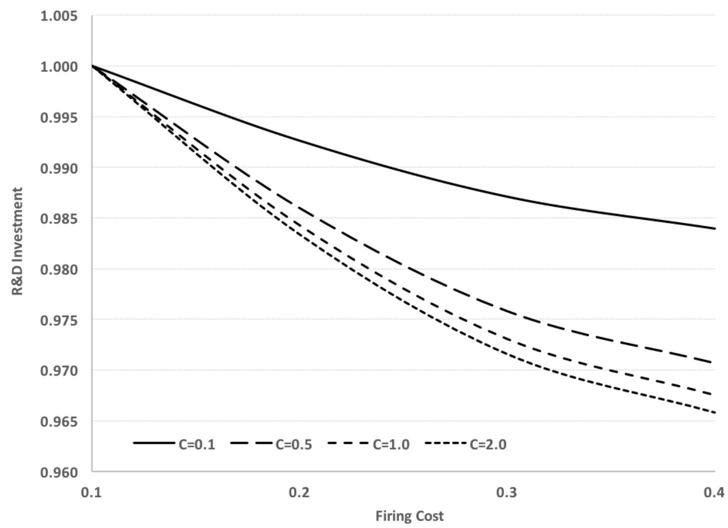
We now assume that there is an exogenous shocks to firing costs τ. Proposition 1 predicts higher variance of the profits generated from the physical capital investment. The concavity of the cumulative distribution of the implementation cost implies that higher variance of liquidity reduces the marginal benefit of R&D investment. Therefore, the firm has less incentive to raise equity to support the same level of R&D. The curve representing equation (2.2) shifts downwards after the shock. In contrast, because the associated probability density function is decreasing and convex, there is a larger marginal benefit of equity issuance for the given level of R&D investment. The curve for equation (2.3) has to shift upwards.

The above discussion implies that R&D investment has to be smaller at the new equilibrium, as depicted in Panel C of Figure 2.3. In Figure 2.4, Panel A illustrates that corporate R&D investment is a decreasing function of firing costs. Panel B plots the responses of R&D to the changes in firing costs both with and without productivity adjustment. We observe that a large part of reduction in R&D investment may stem from the increase in cash flow volatility, rather than the productivity decline associated with the firing cost shock.

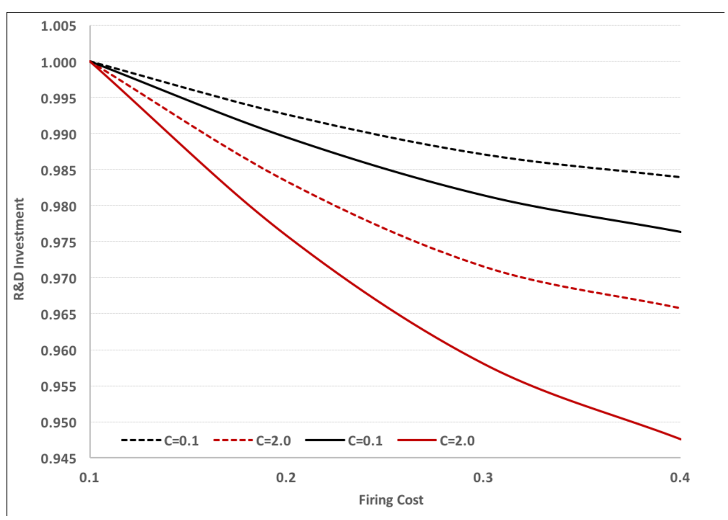
Moreover, the decrease is larger when the firm faces a higher cost of external financing. The large equity cost raises the marginal cost of R&D investment in equation (2.2), and raises the marginal cost and reduces the marginal benefit of equity issuance in equation (2.3). Therefore, equity issuance becomes less elastic to R&D investment in both curves, implying a larger decline in R&D investment after the shock.

Hypothesis 2 (Firing Cost and R&D Investment) An exogenous increase in firing costs

A. Optimal R&D Investment



B. Contribution of Cash Flow Volatility



The above plots present the results from the simulation based on the model in Section 2.3.1. Panel A illustrates the amount of optimal R&D investment as a fraction of the optimal level for $\tau = 0.1$*, when the cost parameter values are* $c = 0.1, 0.5, 1.0,$ *and* 2.0*, respectively. To isolate the impact of cash flow volatility, labor productivity is adjusted so that the average profitability of physical capital investment is not affected by the changes in firing costs. Panel B depicts the optimal R&D investment both with and without labor productivity adjustment, with cost parameter values* $c = 0.1$ *and* 2.0*. The solid lines show the total reduction in R&D investment. The dashed lines indicate the contribution of the increase in cash flow volatility.*

Figure 2.4: *Firing Costs and Optimal R&D Investment*

reduces R&D investment. The magnitude is larger as the firm is more financially constrained and subject to higher cost of external finance.

In the case where an increase in firing costs raises the volatility of cash flow from the physical capital investment, the firm is more likely to fail in implementing a successfully developed blueprint. This reduces the incentive to invest in the R&D project. In particular, when equity is expensive, the firm cannot easily offset the negative impact of higher cash flow volatility by holding more cash. Therefore, the incentive to invest in developing the blueprint decreases further among financially constrained firms.

Furthermore, when the firm has higher probability of low productivity states, the increase in cash flow volatility generates larger decline of the RHS in equation (2.2) and larger increase of the RHS in equation (2.3). Therefore, both curves representing the two equations shift more upon the firing cost shock, and the equilibrium R&D investment falls further. The shifts are even larger when the marginal cost of external financing is higher. Therefore, we derive the next hypothesis.

Hypothesis 3 (Firing Cost and R&D Procyclicality) An exogenous increase in firing costs amplifies R&D procyclicality. The increase in R&D procyclicality is larger as the firm is more financially constrained and subject to higher cost of external finance.

Cash flow volatility reduces the probability of successful implementation, particularly when average cash flow level is lower. Therefore, with larger firing costs, the probability that the firm can implement a successfully developed blueprint and generate profits becomes more procyclical. In turn, the firm's incentive to invest in the R&D project varies in a larger magnitude over the business cycle, generating larger R&D procyclicality. The increase in R&D procyclicality can be mitigated when the firm can hedge against the reduced cash flow in low productivity states by raising more equity. However, since a higher cost of external finance precludes the firm from holding enough cash, R&D becomes more procyclical especially among financially constrained firms.

Our last hypothesis follows by considering the firm's incentive to hoard extra cash before the liquidity shock at the implementation stage. The marginal benefits of R&D investment and equity issuance are larger when the value of successfully implemented blueprint is larger. Therefore, the firms with a high-value R&D project hoard more cash by equity issuance upon a firing cost shock.

Hypothesis 4 (Firing Cost and Cash Holding) An exogenous increase in firing costs raises the amount of equity issuance and cash holding, when the firm's R&D project is more valuable.

We interpret that a firm in an R&D-intensive industry tends to have high-valued R&D projects, thereby accumulating more cash when the firing costs increase.

2.3.2 Discussion

In this section we discuss several key model assumptions. To begin with, consider the timing and duration of R&D investment assumed in the model. In contrast to the capital investment for which the firm's decision is made after the realization of the productivity shock, the R&D investment decision is made prior to the productivity shock. This assumption is based on the observation that the timing of R&D investment is frequently driven by scientific advances and regulatory changes, whereas capital investment decisions are made mostly based on the market demand. We also assume that capital investment is a one-period project while R&D investment consists of two stages over two periods. More importantly, the cost in the second stage is uncertain in the first stage. This setup suggests that the investment durations and costs of many high-value R&D projects are highly uncertain until the completion of the projects. Finally, the model assumes that there is no liquidation value of the intangible asset generated by the first period R&D investment. If the firm fails to meet the requirement in the second period, the accumulated intangible asset just disappears. This assumption is a simple representation of the fact that R&D investment works as if it has a high adjustment cost (Hall and Lerner, 2010). The suspension of an R&D project may result in unwanted dissemination of proprietary information and delayed resolution of technical uncertainty which may be harmful to the firm value. The reduction in R&D spending generally accompanies the loss of R&D workers who have accumulated human capital specific to the firm, and rebuilding the research workforce through recruiting and training new R&D workers requires many firm resources. On the contrary, a substantial part of discontinued capital investment can be liquidated relatively easily without further capital loss, and firms can resume suspended capital investment projects with smaller costs. For the sake of simplicity, we model that capital investment is completed in one period without uncertainty. However, extending the duration of capital investment to two periods and allowing the resaleability of capital would generate the same propositions we derived from the model.

The second key element of the model is the convex cost of external financing for R&D investment. Because capital investment accumulates pledgeable assets, firms can use external sources of finance for capital investment when internal resources are scarce. In contrast, R&D investment mostly builds intangible assets the low redeployability and uncertain liquidation value of which preclude their use as collateral.[12] Furthermore, the highly idiosyncratic, intangible, and unpredictable nature of R&D investment produces a high degree of information and agency problems, rendering external financing very costly.[13] Therefore, positive cash flow and internal financing capacity are more important for R&D than for ordinary investment (Hall, 1992; Himmelberg and Petersen, 1994), and internally generated cash flow and equity issuance are the most important sources of R&D investment, especially among young public firms (Brown *et al.*, 2009). We incorporate this idea by

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[12] R&D projects are generally not collateralizable (Williamson, 1988; Alderson and Betker, 1996), so in most firms R&D investment is financed almost exclusively with cash flow and equity issuance (Brown and Petersen, 2009). Recently, it has been reported that there is an increasing number of cases in which intangible assets such as granted patents and trademarks are used as collateral in the corporate finance market (Loumioti, 2012). However, it is still not feasible to borrow against intangible assets that will be produced in the future. In contrast, most fixed capital investment can be financed concurrently with external sources using the capital as collateral.

[13] The literature has accumulated considerable evidence that using newly issued equity as a resource for R&D investment is costly due to the severe information asymmetry problems (Leland and Pyle, 1977; Alam and Walton, 1995; Zantout, 1997; Blass and Yosha, 2003) and agency problems (Jensen and Meckling, 1976; Hall, 1990, 1994; Cho, 1992; Opler and Titman, 1993; Francis and Smith, 1995; Johnson and Rao, 1997; Majumdar and Nagarajan, 1997; Pugh *et al.*, 1999; Eng and Shackell, 2001; Lerner *et al.*, 2011; Aghion *et al.*, 2013). From an R&D firm's perspective, mitigating information problems through more disclosure must be limited due to the possibility of imitation of ideas and the loss of proprietary information. The manager's incentives to overinvest cannot be controlled by higher financial leverage, because constraining free cash flow may force firms to rely on high-cost external financing to fund their R&D projects, which may result in a larger loss of firm value.

assuming that R&D investment must be financed by the firm's initial endowment or the equity raised in the first period. On the other hand, capital investment can be supported by debt financing. The convexity of the cost function is necessary to derive the optimal level of external financing.

Finally, we assume that the firm determines the initial employment level before observing the productivity shock. This assumption is made to capture the persistence of employment in a parsimonious way. Employment is largely inherited from the past, so we interpret the employment decision in the first period to be the result of past decisions. It is optimal in expectation, but not always optimal after the realization of the productivity shock in the second period.

2.4 Data and Sample Construction

To estimate the impact of wrongful discharge laws on firms' operating leverage and investment, we use two unbalanced panels of COMPUSTAT public firms for the period 1971 to 1999. One is for the analysis of the impact of wrongful discharge laws on corporate investment and the other one is for the analysis of the laws' effects on operating leverage, earnings, and cash management. We truncate observations before 1971 due to data availability, especially the cash flow data we use to construct the measure of financial constraints. Because most of the adoption happened between 1975 and 1995, our sample period is a reasonable boundary to estimate the impact of the adoption of wrongful discharge laws. We exclude utility firms (SIC codes 4900-4999) from both samples because their investment can be driven largely by government policies and regulations rather than economic reasons. We also exclude financial firms (SIC codes 6000-6999) because they have different types of financial constraints compared to the industrial firms that interest us.

We combine the firm annual balance sheet, income statement, and cash flow information from COMPUSTAT with state- and industry-level macroeconomic data obtained from the U.S. Bureau of Economic Analysis (BEA) and the U.S. Bureau of Labor Statistics (BLS). Education and political balance measures of each state are collected from Annual Statistical abstracts of the U.S. Census Bureau. R&D user cost estimates are adopted from Wilson (2009). The annual industry layoff rates are computed using the CPS Displaced Worker Supplements, which report data on layoffs from the displacement survey that was first conducted in 1984. We use the NBER patent dataset for the data on granted patents. Throughout our analyses, we use modified 2-digit SIC codes in order to match with industry classifications in BEA state GDP data. Details on the construction of the regression variables can be found in Appendix Tables B.3 and B.4.

The primary measure of financial constraints we use in this paper is the Whited-Wu index (Whited and Wu, 2006).[14] Because our sample period mostly aligns with the sample period used by Whited and Wu (2006), which was from 1975 to 2001, we directly use the coefficients reported in Whited and Wu (2006) without re-estimating the structural equation. Because this index estimates the marginal value of external equity financing, in equilibrium, it is equal to the marginal cost of external equity financing. The equation to drive the Whited-Wu index, and the procedure to construct each variable in the equation can be found in the Appendix. The index is missing for some firm-year data because of missing data necessary for the index construction.

To construct the sample for the analysis of corporate investment responses to wrongful discharge laws, we first eliminate observations with missing or inconsistent values for the variables and controls, and drop observations of industries with fewer than ten firms in that year. This ensures that we have enough observations to get reliable estimates of annual industry average R&D and capital investment intensity. These criteria guarantee that our sample is consistent throughout our empirical analyses in this paper. We also drop firms with missing values for the financial constraint measure. Our first sample, used for studying investment responses to the adoption of wrongful discharge laws, consists of 28,174 firm-year observations. The sample used for the analysis of operating leverage, earnings, and liquidity management is constructed in a similar fashion with different

[14] We also tested our empirical models using the Kaplan-Zingales index (Kaplan and Zingales, 1997), years since IPO, size measured by market capitalization, and whether a firm has a credit rating. The results are robust to the choice of financial constraint measures.

variables and controls. The second sample consists of 48,859 firm-year observations. Tables 2.1 and 2.2 report the descriptive statistics of the constructed variables and controls we use in the following analyses. In Table 2.1, we find that, when normalized by total assets, the average R&D investment intensity, 7.6%, is the same as the average capital investment intensity in terms of magnitude. The intensity of R&D investment is relatively smaller than that of capital investment when the variables are normalized by market capitalization, but the difference is not substantial. In particular, the share of R&D investment out of total investment is 0.43, slightly less than half. Although the sample is constructed only from the firms who report both R&D and capital investment, considering that literature has mostly focused on capital expenditure and paid less attention to R&D investment, the similar intensity of capital and R&D investment is a surprise.

Table 2.1: *Descriptive Statistics (Firm Investment Variables)*

The following table shows the descriptive statistics of investment variables, measures of financial constraints, and the control variables we use in the analyses of the impact of the adoption of wrongful discharge laws on firm investment decisions. R&D investment, capital investment, and total investment as the sum of R&D and capital investment are normalized by total assets at the end of last fiscal year, or by the value of market equity at the end of calendar year that overlaps with the fiscal year the most. There are four measures of firm financial constraints: the financial constraint index constructed using the structurally estimated equation from Whited and Wu (2006), the measure of financial distress from Kaplan and Zingales (1997) excluding Tobin's Q from the equation, the negative value of the number of years since the firm's initial public offering, and the negative value of the natural log of market capitalization of equity at the end of calendar year that overlaps with the fiscal year the most. In addition to ΔGSP, the difference in the natural log of real gross production within a state where the firm's headquarter is located in, we construct the following time-varying control variables for our regression analyses: Tobin's Q, firm size and its squared value, industry competition measure and its squared value, industry share of gross state product, state population, state unemployment rate, real gross state product, number of institutions for higher education in the state, higher education enrollment in the state, state political balance, and state R&D user cost. The detailed description of these variables can be found in Appendix Table B.3.

Variables	Obs	Mean	Std	Min	Median	Max
Discretionary Investment Variables						
R&D/Asset	28,174	0.076	0.124	0.000	0.039	5.727
CapEx/Asset	28,174	0.076	0.087	0.000	0.057	3.283
Total Investment/Asset	28,174	0.152	0.157	0.000	0.113	7.074
R&D/ME	28,174	0.084	0.179	0.000	0.044	10.351
CapEx/ME	28,174	0.116	0.197	0.000	0.067	7.995
Total Investment/ME	28,174	0.201	0.301	0.000	0.133	13.340
R&D/Total Investment	28,174	0.430	0.272	0.000	0.407	0.999

Table 2.1: *(Continued)*

Variables	Obs	Mean	Std	Min	Median	Max
Measures of Financial Constraint						
Whited and Wu	28,174	−0.238	0.112	−0.533	−0.229	0.007
Kaplan and Zingales/100	28,174	−0.035	0.084	−1.080	−0.016	0.115
IPO Age/10	28,174	−1.137	0.675	−2.900	−1.000	−0.300
Market Capitalization	28,174	−5.033	2.135	−11.439	−4.858	0.303
Investment Controls						
ΔGSP	28,174	0.034	0.031	−0.051	0.036	0.105
Tobin's Q	28,174	0.400	0.563	−0.874	0.272	2.554
Size	28,174	5.220	2.123	0.533	5.054	10.783
Competition	28,174	0.766	0.338	0.000	0.951	1.000
GSP Share	28,174	0.024	0.023	0.001	0.019	0.191
Population	28,174	9.094	0.812	6.742	9.162	10.380
Unemployment Rate	28,174	6.495	1.774	3.250	6.242	11.933
GSP	28,174	12.572	0.882	9.987	12.581	14.100
Higher Education	28,174	4.778	0.774	2.303	4.796	5.981
Enrollment	28,174	13.083	0.857	10.646	13.066	14.498
Political Balance	28,174	0.596	0.127	0.277	0.587	0.893
R&D User Cost	28,174	1.341	0.139	1.132	1.343	1.540

Table 2.2: *Descriptive Statistics (Firm Performance and Capital Structure Variables)*

The following table shows the descriptive statistics of the variables representing firm performance and capital structure, and the control variables we use in the analyses of the impact of the adoption of wrongful discharge laws on these variables. We use four variables as measures of firm performance: earnings, cash flow, ROA, and profit margin. The following control variables are used in the analyses of firm performance: variables that represent the firm's investment opportunities (Tobin's Q, size, capital expenditure, R&D investment) and the influence of capital structure (leverage, net working capital, cash holding). There are four firm choice variables related to capital structure: cash holding, net equity issuance, dividend payout, and changes in debt outstanding. The control variables we use as determinants of corporate cash holding are Tobin's Q, size, capital expenditure, net working capital, dividend dummy, cash flow, industry cash flow risk, and acquisition. Appendix Table B.4 provides the detailed description of these variables.

Variables	Obs	Mean	Std	Min	Median	Max
Firm Performance Measure						
Earnings	48,859	0.192	0.109	0.000	0.173	3.116
Cash Flow	48,859	0.094	0.129	−3.632	0.099	1.664
ROA	48,859	0.101	0.073	−2.661	0.092	2.146
Profit Margin	48,859	0.109	0.103	−1.862	0.091	3.724
Firm Performance Controls						
Sales	48,859	1.731	0.985	0.239	1.530	7.229
Tobin's Q	48,859	0.291	0.488	−0.816	0.196	2.169

Table 2.2: *(Continued)*

Variables	Obs	Mean	Std	Min	Median	Max
Size	48,859	5.178	1.765	1.156	5.067	9.890
Capital Expenditure	48,859	0.086	0.082	0.003	0.063	0.677
R&D Investment	48,859	0.023	0.044	0.000	0.000	0.324
Leverage	48,859	0.222	0.166	0.000	0.208	0.815
Net Working Capital	48,859	0.214	0.164	−0.162	0.211	0.632
Cash Holdings	48,859	0.116	0.132	0.000	0.065	0.726
Firm Capital Structure						
Cash Holdings	48,859	0.113	0.132	0.000	0.062	0.985
Net Equity Issuance	48,859	0.008	0.073	−2.365	0.000	1.424
Dividend Payout	48,859	0.014	0.039	−0.004	0.008	3.093
Changes in Debt Outstanding	48,859	0.013	0.113	−3.820	0.000	1.998
Firm Capital Structure Controls						
Tobin's Q	48,859	0.266	0.470	−0.794	0.177	2.351
Size	48,859	5.275	1.750	1.223	5.167	9.970
Capital Expenditure	48,859	0.075	0.062	0.003	0.058	0.421
R&D Investment	48,859	0.020	0.037	0.000	0.000	0.271
Leverage	48,859	0.223	0.167	0.000	0.209	0.848
Net Working Capital	48,859	0.215	0.163	−0.156	0.210	0.616
Dividend Dummy	48,859	0.570	0.495	0.000	1.000	1.000
Cash Flow	48,859	0.086	0.051	−0.084	0.081	0.283
Industry Cash Flow Risk	48,859	0.049	0.029	0.006	0.040	0.189
Acquisition	48,859	0.017	0.049	0.000	0.000	0.425

We gather the information on the adoption status of wrongful discharge laws by U.S. states from the data archive in David Autor's website and construct dummy variables for the adoption status of each type of wrongful discharge laws.[15] Similar to recent studies that examine the impact of employment protection on corporate financing decisions and R&D labor productivity (Agrawal and Matsa, 2013; Acharya *et al.*, 2014; Serfling, 2016), for each type of wrongful discharge laws we assign 1 to the adoption dummy when it is adopted in the state where a firm's headquarter is located.

[15]Data for Autor *et al.* (2006): http://economics.mit.edu/faculty/dautor/data/autdonschw06

2.5 Empirical Analyses

Using the recognition of wrongful discharge laws as an exogenous shock to the degree of employment protection, we empirically estimate the causal effect of employment protection on operating leverage and corporate R&D investment.

2.5.1 Wrongful Discharge Laws and Operating Leverage

We begin our empirical analysis by showing that the adoption of the good-faith exception works as an exogenous shock to firm operating leverage. In general, operating leverage represents how revenue growth translates into earnings growth, so we estimate operating leverage by directly regressing earnings growth on sales growth. Including the interaction terms between sales growth and the adoption dummies, we can estimate the average operating leverage before the adoption of wrongful discharge laws and after the adoption events, respectively. The regression equation is given by

$$\begin{aligned}\Delta\ln(\text{Earnings})_{ijst} = {} & \beta_1 \Delta\ln(\text{Sales})_{ijst} + \sum_c \beta_2^c \Delta\ln(\text{Sales})_{ijst} \times \text{WDL}_{st}^c \\ & + \delta_X' \text{X}_{ijst} + \delta_F' \text{F}_i + \delta_D' \text{D}_{jt} + \sum_{s'} \delta_{s'} (t \times \mathbb{1}[s' = s]) + \varepsilon_{ijst} \qquad (2.4)\end{aligned}$$

where $\text{WDL}_{st}^c, c = \text{GF}, \text{IC}, \text{PP}$, are the indicator variables for the adoption status of the good-faith, implied contract, and public policy exceptions, X_{ijst} is the set of time-varying control variables, and F_i and D_{jt} are firm fixed effects and industry-year fixed effects, respectively. We also include the state trends to control for any state-specific secular trends that may influence earnings growth of the firms within each state. We are concerned that measures representing investment opportunities and capital structure may be related with unobservable variables that potentially determine the speed of earnings growth. Therefore, our controls include Tobin's Q, size, and capital and R&D expenditures as indicators of investment opportunities, and also include leverage, net working capital, and cash holding as indicators of capital structure.

As shown in Columns (1) and (2) of Table 2.3, only the adoption of the good-faith exception

(GF) by the states in which firms' headquarters are located raises the operating leverage of the firms. The GF adoption increases firm operating leverage by between 0.2 and 0.3 from the pre-adoption level of about 1.5, and all estimates are statistically significant. We also estimate the impact of the GF adoption while allowing for different levels of pre-adoption operating leverage for each industry. In columns (3) and (4), we observe that the significance of the adoption is maintained despite small decrease in the magnitude.

Table 2.3: *Effect of Wrongful Discharge Laws on Firm Operating Leverage*

Columns (1) and (2) show the results from the OLS regressions of log difference in firm annual earnings on log difference in firm annual sales and its interaction terms with the indicator variables for the adoption status of wrongful discharge laws in the state where the firm's headquarter is located in. The regression equation is

$$\Delta\ln(\text{Earnings})_{ijst} = \beta_1\Delta\ln(\text{Sales})_{ijst} + \beta_2\Delta\ln(\text{Sales})_{ijst} \times \text{WDL}_{st} + \delta_X'\text{X}_{ijst} + \delta_F'\text{F}_i + \delta_D'\text{D}_{jt}$$
$$+ \textstyle\sum_{s'} \delta_{s'}(t \times \mathbb{1}[s' = s]) + \varepsilon_{ijst},$$

where is each state's adoption status of the following three types of wrongful discharge laws: good-faith (GF), implied-contract (IC), and public-policy (PP) exceptions. The regressions include the set of firm dummies F_i*, the set of industry (classification used in the BEA reports) times year dummies* D_{jt}*, and time trends in each state. In Columns (3) and (4), we allow each industry to have different pre-adoption operating leverage and estimate the average effects of the adoption decisions on operating leverage. Columns (5) and (6) report the results from the OLS regressions of log difference in firm annual earnings on log difference in firm annual sales and its interaction terms with the indicator variables that represent the distance to the year in which the good-faith exception was first recognized by a court within the state.*[16] *We use operating income before depreciation as the measure of firm earnings. We include control variables that represent the firm's investment opportunities (Tobin's Q, size, capital expenditure, R&D investment) and the influence of capital structure (leverage, net working capital, cash holding). Appendix Table B.4 has detailed description of these variables. All independent variables are winsorized at the 1% and 99% levels. We include firm fixed effects, industry times year fixed effects, and time trends in each state. The standard errors are clustered at state level and given in parentheses.* $*$, $**$, *and* $***$ *denote significance at the 10%, 5%, and 1% levels, respectively.*

Dep.Var: Earnings Growth	(1)	(2)	(3)	(4)	(5)	(6)
Sales Growth	1.537***	1.528***	—	—	1.497***	1.509***
	(0.028)	(0.026)			(0.037)	(0.039)
Sales Growth×GF	0.248***	0.268***	0.192***	0.214***		
	(0.075)	(0.075)	(0.067)	(0.068)		
Sales Growth×IC	0.007	0.023	0.002	0.017		
	(0.046)	(0.048)	(0.041)	(0.043)		
Sales Growth×PP	−0.054	−0.037	−0.054	−0.035		
	(0.054)	(0.056)	(0.046)	(0.048)		
Sales Growth×GF[-4p]					0.105*	0.067
					(0.062)	(0.066)
Sales Growth×GF[-3,-2]					0.149	0.119
					(0.091)	(0.083)
Sales Growth×GF[-1,0]					0.209	0.170
					(0.162)	(0.150)

Table 2.3: *(Continued)*

Dep.Var: Earnings Growth	(1)	(2)	(3)	(4)	(5)	(6)
Sales Growth×GF[+1,+2]					0.279***	0.283***
					(0.093)	(0.104)
Sales Growth×GF[+3,+4]					0.248***	0.268***
					(0.079)	(0.082)
Sales Growth×GF[+5,+6]					0.382***	0.375***
					(0.118)	(0.127)
Sales Growth×GF[+7p]					0.254**	0.297***
					(0.101)	(0.098)
Controls	No	Yes	No	Yes	No	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Industry×Year FE	Yes	Yes	Yes	Yes	Yes	Yes
State Trend	Yes	Yes	Yes	Yes	Yes	Yes
Obs	48,859	48,859	48,859	48,859	48,859	48,859
R-Squared	0.322	0.342	0.328	0.347	0.323	0.342

However, there are other possible factors influencing the court decision to adopt wrongful discharge laws and strengthen employment rigidity at the same time. In other words, the observed increase in operating leverage after the GF adoption might not be driven by the adoption decision, but by the other economic and social circumstances that make employment more rigid, and the adoption decision simply represents these changing circumstances. To alleviate this concern, we use dynamic specification to estimate the relative magnitude of operating leverage between two groups around the adoption years. One group of firms is located in the states with a history of the GF adoption within our sample period, and the other group of firms is located in the states that have never adopted GF within our sample period. If we find that operating leverage tends to rise even before the GF adoption, it would imply the existence of another factor that has contributed to the increase of operating leverage, would violate the parallel trend assumption of difference-in-differences method, and would invalidate our interpretations. Columns (5) and (6) report our dynamic regression results. They confirm that the adoption event works as an exogenous shock to firm operating leverage. We find that operating leverage begins rising immediately after the recognition of good-faith exception. Also, we find no evidence of pre-trend rising operating leverage. The relative magnitude of operating leverage is not statistically different from zero before the adoption, but it becomes highly significant once the exception is adopted. The point estimates are doubled or tripled after the adoption. Furthermore, we observe that the increase in operating leverage is a permanent phenomenon, implying that any empirical findings on corporate investment and liquidity management decisions are not driven by the transitory changes in firm operating leverage. In Section 2.5.4, we revisit this issue and provide evidence that the increase in operating leverage after the adoption is larger among the firms in the industries that are expected to experience a larger increase in firing costs. Finally, Appendix Table B.8 shows that our estimates are stable across a different mix of fixed effects and time trends.

If corporate performance is more sensitive to current revenue generation after the adoption of the good-faith exception, we can expect that the stock returns are also more responsive to the contemporaneous sales news. To see this, we estimate monthly Fama-Macbeth (1973) cross-sectional regressions in the following form:

$$\begin{aligned}\text{Return}_{ist} = \; & \alpha + \gamma_1 \ln(\text{BE/ME})_{it} + \gamma_2 \ln(\text{ME})_{it} + \gamma_3 \text{Momentum}_{it} + \gamma_4 \text{ROA}_{it} \\ & + \gamma_5 \Delta\ln(\text{Sales})_{it} + \gamma_6 \Delta\ln(\text{Sales})_{it} \times \text{GF}_{st} + \varepsilon_{ist}, \end{aligned} \tag{2.5}$$

where ln(BE/ME) and ln(ME) are re-computed at the end of June in each year with book equity at the end of the last fiscal year and market capitalization at the end of December in the last calendar year. Momentum is defined as the average monthly return for past one year except the last month before the report month, and ROA is also measured at the end of June each year as income before extraordinary items plus interest expenses in the last fiscal year normalized by the total assets at the end of the fiscal year one year prior to the last fiscal year. Our sample consists of the stock returns for the months with valid quarterly sales reports for both the current and last quarters.

Table 2.4 documents that sales growth has explanatory power for contemporaneous returns after controlling for other well-known predictive variables such as firm size, book-to-market ratio, momentum returns, and return on assets. In Column (2), we report that a 1% increase in quarterly sales growth translates into 6.5bp to 7.0bp increase in monthly returns. Column (3) shows that the adoption of the good-faith exception raises the sensitivity of stock returns to contemporaneous sales growth news, generating an additional 2.1bp increase in monthly returns for a 1% increase in sales growth. In contrast, columns (4) and (5) report that the sensitivity of monthly returns to earnings growth news remains similar even after the adoption. In sum, our analysis of stock return responses to sales growth news provides additional evidence of an exogenous increase in operating leverage after the adoption of the good-faith exception.

Table 2.4: *Changes in Stock Return Responses to Sales News*

The following table shows the coefficient estimates of monthly Fama-Macbeth (1973) cross-sectional regressions in the following form:

$$\text{Return} = \alpha + \gamma_1 \ln(\text{BE/ME}) + \gamma_2 \ln(\text{ME}) + \gamma_3 \text{Momentum} + \gamma_4 \text{ROA} + \gamma_5 \Delta \ln(\text{Sales}) + \gamma_6 \Delta \ln(\text{Sales}) \times \text{GF} + \varepsilon,$$

where the dependent variable is the monthly return of individual stock for a month in which the firm releases the quarterly sales and earnings report (report month). When the report date is the last trading day of the month, we use average of the monthly returns for the curresponding month and for the next month. GF is the indicator variable for the adoption status of the good-faith exception in the state where the firm's headquarter is located in. Sales growth and earnings growth are defined as the log difference in quarterly sales and quarterly operating income before depreciation from the quarterly records announced in the last quarterly report. For the report months from July of year t to June of year $t+1$, $\ln(\text{ME})$ is the natural log of market capitalization at the end of December in year $t-1$, $\ln(\text{BE/ME})$ is the natural log of the ratio of book equity at the end of the fiscal year $t-1$ to market capitalization at the end of December in year $t-1$, Momentum is the average monthly return for the past 12 months except the last month before the report month, and ROA is income before extraordinary items plus interest expenses in fiscal year $t-1$ divided by total assets at the end of fiscal year $t-2$. All independent variables are winsorized at the 1% and 99% levels. Before estimating the time-series average of the coefficients, we winsorize the cross-sectional estimates at the 10% and 90% levels to minimize the impact of imprecise estimation due to the small number of firms issuing quarterly reports in 1970s. All accounting variables (ln(ME), ln(BE/ME), ROA) are standardized, and return variables are expressed in percentage unit. The sample spans for 312 months, from 07/1973 to 06/1999. $*$, $**$, and $***$ denote significance at the 10%, 5%, and 1% levels, respectively.

Dep.Var: Monthly Return (%)	(1)	(2)	(3)	(4)	(5)
ln(ME)	-0.151	-0.137	-0.129	-0.438^{***}	-0.442^{***}
	(0.104)	(0.100)	(0.099)	(0.115)	(0.113)
ln(BE/ME)	0.507^{***}	0.580^{***}	0.596^{***}	0.305^{**}	0.332^{***}
	(0.101)	(0.101)	(0.100)	(0.123)	(0.120)
Momentum (%)	0.142^{***}	0.110^{***}	0.103^{***}	0.059^{*}	0.058^{*}
	(0.024)	(0.024)	(0.024)	(0.031)	(0.031)
ROA	-0.185	-0.255	-0.249	-0.894^{***}	-0.933^{***}
	(0.161)	(0.162)	(0.162)	(0.227)	(0.226)
Good Faith (GF)			-0.155		-0.103
			(0.125)		(0.137)
Sales Growth (%)		0.069^{***}	0.066^{***}		
		(0.004)	(0.004)		
Sales Growth (%)×GF			0.021^{***}		

Table 2.4: *(Continued)*

Dep.Var: Monthly Return (%)	(1)	(2)	(3)	(4)	(5)
			(0.008)		
Earnings Growth (%)				0.033***	0.034***
				(0.001)	(0.002)
Earnings Growth (%)×GF					0.004
					(0.003)

2.5.2 Wrongful Discharge Laws and Corporate R&D Investment

In this section, we analyze the impact of the adoption of wrongful discharge laws on corporate investment, with a primary focus on R&D investment.

The average level of R&D investment

We first examine the impact of wrongful discharge laws on average investment intensity. Our regression equation is

$$\text{Investment}_{ijst} = \sum_{c} \beta_1^c \text{WDL}_{st}^c + \delta_{\text{X}}' \text{X}_{ijst} + \delta_{\text{F}}' \text{F}_i + \delta_{\text{D}}' \text{D}_{jt} + \sum_{s'} \delta_{s'} (t \times \mathbb{1}[s' = s]) + \varepsilon_{ijst} \quad (2.6)$$

where Investment_{ijst} is R&D or capital expenditure normalized by total assets at the end of last period, and WDL_{st}^c are the indicator variables for the adoption status of the good-faith, implied contract, and public policy exceptions. We employ the same set of fixed effects and trend variables as we did in the previous section. All independent variables are standardized to have mean of zero and standard deviation of one so that we can easily capture the economic magnitude of the effect.

We control for Tobin's Q because firms with higher Q might have more growth opportunities and therefore are likely to invest more in innovation. Firm size and its squared value are also controlled to take into account the possibility that innovation takes place more intensively in larger firms. Aghion *et al.* (2005) document an inverted U-shape relationship between competition in an industry and the number of citation-weighted patents firms generate. Their findings are about innovation outcome rather than the amount of R&D investment, but we do not ignore the possibility that there is a nonlinear relationship between competition and investment for innovation. Therefore, we include the measure of competition and its squared value in our control variables.

For controls at the state level, we include log real gross state product (GSP) and log real GSP per capita, as firms in large and rich states might have more innovation opportunities. To control for the changes in R&D investment through the business cycle, we also include real GSP growth rate and state unemployment rate. Following Acharya *et al.* (2014), we include the ratio of GSP generated by each industry in a given state to the total GSP of the state to control for the possibility that the comparative advantage of an industry in each state determines the R&D intensity of the industry in that state. Incentives for R&D investment can be also influenced by the political disposition of the state and the R&D tax credits given to the firms in that state. Thus, we include the measure of political balance, defined as the percentage of democrats in the state houses, and the measure of R&D user cost from Wilson (2009). Finally, corporate R&D investment can depend on the human capital available in each state. Therefore, we also control for each state's population, number of colleges, and total enrollment in higher educational institutions.

Table 2.5: *Effect of Wrongful Discharge Laws on Corporate Investment*

This table reports the results from the OLS regressions of firm investment on the dummies for the adoption status of wrongful discharge laws and their interaction terms with the index of financial constraint, which is the proxy for the cost of external finance. For both R&D and capital investments, the regression specification for the first two columns is given by

$$\mathrm{I}_{ijst} = \beta_1 \mathrm{WDL}_{st} + \delta'_{\mathrm{X}}\mathrm{X}_{ijst} + \delta'_{\mathrm{F}}\mathrm{F}_i + \delta'_{\mathrm{D}}\mathrm{D}_{jt} + \textstyle\sum_{s'} \delta_{s'}(t \times \mathbb{1}[s' = s]) + \varepsilon_{ijst}.$$

The dependent variable, R&D and capital investment intensity, is defined as R&D and capital expenditure normalized by total assets at the end of last fiscal year. The main explanatory variables are indicator variables for each state's adoption status of three types of wrongful discharge laws: good-faith (GF), implied-contract (IC), and public-policy (PP) exceptions. In addition to the log difference in the state real gross production, we employ the extensive set of control variables including: Tobin's Q, firm size and its squared value, industry competition measure and its squared value, industry share of gross state product, state population, state unemployment rate, real gross state product, number of institutions for higher education in the state, higher education enrollment in the state, state political balance, and state R&D user cost (detailed description of these controls can be found in Appendix Table B.3). All non-dummy independent variables are winsorized at the 1% and 99% levels, and standardized to zero mean and 1 standard deviation. The regressions include the set of firm dummies F_i*, the set of industry (classification used in the BEA reports) times year dummies* D_{jt}*, and time trends in each state. The specification for next two columns includes the terms used for the above specification and their interaction terms with financial constraint index.*

$$\mathrm{I}_{ijst} = \beta_1 \mathrm{WDL}_{st} + \beta_2 \mathrm{FC}_{ist} + \beta_3 \mathrm{WDL}_{st} \times \mathrm{FC}_{ist} + \delta'_{\mathrm{X}}\mathrm{X}_{ijst} + \delta'_{\mathrm{F}}\mathrm{F}_i + \delta'_{\mathrm{D}}\mathrm{D}_{jt} + \textstyle\sum_{s'} \delta_{s'}(t \times \mathbb{1}[s' = s]) + \varepsilon_{ijst}$$

FC is the measure of firm financial constraint constructed using the structural estimation equation for the marginal value of external financing adopted from Whited and Wu (2006). The same set of control variables, fixed effects, and time trends are used. For both specifications, the standard errors are clustered at state level and given in parentheses. $*$, $**$, *and* $***$ *denote significance at the 10%, 5%, and 1% levels, respectively.*

Dep.Variable	R&D Investment/Asset (%)				Capital Investment/Asset (%)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Good Faith (GF)	−0.455***	−0.310	−0.953***	−0.825***	0.372	0.250	0.333	0.150
	(0.146)	(0.186)	(0.214)	(0.260)	(0.320)	(0.307)	(0.334)	(0.322)
Implied Contract (IC)	0.303	0.226	0.324	0.245	0.034	0.055	0.090	0.054
	(0.206)	(0.155)	(0.216)	(0.173)	(0.296)	(0.234)	(0.297)	(0.236)
Public Policy (PP)	0.181	0.132	0.187	0.146	−0.473*	−0.507**	−0.385	−0.533**
	(0.209)	(0.192)	(0.241)	(0.236)	(0.282)	(0.237)	(0.294)	(0.257)
FC Index (FC)			−0.732*	−2.026***			−2.365***	−0.544
			(0.388)	(0.668)			(0.410)	(0.464)
FC×GF			−1.690***	−1.680***			−0.155	−0.328
			(0.459)	(0.464)			(0.255)	(0.256)
FC×IC			0.074	0.146			0.074	0.008
			(0.240)	(0.216)			(0.243)	(0.198)
FC×PP			0.182	0.186			0.229	−0.053
			(0.215)	(0.238)			(0.229)	(0.193)
Tobin's Q		1.621***		1.568***		2.114***		2.099***
		(0.202)		(0.191)		(0.175)		(0.171)
Controls	No	Yes	No	Yes	No	Yes	No	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry×Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State Trend	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Obs	28,174	28,174	28,174	28,174	28,174	28,174	28,174	28,174

Table 2.5: *(Continued)*

Dep.Variable	R&D Investment/Asset (%)				Capital Investment/Asset (%)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
R-Squared	0.015	0.032	0.019	0.038	0.077	0.118	0.085	0.119

Columns (1) and (2) in Table 2.5 report our estimates of the impact of the adoption of wrongful discharge laws on corporate R&D investment. The estimated coefficient on the adoption status of the good-faith exception is statistically significant without control variables, but both the magnitude and statistical significance of the estimate decline as we include the control variables. Hence, we cannot reject the null hypothesis that the adoption of the good-faith exception has no effect on the average level of corporate R&D investment. This result is not surprising given our prediction in Section 2.3 that the impact of wrongful discharge laws on R&D expenditure is ambiguous due to the existence of multiple possible channels, with both positive and negative effects, through which employment protection could affect R&D investment.

We next examine the possibility that the exogenous increase in operating leverage may result in different investment responses, depending on the level of financial constraints. The main contribution of our empirical analysis is the estimation of the joint effect of employment protection and financial constraints. Thus, we include the interaction terms between the adoption dummies and the measure of financial constraints in our regression:

$$\begin{aligned} \text{Investment}_{ijst} = & \sum_c \beta_1^c \text{WDL}_{st}^c + \beta_2 \text{FC}_{ist} + \sum_c \beta_3^c (\text{WDL}_{st}^c \times \text{FC}_{ist}) \\ & + \delta_X' \text{X}_{ijst} + \delta_F' \text{F}_i + \delta_D' \text{D}_{jt} + \sum_{s'} \delta_{s'} (t \times \mathbb{1}[s' = s]) + \varepsilon_{ijst}. \end{aligned} \tag{2.7}$$

The results are shown in columns (3) and (4) in Table 2.5. When an interaction term between the good-faith exception (GF) dummy and the measure of financial constraints (FC) is introduced, coefficients on the GF dummy and the interaction term are both negative and significant. Because we standardized all explanatory variables, the coefficient on the adoption dummy is interpreted as the average effect of the adoption across all firms with different levels of financial constraints.[17] In this sense, we find that the adoption of the good-faith exception, on average, reduces corporate R&D intensity by 0.8%p to 1.0%p. More importantly, firms additionally reduce R&D intensity by 1.5%p to 1.7%p when their level of financial constraints increase by one standard deviation. This provides evidence that the exogenous increase in operating leverage generates substantial decline in R&D investment only among the financially constrained firms whose marginal cost of external financing is high. Similar to the adoption's impact on operating leverage, we do not find any effect from other kinds of exceptions even when the interaction terms are introduced. This is consistent with the discussion of wrongful discharge laws above that the implied contract and the public policy exceptions are not believed to be significant binding constraints for firms.

It is noteworthy that, while coefficient estimates for the GF dummy and its interaction term with financial constraints are both negative and significant, the estimates for the GF dummy in columns (1) and (2) are much smaller and less significant. These seemingly mutually inconsistent estimation results can be explained if there is a nonlinear relationship between financial constraints and the impact of the GF adoption on R&D intensity. To check this, we perform the following quintile regressions using the quintiles sorted by the level of financial constraints.

$$\begin{aligned} \text{Investment}_{ijst,z} = & \sum_{z'=1}^{5} (\beta_{2,z'} + \beta_{3,z'}\text{GF}_{st})\mathbb{1}[z' = z] \\ & + \delta_{\text{X}}'\text{X}_{ijst} + \delta_{\text{F}}'\text{F}_i + \delta_{\text{D}}'\text{D}_{jt} + \sum_{s'} \delta_{s'}(t \times \mathbb{1}[s' = s]) + \varepsilon_{ijst} \end{aligned} \tag{2.8}$$

Columns (1) and (2) in Table 2.6 clearly show the nonlinear relationship between financial constraints and the impact of the GF adoption. The negative impact of the GF adoption is concentrated in the fourth and fifth quintiles, highly constrained groups, with estimated reduction in R&D intensity of around 2%p and between 3%p and 4%p, respectively. In contrast, the GF adoption does not change or may slightly increase R&D investment across

[17] Here we intentionally avoid stating that the coefficients imply the effect of wrongful discharge laws on a firm with average financial constraints, because we document a nonlinear relationship between financial constraints and the adoption's impact on R&D investment below.

the first three quintiles. Also, the point estimates are relatively flat for the less constrained groups.

Table 2.6: *Effect of Wrongful Discharge Laws on Corporate Investment: Financial Constraint Quintile Analysis*

We compare the average effect of financial constraint on corporate investments and the changes in its magnitude after the adoption of good-faith exceptions, across the quintiles constructed based on the level of financial constraint. The regression equation is

$$I_{ijst,z} = \sum_{z'} (\beta_{2,z'} + \beta_{3,z'} GF_{st}) \mathbb{1}[z' = z] + \delta'_X X_{ijst} + \delta'_F F_i + \delta'_D D_{jt} + \sum_{s'} \delta_{s'} (t \times \mathbb{1}[s' = s]) + \varepsilon_{ijst},$$

where z is the quintile indicator. For both R&D and capital investments, the first two columns use quintiles divided out of the full sample, and the next two columns use quintiles divided at the industry level. We employ the same set of control variables used in Table 2.5 regressions. All independent variables are winsorized at the 1% and 99% levels, and standardized to zero mean and 1 standard deviation. The regressions include firm fixed effects, industry times year fixed effects, and time trends in each state. The standard errors are clustered at state level and given in parentheses. $*$, $**$, *and* $***$ *denote significance at the 10%, 5%, and 1% levels, respectively.*

Dep.Variable	R&D Investment/Asset (%)				Capital Investment/Asset (%)			
Quintile based on	Full Sample		Each Industry		Full Sample		Each Industry	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
[FC Quintile=2]	−0.436	−0.700**	−0.477*	−0.738**	0.104	0.246	−0.037	0.103
	(0.266)	(0.331)	(0.268)	(0.351)	(0.362)	(0.364)	(0.337)	(0.338)
[FC Quintile=3]	−0.934**	−1.448**	−0.741**	−1.330**	−0.389	0.527	−0.585	0.245
	(0.393)	(0.586)	(0.312)	(0.515)	(0.498)	(0.524)	(0.464)	(0.509)
[FC Quintile=4]	−1.287**	−2.137**	−1.388**	−2.307***	−1.992***	−0.103	−2.187***	−0.416
	(0.581)	(0.857)	(0.552)	(0.824)	(0.730)	(0.763)	(0.638)	(0.702)
[FC Quintile=5]	−0.879	−2.497**	−1.345	−3.004**	−3.370***	−0.028	−3.426***	−0.278
	(0.746)	(1.123)	(0.806)	(1.222)	(0.576)	(0.492)	(0.525)	(0.482)
GF×[FC Quintile=1]	0.474	0.653	1.067**	1.639***	0.944*	1.041*	0.586	0.554
	(0.439)	(0.412)	(0.513)	(0.600)	(0.475)	(0.524)	(0.380)	(0.485)
GF×[FC Quintile=2]	0.278	0.593**	1.210***	1.805***	0.305	0.252	0.512	0.215
	(0.330)	(0.272)	(0.426)	(0.434)	(0.363)	(0.418)	(0.442)	(0.505)
GF×[FC Quintile=3]	0.209	0.242	−0.329	0.026	−0.090	−0.466	0.185	−0.186
	(0.221)	(0.233)	(0.281)	(0.268)	(0.415)	(0.319)	(0.535)	(0.407)
GF×[FC Quintile=4]	−2.149***	−2.127***	−2.136***	−2.063***	−0.146	−0.538	0.299	0.104
	(0.508)	(0.567)	(0.361)	(0.487)	(0.623)	(0.506)	(0.389)	(0.294)
GF×[FC Quintile=5]	−4.101***	−4.104***	−2.941***	−3.488***	−0.134	−0.409	−0.475	−0.166
	(0.621)	(0.650)	(0.377)	(0.400)	(0.569)	(0.534)	(0.708)	(0.590)
Controls	No	Yes	No	Yes	No	Yes	No	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry×Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State Trend	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Obs	28,174	28,174	28,174	28,174	28,174	28,174	28,174	28,174
R-Squared	0.020	0.038	0.020	0.039	0.083	0.119	0.083	0.118

There are two potential concerns about the regression model we employed to test the impact of wrongful discharge laws on R&D investment through an operating leverage channel. First, because we assign 1 to an adoption dummy when the state in which a firm's headquarter is located adopts the corresponding type of wrongful discharge law, the measure of the adoption status of wrongful discharge laws we use would be a "noisy" version of the true measure of the average adoption status across the states in which the firm operates. Therefore, there is a potential attenuation bias in our estimation, but the bias tends to underestimate rather than overestimate the effects that interest us.[18] Second, our finding that the magnitude of decline in R&D investment is larger as firms are more financially constrained may simply imply that financially constrained firms experience a larger increase in firing costs after the GF adoption. Because the adoption's impact on firing costs is mostly determined by industry characteristics, we can rule out this possibility by controlling for the variations in the average level of financial constraints across industries. For each industry, we construct quintiles sorted by the level of financial constraints, and aggregate each quintile over all industries. Then we run the same quintile regressions with the newly constructed quintiles that control for industry heterogeneity. Columns (3) and (4) in Table 2.6 confirm that the new estimates are quite similar to the estimates we obtained using the quintiles constructed over the full sample. Therefore, we conclude that there are large and significant differences in the magnitude of the adoption's impact across different levels of financial constraints.

We check whether our estimates for the interaction term between financial constraints and the GF dummy are robust to different choices of fixed effects and state trend controls. Appendix Table B.9 confirms that they are indeed stable across specifications with different choices of fixed effects and state trend controls. We include firm and industry-year fixed effects as well as state trends for our baseline specification, because it shows the highest explanatory power among the specifications that control for the most important sources of common variations not related to the adoption of wrongful discharge laws.

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[18] The estimation can be improved by using installation-level data from Longitudinal Business Database (LBD) or Annual Survey of Manufacturers (ASM) to correctly measure the degree to which WDL apply to firms that operate in multiple states.

R&D Investment Procyclicality

R&D investment of financially constrained firms is expected to be more procyclical when operating leverage increases after the adoption of wrongful discharge laws because they now have to rely on more volatile internal financial resources to fund their R&D projects. In the following, we present firm-level evidence that the procyclicality of R&D is amplified with the introduction of a higher degree of employment protection, and that the magnitude of the amplification is larger for firms that are more financially constrained. Therefore, our analysis complements past literature that documented procyclical R&D investment (Barlevy, 2007; Fabrizio and Tsolmon, 2014) and the predictability of the procyclicality of country-level investment composition between R&D and physical capital investment by the level of the country's financial development (Aghion *et al.*, 2010).

The cyclicality of R&D investment over the business cycle is represented by the sensitivity of R&D investment to the growth rate of gross state product (GSP). After the adoption of wrongful discharge laws, operating leverage and the volatility of internally generated cash flows increase. Thus, we expect corporate R&D investment, which is generally funded by internal financial resources, to covary more with the business cycle after the adoption. We test this prediction with the following regression:

$$\begin{aligned}\text{Investment}_{ijst} = \beta_1 \Delta y_{st} + \sum_{c} \beta_2^{l}(\Delta y_{st} \times \text{WDL}_{st}^{c}) + \beta_{\text{L}}' \text{L}_{ist} \\ + \delta' \text{X}_{ijst} + \text{D}_{ijt} + \sum_{s'} \delta_{s'}(t \times \mathbb{1}[s' = s]) + \varepsilon_{ijst}.\end{aligned} \tag{2.9}$$

where L_{ist} is the vector of explanatory variables we used in Section 2.5.2, including the adoption dummies.

Columns (1) and (2) in Table 2.7 provide evidence that the adoption of the good-faith exception raises corporate R&D procyclicality. After the GF adoption, one standard deviation, or 3% increase in GSP growth rate induces an additional increase in R&D intensity by 0.2 to 0.3%p. The results also suggest that procyclicality of firm-level R&D investment does not exist before the adoption. Considering that our sample consists of the U.S public firms, this result is consistent with the finding of Aghion *et al.* (2010) that R&D procyclicality vanishes as the financial market develops.

Table 2.7: *Effect of Wrongful Discharge Laws on the Cyclicality of Corporate Investment*

The following table shows results from the OLS regressions of firm R&D and capital investment intensity, defined as R&D and capital expenditure normalized by total assets at the end of last fiscal year, on various sets of explanatory variables including: GF, IC, and PP (indicator variables for the adoption status of wrongful discharge laws in the state where a firm's headquarter is located in), their interaction terms with ΔGSP (log difference in the real gross production in that state), and interaction terms between all previously mentioned variables and FC (measure of firm financial constraint). Control variables used in Table 2.5 are included in the regressions. All independent variables are winsorized at the 1% and 99% levels, and standardized to zero mean and 1 standard deviation. We include firm fixed effects, industry times year fixed effects, and time trends specific to each state. The standard errors are clustered at state level and given in parentheses. ∗, ∗∗, and ∗∗∗ denote significance at the 10%, 5%, and 1% levels, respectively.

Dep.Variable	R&D Investment/Asset (%)				Capital Investment/Asset (%)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Good Faith (GF)	−0.527***	−0.310	−1.037***	−0.845***	0.248	0.269	0.214	0.168
	(0.176)	(0.197)	(0.218)	(0.258)	(0.319)	(0.318)	(0.322)	(0.332)
Implied Contract (IC)	0.427*	0.285*	0.462*	0.328*	0.170	0.092	0.232	0.096
	(0.228)	(0.168)	(0.231)	(0.180)	(0.297)	(0.249)	(0.310)	(0.260)
Public Policy (PP)	0.196	0.147	0.193	0.156	−0.443*	−0.479*	−0.371	−0.513*
	(0.222)	(0.196)	(0.254)	(0.239)	(0.262)	(0.247)	(0.268)	(0.262)
ΔGSP	−0.012	−0.065	0.003	−0.051	0.214	0.082	0.246*	0.112
	(0.055)	(0.076)	(0.061)	(0.090)	(0.136)	(0.153)	(0.143)	(0.160)
ΔGSP×GF	0.320***	0.256***	0.288**	0.236**	0.136	0.105	0.121	0.078
	(0.110)	(0.082)	(0.109)	(0.093)	(0.122)	(0.114)	(0.135)	(0.123)
ΔGSP×IC	0.103*	0.114*	0.076	0.090	0.132	0.127	0.108	0.108
	(0.057)	(0.061)	(0.056)	(0.063)	(0.124)	(0.113)	(0.129)	(0.118)
ΔGSP×PP	0.003	0.011	−0.013	0.006	0.033	0.036	0.024	0.038
	(0.051)	(0.054)	(0.062)	(0.069)	(0.127)	(0.115)	(0.140)	(0.129)
FC Index (FC)			−0.750*	−2.054***			−2.352***	−0.557
			(0.394)	(0.672)			(0.427)	(0.477)
FC×GF			−1.703***	−1.698***			−0.150	−0.334
			(0.465)	(0.470)			(0.248)	(0.244)
FC×IC			0.150	0.217			0.106	0.024
			(0.226)	(0.205)			(0.235)	(0.209)
FC×PP			0.137	0.155			0.196	−0.061
			(0.208)	(0.231)			(0.220)	(0.192)
FC×ΔGSP			0.022	0.002			0.186***	0.133*
			(0.050)	(0.056)			(0.059)	(0.078)
FC×ΔGSP×GF			0.312***	0.279***			−0.028	−0.009
			(0.101)	(0.096)			(0.128)	(0.111)
FC×ΔGSP×IC			−0.106	−0.093			−0.045	−0.042
			(0.073)	(0.071)			(0.084)	(0.073)
FC×ΔGSP×PP			0.019	0.061			−0.011	0.024
			(0.100)	(0.104)			(0.119)	(0.118)
Tobin's Q		1.620***		1.567***		2.114***		2.097***
		(0.201)		(0.192)		(0.174)		(0.172)
Controls	No	Yes	No	Yes	No	Yes	No	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table 2.7: *(Continued)*

Dep.Variable	R&D Investment/Asset (%)				Capital Investment/Asset (%)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Industry×Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State Trend	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Obs	28,174	28,174	28,174	28,174	28,174	28,174	28,174	28,174
R-Square	0.016	0.032	0.019	0.039	0.078	0.118	0.086	0.119

Furthermore, R&D procyclicality is likely to rise more among the financially constrained firms, as they are generally unable to smooth volatile operating cash flows. In the following regression, we also include interaction terms between the explanatory variables of interest and the measure of firm financial constraints.

$$\text{Investment}_{ijst} = \beta_1 \Delta y_{st} + \sum_c \beta_2^c \Delta y_{st} \times \text{WDL}_{st}^c + \beta_3 \text{FC}_{ist} \times \Delta y_{st} + \sum_c \beta_4^c \text{FC}_{ist} \times \Delta y_{st} \times \text{WDL}_{st}^c + \beta_L' \text{L}_{ist} + \delta_F' \text{F}_i + \delta_D' \text{D}_{jt} + \sum_{s'} \delta_{s'} (t \times \mathbb{1}[s' = s]) + \varepsilon_{ijst} \tag{2.10}$$

Columns (3) and (4) in Table 2.7 show clear evidence that the increase in the procyclicality of R&D intensity is greater for the firms that are more financially constrained, verifying our prediction. We report that the R&D investment sensitivity to GSP growth rate after the GF adoption increases further by 0.25%p to 0.3%p when the degree of financial constraints increases by one standard deviation. Interestingly, while we are unable to find any relationship between procyclicality of R&D and firm financial constraints before the GF adoption, the procyclicality amplification after the adoption depends on the level of financial constraints. Unlike employment protection's effect on average R&D intensity, no nonlinear relationship is found between firm financial constraints and the extent of procyclicality amplification after the adoption of wrongful discharge laws. Appendix Table B.10 confirms that our estimations are robust to different choices of fixed effects and state trend controls.

Comparison to Capital Investment

The above analyses show that corporate R&D investment is highly responsive to the changes in operating leverage when firms are financially constrained and subject to high cost of external financing. The unique characteristics of R&D investment that generate these results can be highlighted by comparing it with (physical) capital investment, a more traditional focus of corporate investment analysis.

To examine how the effects of adoption of the good-faith exception differ in magnitude for capital investment versus R&D investment, we replicate the same regressions we performed in past three sections using capital expenditure as dependent variable. The results, which are reported in columns (5) to (8) of each table, are consistent with our predictions. Table 2.5 shows that the adoption does not change average capital investment intensity, and the magnitude of the impact does not vary depending on the level of financial constraints. The quintile regressions in Table 2.6 also confirm that financial constraints play an insignificant role in determining the impact of the adoption on capital investment. Table 2.7 deserves special attention. We first document that the adoption of the good-faith exception, and higher operating leverage induced by the adoption, do not raise average capital investment procyclicality, but do significantly raise average R&D procyclicality. The result confirms our prediction that R&D investment is more sensitive to the availability of internal financial resources. We also report that financially constrained firms undertake capital investment in a more procyclical manner, but the adoption does not amplify the procyclicality further. Because a substantial part of capital investment can be financed through debt issuance, an increase in the volatility of internal financial resources makes little impact on the procyclicality of capital investment regardless of the level of financial constraints that firms face. R&D investment, on the other hand, generally cannot be supported by debt financing. Therefore, financial constraints amplify the impact of the operating leverage shock on the procyclicality of R&D investment by rendering cash flow smoothing more difficult. The higher procyclicality of capital investment among financially constrained firms is not explained by our framework. We conjecture that the business cycle is correlated with the general availability of credit, and more financially constrained firms tend to be at a disadvantage in debt financing, especially in an economic downturn. Because our analysis mostly focuses on R&D investment, we leave the test of this conjecture for future research.

Finally, because both operating leverage and financial leverage raise the volatility of operating cash flow, one might wonder why the exogenous increase in operating leverage does not result in any reduction in capital investment unlike what past literature has documented for financial leverage (McConnell and Servaes, 1995; Lang *et al.*, 1996; Aivazian *et al.*, 2005). There are two mechanisms discussed in the literature that generate a negative relationship between financial leverage and corporate investment. First, because financial leverage reduces average operating cash flow by requiring firms to pay more interest from operating income, it constrains firm managers, who generally have incentives to scale up the firm regardless of the quality of investment projects. Hence, financial leverage raises the value of firms with low growth opportunities by thwarting unnecessary investments. Second, firms with high financial leverage may suffer from debt overhang unless their investment opportunities are sufficiently valuable. Unlike financial leverage, however, operating leverage does not lower the average operating cash flow by itself, and there is no redistribution of cash flow between debtors and shareholders when operating leverage increases. Therefore, the previously documented channels through which financial leverage reduces corporate investment are not applicable to operating leverage. It is still possible that stronger employment protection may suppress operating profitability and average operating cash flow, generating an effect similar to financial leverage to some degree. However, considering that the literature has reported evidence of substantial capital deepening motivation after the adoption of new employment protection measures in countries with lower levels of employment protection (Autor *et al.*, 2007; Janiak and Wasmer, 2014; Cingano *et al.*, 2016), it is not surprising that we do not find significant changes in capital investment after the adoption of the good-faith exception.

2.5.3 Highly Innovative Industries

R&D processes in highly innovative industries are characterized by a high degree of technical uncertainty and long time lags between project inception and completion. The information and agency problems associated with the external financing of R&D investment can be more substantial in these industries as well. Therefore, if financial friction plays an important role in determining the impact of the operating leverage shock on corporate investment, we may expect larger investment responses among firms in highly innovative industries compared to those in less innovative industries.

Similar to other popular proxies for firms' financing constraints (e.g. Kaplan-Zingales index (Kaplan and Zingales, 1997), firm age, firm size), our primary measure of firm financial constraints, the Whited-Wu index (Whited and Wu, 2006), is constructed based on accounting variables. It is therefore not likely to capture the heterogeneity of financial frictions that firms face due to different degrees of information and agency problems. Thus, the WW index tends to underestimate the financial constraints of the firms in highly innovative industries, implying that a larger investment response to the operating leverage shock will be captured by larger estimated coefficients in our regressions.

To examine how industries with different degrees of innovativeness respond differently to the adoption of the good-faith exception, we group industries into two based on the patent grant records as proxies for the innovativeness of each industry. The highly innovative industry group consists of the top four industries (chemical and allied products, electronic and other electric equipment, business services, and industrial machinery and equipment) with the largest number of high technology patents granted to its firms over the sample period. Following Hall *et al.* (2005) and Tian and Wang (2014), the following five patent categories are considered as high technology: pharmaceuticals and medical instruments, chemicals, computers and communications, electrical, and metals and machinery. We then compare how the adoption raises the operating leverage of each group, and how R&D investment in each group changes after the adoption. The results are presented in Tables 2.8 and 2.9.

Table 2.8: *Effect of Wrongful Discharge Laws on Firm Operating Leverage in Highly Innovative Industries*

The following table estimates the changes in operating leverage after the adoption of wrongful discharge laws as in Table 2.3 over the two separate samples divided by industry innovativeness. Highly innovative industry group consists of top four industries (chemical and allied products, electronic and other electric equipment, business services, industrial machinery and equipment) with the largest number of high technology patents granted to the firms within the industry over the sample period. Following Hall et al. (2005) and Tian and Wang (2014), the following patent categories are considered as high technology: pharmaceuticals and medical instruments, chemicals, computers and communications, electrical, and metals and machinery. Control variables used in Table 2.3 are included in the regressions. All independent variables are winsorized at the 1% and 99% levels, and all except sales growth are standardized to zero mean and 1 standard deviation. We include firm fixed effects, industry times year fixed effects, and time trends specific to each state. The standard errors are clustered at state level and given in parentheses. $*$, $**$, *and* $***$ *denote significance at the 10%, 5%, and 1% levels, respectively.*

Dep.Var: Earnings Growth	Highly Innovative		Others	
	(1)	(2)	(3)	(4)
Sales Growth	1.660***	1.661***	1.482***	1.470***
	(0.045)	(0.043)	(0.032)	(0.031)
Sales Growth×GF	0.203*	0.235**	0.238***	0.253***
	(0.113)	(0.114)	(0.067)	(0.067)
IC, PP Terms	Yes	Yes	Yes	Yes
Controls	No	Yes	No	Yes
Firm FE	Yes	Yes	Yes	Yes
Industry×Year FE	Yes	Yes	Yes	Yes
State Trend	Yes	Yes	Yes	Yes
Obs	14,476	14,476	34,383	34,383
R-Squared	0.320	0.343	0.327	0.345

Table 2.9: *Effect of Wrongful Discharge Laws on R&D Investment in Highly Innovative Industries*

The following table estimates the changes in R&D investment after the adoption of wrongful discharge laws as in Table 2.5 over the two separate samples divided by industry innovativeness. Highly innovative industry group consists of top four industries (chemical and allied products, electronic and other electric equipment, business services, industrial machinery and equipment) with the largest number of high technology patents granted to the firms within the industry over the sample period. Following Hall et al. (2005) and Tian and Wang (2014), the following patent categories are considered as high technology: pharmaceuticals and medical instruments, chemicals, computers and communications, electrical, and metals and machinery. Control variables used in Table 2.5 are included in the regressions. All independent variables are winsorized at the 1% and 99% levels, and standardized to zero mean and 1 standard deviation. We include firm fixed effects, industry times year fixed effects, and time trends specific to each state. The standard errors are clustered at state level and given in parentheses. $*$, $**$, *and* $***$ *denote significance at the 10%, 5%, and 1% levels, respectively.*

Dep.Var: R&D/Asset (%)	Highly Innovative				Others			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Good Faith (GF)	−0.316	−0.640	−0.311	−0.678	−0.045	−0.237	−0.065	−0.246
	(0.341)	(0.466)	(0.332)	(0.426)	(0.313)	(0.397)	(0.287)	(0.372)

Table 2.9: *(Continued)*

Dep.Var: R&D/Asset (%)	Highly Innovative				Others			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
ΔGSP			−0.093	−0.064			0.035	0.032
			(0.145)	(0.164)			(0.072)	(0.078)
ΔGSP×GF			0.442***	0.357**			−0.095	−0.097
			(0.127)	(0.138)			(0.115)	(0.119)
FC Index (FC)		−2.528***		−2.590***		−1.179		−1.201
		(0.656)		(0.684)		(0.855)		(0.841)
FC×GF		−2.539***		−2.574***		−0.423		−0.449
		(0.635)		(0.651)		(0.477)		(0.479)
FC×ΔGSP				0.008				−0.001
				(0.083)				(0.058)
FC×ΔGSP×GF				0.587***				−0.097
				(0.173)				(0.100)
Tobin's Q	2.033***	1.963***	2.033***	1.963***	0.845***	0.808***	0.846***	0.811***
	(0.261)	(0.258)	(0.262)	(0.262)	(0.151)	(0.146)	(0.151)	(0.146)
IC, PP Terms	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry×Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State Trend	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Obs	15,645	15,645	15,645	15,645	12,529	12,529	15,645	15,645
R-Squared	0.046	0.057	0.047	0.059	0.020	0.021	0.020	0.022

Table 2.8 shows that both groups experience a similar degree of increase in operating leverage once the good-faith exception is adopted, implying that the changes in the volatility of operating cash flow are not different between the groups. On the other hand, we find that the good-faith exception's impact on R&D investment is mostly concentrated among the firms in highly innovative industries. Table 2.9 shows only a modest relationship between financial constraints and the negative impact of the GF adoption in the less innovative industry group. In particular, the effect of the good faith exception on R&D procyclicality is nonexistent outside of the highly innovative industries. Overall, the results of our analysis support the hypothesis that the impact of the good-faith exception is stronger when firms face larger frictions in the external financial market.

2.5.4 Layoff Elasticity and the Impact of the Good-Faith Exception

We have documented that a state's adoption of the good faith exception raises operating leverage of the firms headquartered in that state, and that the adoption reduces R&D

investment and raises its procyclicality among financially constrained firms. Despite the strong evidence that the adoption of the good-faith exception works as an exogenous shock to operating leverage, one may still note the existence of other channels through which the adoption could reduce the R&D investment of financially constrained firms. Furthermore, it is possible that R&D responses were not driven by the good-faith adoption, but by other latent state-level factors. The dynamic regression of annual R&D investment around the adoption year may be one solution, but it does not provide clear evidence due to the high persistence of firm-level R&D investment. We need another strategy to clearly show that the adoption affects R&D investment through its impact on operating leverage.

In order to identify the operating leverage channel, we first sort firms by how much they are expected to experience additional rigidity in labor management after the adoption of the good-faith exception. We then examine whether firms that are expected to have greater exposure to the shock indeed experience larger increase in operating leverage and larger reduction in R&D investment. Furthermore, using this approach alleviates the concern that the observed changes in R&D investment are driven by a tendency in favor of stronger employment protection, not by the GF adoption itself.

We estimate each industry's layoff elasticity to the industry business cycle and use it as the measure of the degree of exposure to the shock in firing costs. Our assumption is that firms that adjust the size of layoffs more actively through the business cycles are more likely to face a larger increase in the frequency of wrongful termination litigation by ordinary workers after the adoption. To construct the measure, we compute each industry's annual layoff rates from CPS Displaced Workers Supplements and regress them on the annual growth rates of real industry output that are standardized at the industry level. Because employment cyclicality is largely determined by industry characteristics, we use industry-level elasticity estimates as proxies for each firm's degree of exposure to the adoption.

In Panels A and B of Table 2.10, we present the list of the industries with highest layoff elasticity estimates and with lowest estimates, respectively. For example, layoff rates of the mining industry turn out to be the most elastic to the industry business cycle, followed by oil and gas extraction, furnitures, industrial machinery and equipment, and primary and metal industries. The lowest elasticity estimates are not statistically different from zero. Table 2.11 shows that layoff elasticity is a qualitatively different measure from average layoff rate, labor share, and industry average R&D and capital investment. In particular, layoff elasticity is not correlated with R&D intensity. In the last columns of Panels A and B of Table 2.10, we also report the measure of each industry's innovativeness computed as the number of granted patents over the sample period, and confirm that an industry's innovativeness is generally not correlated with its layoff elasticity.

Table 2.10: *Industry Layoff Elasticity, Labor Share, and Investment*

The following table reports the estimates of the industry layoff elasticity to the growth rate of the real industry output. We also report each industry's time-series mean and standard deviation of annual labor share and average R&D intensity and capital investment intensity. The annual layoff rates are computed using the biannual CPS Displaced Worker Supplements within our sample period.[19] *The layoff elasticity of an industry is computed from the regression of the layoff rates on the growth rate of real industry output of that industry obtained from the U.S. Bureau of Economic Analysis. Because the data on real industry output growth rates consistent with our industry classification are available only up to 1997, each regression uses industry-level observations from 1982 to 1997. We require that, to be reported as a valid elasticity estimate, at least 6 observations exist out of the maximum number of observations 16. We present the negative value of the slope estimates and standard errors from the regressions. The annual labor share of each industry is defined as total labor compensation divided by total value added of the industry. The data are drawn from the U.S. Bureau of Economic Analysis. Because the labor share data is available with SIC codes up to 1997, we use the data from 1971 to 1997. The annual average R&D intensity in each industry is obtained by calculating the annual industry mean of the R&D intensity we computed from the COMPUSTAT firm-level data between 1971 and 1999. To make sure that we have enough observations to get a reliable industry mean, we require the number of firms in each industry to be at least 10 for a given year. The annual average capital investment intensity of each industry is computed in the same manner. In the last column, we present the industry rank assigned based on the number of high technology patents granted over the sample period to the industry (shown in the bracket). Following Hall et al. (2005) and Tian and Wang (2014), the following patent categories are considered as high technology: pharmaceuticals and medical instruments, chemicals, computers and communications, electrical, and metals and machinery. To examine whether firm performance and capital structure differentially respond to the adoption of wrongful discharge laws in the cross-section of industry layoff elasticity, we drop all observations without data on the industry layoff elasticity, and the annual industry mean R&D intensity and capital investment intensity. This process reduces the number of our observations from 48,859 to 38,273. Panels A and B present five industries with highest and lowest labor elasticity estimates, respectively. Elasticity reports estimated industry layoff elasticity, and Rate, Share, R&D, and CapEx report industry time-series mean and standard deviation of annual layoff rate, labor share, average R&D intensity, and average capital expenditure intensity. All measures are reported in percentage units. The complete list can be found in Appendix Table B.5.*

A. Industries with Highest Layoff Elasticity

Industry Description	Elasticity (%)	Rate (%)	Share (%)	R&D (%)	CapEx (%)	Innovations
Metal mining	6.55	8.42	57.41	0.13	15.76	43 [11]

Table 2.10: *(Continued)*

Industry Description	Elasticity (%)	Rate (%)	Share (%)	R&D (%)	CapEx (%)	Innovations
	(2.60)	(10.62)	(14.28)	(0.16)	(6.59)	
Oil & gas extraction	2.67	5.72	21.95	0.34	19.67	12 [5,134]
	(0.82)	(2.84)	(3.68)	(0.16)	(5.98)	
Furniture & fixtures	1.30	5.12	80.80	0.87	6.82	21 [607]
	(0.73)	(2.65)	(3.90)	(0.16)	(1.72)	
Machinery, equipments	1.14	4.61	75.27	5.11	7.13	3 [65,068]
	(0.32)	(1.88)	(2.86)	(1.49)	(1.32)	
Primary metal industries	1.07	3.98	75.67	0.73	8.02	16 [3,059]
	(0.57)	(2.70)	(6.47)	(0.35)	(1.21)	

B. Industries with Lowest Layoff Elasticity

Industry Description	Elasticity (%)	Rate (%)	Share (%)	R&D (%)	CapEx (%)	Innovations
Motion pictures	−0.12	4.02	61.19	0.04	13.19	40 [18]
	(0.58)	(1.78)	(6.94)	(0.07)	(5.28)	
Elec., electric equipment	−0.16	4.61	70.31	5.46	8.46	2 [91,007]
	(0.45)	(1.53)	(12.28)	(1.34)	(1.46)	
Petroleum & coal products	−0.18	2.98	47.49	0.68	10.80	9 [18,442]
	(1.38)	(2.86)	(12.02)	(0.30)	(2.55)	
Food & kindred products	−0.23	3.67	58.05	0.35	8.63	17 [1,895]
	(0.49)	(1.20)	(4.69)	(0.09)	(0.97)	
Leather & leather products	−0.42	7.93	71.22	0.43	3.98	38 [26]
	(1.06)	(4.11)	(9.21)	(0.32)	(0.90)	

Table 2.11: *Pairwise Correlations among Industry Labor and Investment Intensity Measures*

The following table shows the pairwise correlation among the five industry-level measures presented in Table 2.10: industry layoff elasticity, and time-series industry-level averages of layoff rate, labor share, R&D intensity, and capital investment intensity.

	Elasticity (%)	Rate (%)	Share (%)	R&D (%)	CapEx (%)
Elasticity (%)	1.00				
Rate (%)	0.50	1.00			
Share (%)	−0.01	0.54	1.00		
R&D (%)	−0.12	0.14	0.39	1.00	
CapEx (%)	0.24	0.42	0.64	0.07	1.00

Based on our estimates, we create two subsamples that consist of the firms with industry layoff elasticity above the median and those for which industry layoff elasticities are below the median. We then check whether the adoption generates a larger impact on operating leverage and R&D investment in the group of industries with high layoff elasticity.

Ideally, the proposed measure must represent the cross-sectional differences in the adoption's impact on the labor adjustment decisions for ordinary workers. At the same time, it has to be uncorrelated, or at least not positively correlated, with the strength of other potential channels through which the adoption reduces the R&D investment for the financially constrained firms. To validate this requirement, we discuss whether there are other potential channels which can generate a larger degree of changes in R&D investment in an industry with a higher layoff elasticity.

To begin with, it has been reported that employment rigidity induces firms to raise productivity through capital accumulation (Autor *et al.*, 2007; Cingano *et al.*, 2016; Janiak and Wasmer, 2014). Because R&D investment also produces intangible assets that can improve labor productivity, firms may have more incentives to invest in R&D projects. This motivation has to be stronger for firms in an industry with higher layoff elasticity, which is inconsistent with our prediction that the adoption's negative impact is larger in the group of high layoff elasticity industries.

Second, Acharya *et al.* (2014) document that employment protection incentivizes R&D workers to pursue riskier but profitable projects, improving the productivity of R&D investment. However, it is unlikely that the motivating impact of wrongful discharge laws depends on the layoff elasticity of an R&D worker's industry. The layoff elasticity approximates the degree of the firms' exposure to the firing cost shock introduced by the adoption of wrongful discharge laws, but it does not represent how much each worker will be additionally protected after the adoption.

Third, because higher firing costs raise the R&D worker adjustment costs, firms that may need to frequently adjust the size of their R&D workforce over the business cycle would suppress R&D investment in order to avoid incurring the expected high costs of firing R&D workers. In order for this channel to generate larger R&D responses for the industries with high layoff elasticity, R&D worker procyclicality has to be larger in the high elasticity group as well. Due to the data availability, however, we do not know the exact flows of R&D workers over the business cycle. Considering that more than half of R&D expenses consists of wages for highly skilled R&D workers (Hall and Lerner, 2010), however, we can infer the procyclicality of R&D worker employment from the procyclicality of R&D investment for each industry. Table 2.12 shows that there is no significant difference in the R&D procyclicality between the groups divided by industry layoff elasticity estimates. The point estimates indicate that R&D procyclicality may be larger, rather than smaller, in the group of low elasticity industries. Therefore, the third channel cannot produce the hypothesized differences in R&D responses between the two groups.

Table 2.12: *Industry Layoff Elasticity and Procyclicality of Corporate R&D and Capital Investment*

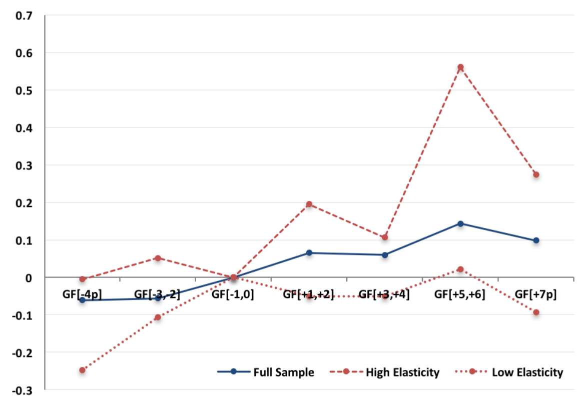
The following table shows results from the regressions of firm investment on the log difference in the state real gross production, ΔGSP, and the log difference in the industry real gross value added, ΔGIP. The dependent variable, R&D and capital investment intensity, is defined as R&D and capital expenditure normalized by total assets at the end of last fiscal year. We employ the same set of control variables used in Table 2.5 regressions. ΔGIP is winsorized at the 1% and 99% levels and standardized to zero mean and 1 standard deviation for each industry. All other independent variables are winsorized at the 1% and 99% levels, and standardized to zero mean and 1 standard deviation over full sample. We also run the same regressions allowing different coefficients for the observations in an industry whose layoff elasticity estimate is above the median and for those whose industry layoff elasticity estimate is below the median. We use the indicator variables "High" and "Low" to denote each type of industry, respectively. The regressions include firm fixed effects, industry times year fixed effects, and time trends in each state. The standard errors are clustered at state level and given in parentheses. $*$, $**$, and $***$ denote significance at the 10%, 5%, and 1% levels, respectively.

Dep.Variable	R&D Investment/Asset (%)				Capital Investment/Asset (%)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
[Full Sample]								
ΔGSP	0.099	0.039			0.336***	0.185*		
	(0.065)	(0.058)			(0.071)	(0.097)		
ΔGIP	0.350	0.332			2.868***	2.829***		
	(0.249)	(0.242)			(0.514)	(0.479)		
[Elasticity = High]								
ΔGSP			0.125	0.060			0.366***	0.193*
			(0.108)	(0.058)			(0.076)	(0.105)
ΔGIP			−0.059	−0.367			1.874***	0.387
			(0.062)	(0.275)			(0.570)	(0.524)
[Elasticity = Low]								
ΔGSP			0.052	0.003			0.280*	0.169
			(0.082)	(0.128)			(0.145)	(0.153)
ΔGIP			0.517	0.545			3.258***	3.429***
			(0.346)	(0.332)			(0.673)	(0.667)
Controls	No	Yes	No	Yes	No	Yes	No	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry×Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State Trend	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Obs	28,174	28,174	28,174	28,174	28,174	28,174	28,174	28,174
R-Squared	0.015	0.032	0.015	0.032	0.078	0.118	0.078	0.118

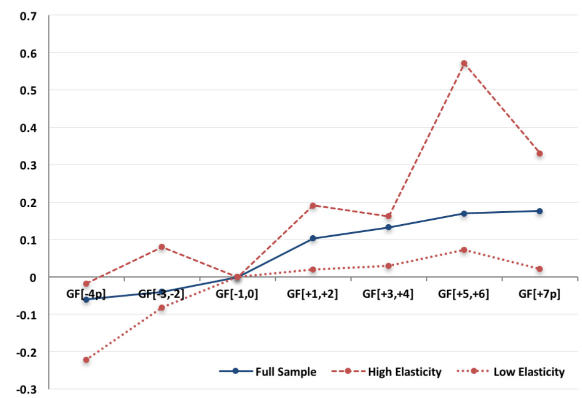
Finally, employment protection may lead to a general decline in operating profitability that may suppress investment in R&D projects which are not sufficiently profitable. On the contrary, the results of dynamic regressions of firm earnings presented in Panel B of Figure 2.5 show that there is no meaningful divergence of operating profitability between the two groups over time. In sum, except for the differential impact of the adoption on the employment rigidity of ordinary workers, we conclude that any alternative channels cannot generate the hypothesized differences in R&D responses between the two groups.

We are now ready to examine whether the group of industries with high layoff elasticity experiences a larger increase in operating leverage. Panel A of Figure 2.5 shows the point estimates of the average movement of firm operating leverage around the adoption year relative to the operating leverage in the adoption year for each group. We see the clear divergence of operating leverage between the two groups; there is substantial increase in the operating leverage for the firms in the high layoff elasticity group, whereas the operating leverage of the firms in the low layoff elasticity group remains relatively stable. Table 2.13 also confirms that the magnitude of the increase in operating leverage differs between the two groups. The groups share a similar degree of operating leverage before the adoption, between 1.5 and 1.6. However, while the GF adoption's impact on the operating leverage of the firms in the high elasticity group is large, with point estimates of about 0.35 and statistically significant at 1% level, its impact in the low elasticity group is much smaller and statistically insignificant. In columns (3) and (4) we also confirm that financial constraints do not play an important role in determining the adoption's impact on operating leverage in both groups. This result is consistent with our interpretation of the results in earlier sections, which indicate that the negative relationship between financial constraints and the impact of the GF adoption on R&D investment is largely driven by the cost of external financing, rather than by the possibility that financially constrained firms experience a larger increase in operating leverage after the adoption.

A. Firm Operating Leverage

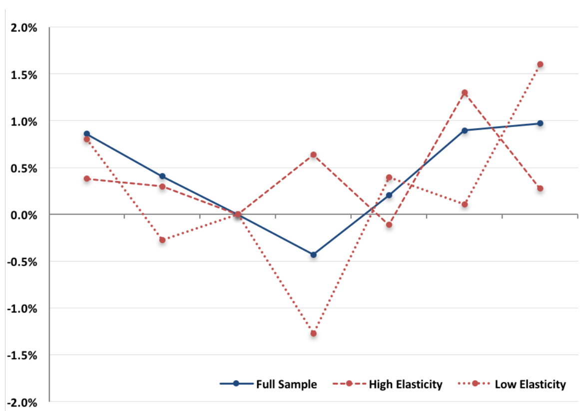


(a) Without Control Variables

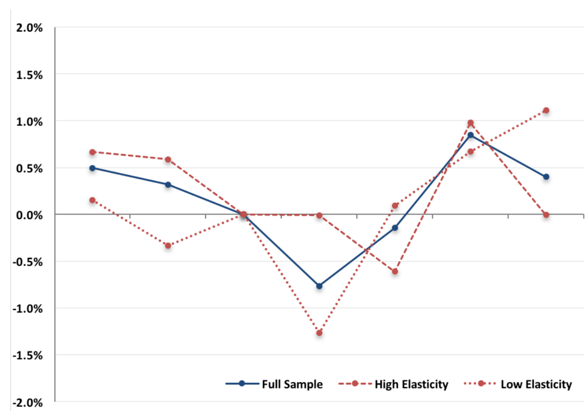


(b) With Control Variables

B. Firm Earnings



(a) Without Control Variables



(b) With Control Variables

The above plots show the point estimates of the average impact of the adoption of the good-faith exception in the state where each firm's headquarter is located in. Panel A presents the adoption's impact on firm operating leverage (elasticity of firm earnings with respect to sales) around the year when the exception is first recognized by a court in the state, and Panel B show its impact on firm earnings.[20] *We use operating income before depreciation as the measure of firm earnings. The right side figures are based on the regressions with control variables that represents the firm's investment opportunities (Tobin's Q, size, capital expenditure, R&D investment) and the influence of capital structure (leverage, net working capital, cash holding), while the left side figures are estimated without including these controls. Appendix Table B.4 has detailed description of these variables.*

Figure 2.5: *Effect of Wrongful Discharge Laws on Firm Operating Leverage and Earnings: Dynamic Changes*

Table 2.13: *Layoff Elasticity and the Effect of Wrongful Discharge Laws on Firm Operating Leverage*

Columns (1) and (2) report the results from the same OLS regressions reported in Table 2.3, allowing different coefficients for the observations in an industry whose layoff elasticity estimate is above the median and for those whose industry layoff elasticity estimate is below the median. We use the indicator variables "High" and "Low" to denote each type of industry, respectively. The next two columns include the financial constraint index and its interaction terms with explanatory variables used in the regressions for the first two columns. The same set of control variables are employed as in the regressions in Table 2.3. All independent variables are winsorized at the 1% and 99% levels, and standardized to zero mean and 1 standard deviation. We include firm fixed effects, industry times year fixed effects, and state-specific time trends. The standard errors are clustered at state level and given in parentheses. ∗, ∗∗, and ∗∗∗ denote significance at the 10%, 5%, and 1% levels, respectively.

Dep.Var: Earnings Growth	(1)	(2)	(3)	(4)
[Elasticity = High]				
Sales Growth	1.569***	1.561***	1.595***	1.587***
	(0.040)	(0.039)	(0.068)	(0.067)
Sales Growth×GF	0.332***	0.332***	0.338**	0.362**
	(0.093)	(0.095)	(0.141)	(0.140)
Sales Growth×IC	−0.012	−0.009	−0.022	−0.016
	(0.056)	(0.058)	(0.096)	(0.094)
Sales Growth×PP	−0.050	−0.029	0.055	0.031
	(0.055)	(0.056)	(0.076)	(0.071)
FC Index (FC)			0.120***	−0.089**
			(0.028)	(0.042)
FC×Sales Growth			0.311***	0.275***
			(0.055)	(0.058)
FC×Sales Growth×GF			0.172	0.183
			(0.180)	(0.168)
FC×Sales Growth×IC			−0.107	−0.057
			(0.120)	(0.111)
FC×Sales Growth×PP			−0.037	−0.052
			(0.095)	(0.095)
[Elasticity = Low]				
Sales Growth	1.555***	1.546***	1.638***	1.621***
	(0.037)	(0.032)	(0.109)	(0.110)
Sales Growth×GF	0.199	0.237*	0.159	0.202
	(0.130)	(0.127)	(0.164)	(0.154)
Sales Growth×IC	−0.003	0.023	0.187*	0.170
	(0.059)	(0.063)	(0.111)	(0.118)
Sales Growth×PP	0.009	0.019	−0.089	−0.055
	(0.071)	(0.076)	(0.123)	(0.131)
FC Index (FC)			0.088***	−0.106**
			(0.031)	(0.044)
FC×Sales Growth			0.312***	0.243***
			(0.073)	(0.073)
FC×Sales Growth×GF			−0.019	−0.034
			(0.188)	(0.177)
FC×Sales Growth×IC			0.079	0.122
			(0.118)	(0.117)

Table 2.13: *(Continued)*

Dep.Var: Earnings Growth	(1)	(2)	(3)	(4)
FC×Sales Growth×PP			0.002	−0.001
			(0.133)	(0.127)
Controls	No	Yes	No	Yes
Firm FE	Yes	Yes	Yes	Yes
Industry×Year FE	Yes	Yes	Yes	Yes
State Trend	Yes	Yes	Yes	Yes
Obs	38,273	38,273	14,779	14,779
R-Squared	0.327	0.347	0.350	0.371

In Table 2.14, we also replicate the baseline regressions and estimate the impact of the good-faith exception on R&D and capital investment for firms with different levels of financial constraints. As expected, financial constraints substantially exacerbate the negative impact of the GF adoption on R&D investment for the firms in the high elasticity group, but the effect is muted in the low elasticity group. For the purposes of robustness in our testing, we report the results from the restricted regressions, in which we assume the same coefficients on all covariates for both groups except for the variables of interest, and from the unrestricted regressions, allowing different coefficients for all variables including the fixed effects and time trends. The quintile regression results presented in Figure 2.6 also show that the nonlinear relationship between financial constraints and the impact of the GF adoption is stronger in the high elasticity group, whether the quintiles are constructed from the full sample or constructed for each industry and then aggregated to control for industry-level heterogeneity of financial constraints.

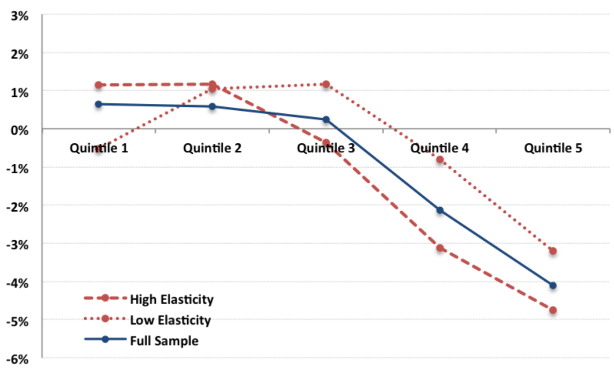
Table 2.14: *Layoff Elasticity and the Effect of Wrongful Discharge Laws on Corporate Investment*

The following table reports the results of the OLS regressions of firm R&D and capital investments on the adoption status of the good-faith exception within the state where the firm's headquarter is located in (GF) and its interaction term with the financial constraint index (FC), while allowing different coefficients for the firms in an industry whose layoff elasticity estimate is above the median and for those whose industry layoff elasticity estimate is below the median. We use the indicator variables "High" and "Low" to denote each industry type, respectively. The dependent variables, R&D intensity and capital investment intensity, are defined as R&D and capital expenditure normalized by total assets at the end of last fiscal year. FC indicates the measure of firm financial constraint constructed by Whited and Wu (2006). The same set of control variables we employed for the regressions reported in Table 2.5 are also included in the following regressions. All independent variables are winsorized at the 1% and 99% levels, and standardized to zero mean and 1 standard deviation. We include firm fixed effects, industry times year fixed effects, and time trends specific to each state. Restricted regressions allow different coefficients for each layoff elasticity subsample only for explanatory variables, while unrestricted regressions allow different coefficients for controls and all fixed effects and time trends as well as for explanatory variables. The standard errors are clustered at state level and given in parentheses. ∗, ∗∗, and ∗∗∗ denote significance at the 10%, 5%, and 1% levels, respectively.

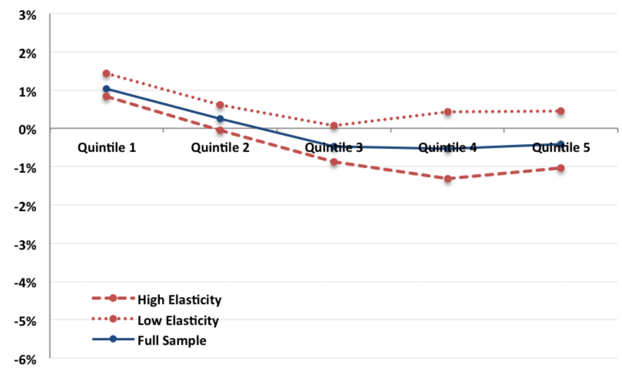
Dep.Variable	R&D Investment/Asset (%)				Capital Investment/Asset (%)			
	Restricted		Unrestricted		Restricted		Unrestricted	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
[Elasticity = High]								
Good Faith (GF)	−0.338	−1.205***	−0.245	−1.046***	−0.178	−0.332	−0.523	−0.654*
	(0.206)	(0.290)	(0.283)	(0.367)	(0.361)	(0.311)	(0.332)	(0.333)
FC Index (FC)		−1.768**		−2.006**		−0.440		−0.376
		(0.729)		(0.878)		(0.399)		(0.362)
FC×GF		−1.985***		−2.064***		−0.393		−0.339
		(0.507)		(0.528)		(0.389)		(0.372)
[Elasticity = Low]								
Good Faith (GF)	−0.288	−0.283	−0.464	−0.603	0.633**	0.587**	1.049***	0.992**
	(0.254)	(0.294)	(0.352)	(0.411)	(0.261)	(0.279)	(0.349)	(0.382)
FC Index (FC)		−1.716**		−1.031		−0.920		−1.255
		(0.852)		(0.642)		(0.614)		(0.976)
FC×GF		−0.890		−0.830		−0.284		−0.235
		(0.549)		(0.551)		(0.462)		(0.478)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry×Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State Trend	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Obs	28,174	28,174	28,174	28,174	28,174	28,174	28,174	28,174
R-sq	0.032	0.039	0.034	0.041	0.118	0.119	0.120	0.121

In this section, we compared the magnitude of the GF adoption's impact on operating leverage and R&D investment between the groups of industries sorted by their degree of exposure to the shock. We showed that there is a causal link between the GF adoption and the observed changes in corporate R&D investment, and that this is through the operating leverage channel. We also examined potential other channels and argue that they cannot

A. Quintiles Constructed on Full Sample

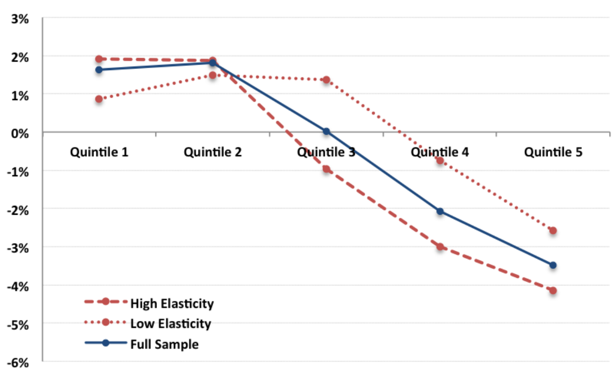


(a) R&D Investment

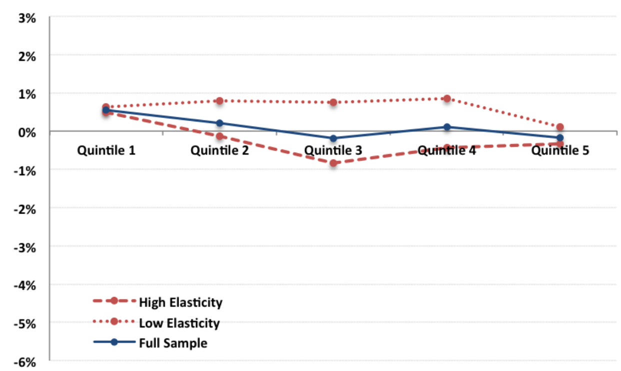


(b) Capital Investment

B. Quintiles Constructed on Each Industry



(a) R&D Investment



(b) Capital Investment

The following figures present the point estimates of the average effect of financial constraint on corporate R&D and capital investments and the changes in its magnitude after the adoption of good-faith exceptions, across the quintiles constructed based on the level of financial constraint. Plots in Panel A are constructed based on the quintiles divided out of the full sample, and plots in Panel B use quintiles divided at the industry level.

Figure 2.6: *Layoff Elasticity and the Effect of Wrongful Discharge Laws on Firm Investment: Quintile Analyses*

generate the observed cross-sectional differences in R&D investment responses between the two group.

2.5.5 Corporate Cash Holding

When higher operating leverage amplifies the volatility of the internally generated cash flow, firms would have an incentive to build more cash reserves in order to smooth the level of financial resources that can be used to support R&D investment. In this section, we provide evidence of this prediction by empirically examining the changes in the level of cash holding after the adoption of wrongful discharge laws. Past literature has documented ample evidence of precautionary cash holding. Most relevant is the work by Opler *et al.* (1999), which shows that firms with riskier cash flow and a high cost of external capital hold more cash. In addition, Bates *et al.* (2009) find that the cash-to-asset ratio of U.S. industrial firms has increased as cash flows became increasingly riskier. One strand of research also theorizes the positive relationship between a firm's risk and its cash holding level (Almeida *et al.*, 2004; Han and Qiu, 2007; Riddick and Whited, 2009; Bolton *et al.*, 2011). Some research directly focuses on the financing of R&D investment. Hall (1992), Himmelberg and Petersen (1994), and Brown *et al.* (2009) find that positive cash flow and internal financing capacity are more important for R&D than for ordinary investment. In a recent paper, Brown and Petersen (2011) also show that firms most likely to face financing friction tend to rely on cash holdings to smooth R&D. We complement this literature by providing evidence that an exogenous increase in the volatility of internal financial resources raises the average cash holding level of the firms in R&D-intensive industries.

We regress corporate cash holdings, defined as cash and marketable securities divided by total assets, on the dummies for the adoption of wrongful discharge laws. Following Bates *et al.* (2009), we control for Tobin's Q, firm size, capital expenditure, net working capital, dividend dummy, cash flow, industry cash flow risk, and acquisition as determinants of firm cash holdings. Columns (1) and (2) of Table 2.15 report the results. We find that cash holding increases as the good-faith exception is adopted. The GF adoption raises the average cash-to-asset ratio by 1.3%p when measured with controls. The signs of the estimated coefficients on control variables are consistent with the signs reported in Bates *et al.* (2009). The exception is the coefficient estimate on the industry cash flow risk, which is spurious because we already controlled for the annual variations in each industry by including industry-year fixed effects. Most notably, a firm that has an R&D investment intensity of one standard deviation higher has a 1.0%p higher cash-to-asset ratio, representing the firm's effort to smooth liquid assets. In contrast, contemporaneous capital investment intensity is negatively related to cash holding as capital investment depletes the cash reserve.

Table 2.15: *Effect of Wrongful Discharge Laws on Firm Cash Holding*

Columns (1) and (2) report the results from the OLS regressions of firm cash holdings at the end of each fiscal year on the indicator variables for the adoption status of different types of wrongful discharge laws in the state where the firm's headquarter is located in. Corporate cash holding is defined as cash and marketable securities divided by total assets. We also use the following control variables adopted from Bates et al. (2009): Tobin's Q, firm size, capital expenditure, net working capital, dividend dummy, cash flow, industry cash flow risk, and acquisition. Appendix Table B.4 has detailed description of these variables. In the next columns, we include the interaction terms between the adoption status indicator variables and the average R&D and capital investment intensities of each industry in a given year. The annual average R&D and capital investment intensity are calculated as described in Table 2.10. All independent variables, including the measures of annual industry average investment intensity, are winsorized at the 1% and 99% levels, and standardized to zero mean and 1 standard deviation. We include industry times year fixed effects and time trends in each state. The standard errors are clustered at state level and given in parentheses. $*$, $**$, and $***$ denote significance at the 10%, 5%, and 1% levels, respectively.

Investment Dep.Var: Cash Holding/Asset (%)	 (1)	 (2)	R&D/Asset (%) (3)	 (4)	CapEx/Asset (%) (5)	 (6)
Good Faith (GF)	2.539***	1.272**	1.587**	0.609	2.829***	1.257*
	(0.809)	(0.569)	(0.617)	(0.519)	(0.897)	(0.639)
Implied Contract (IC)	−0.362	−0.377	−0.255	−0.287	−0.295	−0.325
	(0.642)	(0.444)	(0.645)	(0.492)	(0.723)	(0.500)
Public Policy (PP)	−0.402	−0.481	−0.504	−0.524	−0.526	−0.538
	(0.490)	(0.358)	(0.483)	(0.398)	(0.502)	(0.408)
Investment×GF			2.586***	1.420***	−1.456***	−0.850**
			(0.701)	(0.465)	(0.502)	(0.337)
Investment×IC			−0.082	−0.126	0.194	0.200
			(0.405)	(0.236)	(0.331)	(0.204)
Investment×PP			0.392	0.205	−0.611	−0.316
			(0.604)	(0.355)	(0.539)	(0.300)
Tobin's Q		3.104***		3.163***		3.172***
		(0.189)		(0.203)		(0.204)
Size		−2.745***		−2.740***		−2.731***
		(0.207)		(0.226)		(0.228)
Capital Expenditure		−2.676***		−2.681***		−2.678***
		(0.164)		(0.172)		(0.173)

Table 2.15: *(Continued)*

Investment			R&D/Asset (%)		CapEx/Asset (%)	
Dep.Var: Cash Holding/Asset (%)	(1)	(2)	(3)	(4)	(5)	(6)
R&D Investment		1.104***		0.917***		0.994***
		(0.148)		(0.150)		(0.153)
Leverage		−4.987***		−5.303***		−5.301***
		(0.235)		(0.267)		(0.265)
Net Working Capital		−5.753***		−6.028***		−6.056***
		(0.262)		(0.287)		(0.302)
Dividend Dummy		−0.473***		−0.620***		−0.652***
		(0.137)		(0.138)		(0.144)
Cash Flow		−1.597***		−1.644***		−1.647***
		(0.130)		(0.140)		(0.138)
Industry Cash Flow Risk		−27.659***		3.394		2.916
		(6.221)		(5.398)		(5.436)
Acquisitions		−1.032***		−1.058***		−1.054***
		(0.088)		(0.108)		(0.106)
Industry×Year FE	Yes	Yes	Yes	Yes	Yes	Yes
State Trend	Yes	Yes	Yes	Yes	Yes	Yes
Obs	48,859	48,859	48,859	48,859	48,859	48,859
R-Squared	0.142	0.465	0.144	0.475	0.140	0.473

Next, we examine whether firms with different levels of investment intensity respond differently to the adoption of wrongful discharge laws, and whether the responses are different depending on the type of investment. Due to the sporadic nature of capital investment, instead of using each firm's annual R&D and capital investment record, we use annual industry averages of R&D and capital investment intensities as proxies for the firm's R&D and capital investment intensities. We include in the regression equations the interaction terms between the adoption dummies and the industry averages of R&D or capital investment intensities. In Columns (3) and (4), we find that firms in R&D-intensive industries tend to increase cash holdings by a larger magnitude after the adoption. When the GF is adopted, an increase of one standard deviation in the industry average R&D investment intensity raises average cash holdings additionally by 1.4%p, when measured with controls.

The results presented in Table 2.15 are consistent with the prediction of the model from Acharya *et al.* (2007) that firms hoard cash instead of reducing debt when investment opportunities are less correlated with operating income. Because R&D investment demand is frequently driven by scientific discovery or regulatory changes unrelated to economic conditions, R&D-intensive firms assume a high risk of mismatch between investment demand and operating cash flows. Conversely, investment opportunities of the firms in capital-intensive industries are relatively well correlated with operating profitability, explaining why R&D-intensive firms hoard more cash after the GF adoption while capital-intensive firms do not. In their seminal paper, Opler *et al.* (1999) argue that firms with more investment opportunities, represented by larger Tobin's Q or R&D investment, tend to hold more cash because liquidity shortage leads to greater destruction of their firm value. We further argue that because R&D investment requires much more stable financing capability than ordinary capital investment, it demands much larger cash stock given the same level of investment opportunities. R&D investment is not just an indicator of the opportunities firms have, it is another form of investment that has to be supported by larger amount of cash.

Layoff elasticity measures can be also used for cash regressions to verify that the change in cash holding is caused by the adoption of the good-faith exception. We put firms into two groups based on their measured industry layoff elasticities. Then we perform the same regressions as in Table 2.15 while allowing for different coefficients on the adoption dummies and on the interactions of the dummies with the average industry investment intensities. The results presented in Table 2.16 confirm that the post-adoption association between firm cash stock and industry R&D intensity is higher for industries with high layoff elasticity. After the adoption, when estimated with control variables, an increase of one standard deviation in the industry R&D intensity is associated with a 2.6%p increase in cash stock for the firms in industries with high layoff elasticity. The increase is only 1.0%p for those firms in industries with low layoff elasticity, however. On the other hand, there is no cross-sectional difference between the two groups with respect to the role of capital investment intensity in determining the adoption's impact on corporate cash holding.

Table 2.16: *Layoff Elasticity and the Effect of Wrongful Discharge Laws on Firm Cash Holding*

In columns (1) and (2), we report the results from the OLS regressions of firm cash holdings at the end of each fiscal year on the indicator variables for the adoption status of different types of wrongful discharge laws in the state where the firm's headquarter is located in, allowing different coefficients for the observations in an industry whose layoff elasticity estimate is above the median and for those whose industry layoff elasticity estimate is below the median. We use the indicator variables "High" and "Low" to denote both types of industries, respectively. In the next columns, we include the interaction terms between the indicator variables and the average R&D and capital investment intensities of each industry in a given year, still allowing different slopes for both types of industries. The annual average R&D and capital investment intensity are calculated as described in Table 2.10. The same set of control variables are used as in the regressions reported in Table 2.15. All independent variables, including the measures of annual industry average investment intensity and industry layoff elasticity, are winsorized at the 1% and 99% levels, and standardized to zero mean and 1 standard deviation. We include industry times year fixed effects and time trends in each state. The standard errors are clustered at state level and given in parentheses. $*$, $**$, and $***$ denote significance at the 10%, 5%, and 1% levels, respectively.

Investment			R&D/Asset (%)		CapEx/Asset (%)	
Dep.Var: Cash Holding/Asset (%)	(1)	(2)	(3)	(4)	(5)	(6)
[Elasticity = High]						
Good Faith (GF)	2.660***	1.107*	2.330***	0.890	2.624***	1.052*
	(0.784)	(0.575)	(0.767)	(0.577)	(0.801)	(0.580)
Implied Contract (IC)	−0.741	−0.640	−0.858	−0.662	−0.640	−0.583
	(0.605)	(0.515)	(0.544)	(0.465)	(0.589)	(0.502)
Public Policy (PP)	−0.970**	−0.689*	−0.864**	−0.579*	−0.965**	−0.691*
	(0.461)	(0.377)	(0.424)	(0.339)	(0.456)	(0.353)
Investment×GF			4.417***	2.552***	−1.054	−0.813
			(1.327)	(0.911)	(0.805)	(0.564)
Investment×IC			−1.086	−0.283	0.398	0.256
			(0.797)	(0.589)	(0.397)	(0.248)
Investment×PP			−0.405	0.162	−0.936	−0.589
			(1.006)	(0.660)	(0.776)	(0.521)
[Elasticity = Low]						
Good Faith (GF)	3.067***	1.442*	1.346*	0.660	3.013***	1.437*
	(1.030)	(0.737)	(0.788)	(0.661)	(1.010)	(0.742)
Implied Contract (IC)	0.180	0.024	0.107	0.155	0.134	−0.016
	(1.099)	(0.599)	(0.802)	(0.511)	(1.030)	(0.571)
Public Policy (PP)	−0.213	−0.469	−0.350	−0.460	−0.035	−0.389
	(0.799)	(0.581)	(0.812)	(0.617)	(0.755)	(0.561)
Investment×GF			1.969***	0.968***	−2.046**	−0.812**
			(0.629)	(0.346)	(0.828)	(0.367)
Investment×IC			0.223	−0.232	−0.192	0.174
			(0.583)	(0.299)	(0.639)	(0.353)
Investment×PP			0.700	0.209	−0.360	0.040
			(0.648)	(0.377)	(0.654)	(0.322)
Controls	No	Yes	No	Yes	No	Yes
Industry×Year FE	Yes	Yes	Yes	Yes	Yes	Yes
State Trend	Yes	Yes	Yes	Yes	Yes	Yes
Obs	38,273	38,273	38,273	38,273	38,273	38,273

Table 2.16: *(Continued)*

Investment Dep.Var: Cash Holding/Asset (%)	(1)	(2)	R&D/Asset (%) (3)	(4)	CapEx/Asset (%) (5)	(6)
R-Squared	0.139	0.473	0.141	0.474	0.146	0.479

Finally, we examine the source of the extra cash that firms accumulate after the GF adoption. Because we cannot find evidence of changes in firm profitability after the good-faith adoption, firms are required to adjust their financial cash flows to hoard more cash. In particular, changes in debt outstanding, equity issuance, and dividends can be considered to be the candidates for potential sources of extra cash. To see which source firms rely on most heavily to build their cash buffer, we perform dynamic regressions of these variables on the indicator variables that represent the distance to the year of the GF adoption. Each estimate indicates the average level of the variable in the year that the dummy represents, relative to the average level in the states where the good-faith exception has never been adopted. The first column in Table 2.17 shows that firms are retaining more cash after the GF adoption, but the accumulation process takes considerable time, as much as five to seven years. Column (2) shows that the changes in debt outstanding are not statistically significant over time, and the point estimates are negative rather than positive, implying that debt cannot be a source of extra cash. In fact, as firms have higher operating leverage after the adoption, the traditional theory of optimal leverage targeting predicts that firms will start to delever. Considering this motivation, it is unlikely that firms will issue more debt to hoard extra liquidity. Column (3) documents that the GF adoption generates a permanent increase in the equity issuance level. The reported magnitude is also substantial, as the estimates predict 0.5%p to 0.9%p increase in equity issuance over time. We also find a statistically significant drop in the dividend level immediately after the GF adoption. However, it seems that the adoption's impact on GF is only transitory and largely not found for at least five years after the adoption. In short, the accumulation of a liquidity buffer after the GF adoption is a gradual process, and the equity market is the major source of extra cash. The recent paper by Serfling (2016) shows that firms reduce financial leverage after the adoption of the good-faith exception. We complement his result by documenting that changes in capital structure are mostly associated with cash accumulation through the issuing of more equities rather than debt reduction.

Table 2.17: *Effect of Wrongful Discharge Laws on Funding Sources: Dynamic Changes*

The following table reports the results from the OLS regressions of firm cash holding at the end of each fiscal year and the amount of the potential sources of cash on the indicator variables that represent the distance to the year when good-faith exception was first recognized by a court within the state where the firm's headquater is located in.[21] Debt changes is defined as the changes in the sum of total long-term debt and debt in current liabilities divided by total assets. Equity issuance is defined as sale of common and preferred stocks minus purchase of common and preferred stocks divided by total assets, and dividend payout is the sum of dividends on common and preferred stock divided by total assets. The same set of control variables are employed as in the regressions reported in Table 2.15. All independent variables are winsorized at the 1% and 99% levels, and standardized to zero mean and 1 standard deviation. We use industry times year fixed effects and time trends in each state. The standard errors are clustered at state level and given in parentheses. ∗, ∗∗, and ∗∗∗ denote significance at the 10%, 5%, and 1% levels, respectively.

Dep.Var: % of Asset	Cash Holding (1)	Debt Changes (2)	Equity Issuance (3)	(−) Dividends (4)
GF[-4p]	−0.096	−0.598	0.005	0.276
	(0.790)	(0.708)	(0.240)	(0.233)
GF[-3,-2]	0.307	−0.925	0.399	0.271
	(0.781)	(0.841)	(0.301)	(0.219)
GF[-1,0]	−0.147	−0.924	−0.030	−0.264
	(0.825)	(0.784)	(0.209)	(0.336)
GF[+1,+2]	−0.134	−0.646	0.628**	0.481**
	(0.793)	(0.805)	(0.251)	(0.228)
GF[+3,+4]	0.266	−0.947	0.780**	0.418*
	(0.903)	(0.740)	(0.313)	(0.219)
GF[+5,+6]	1.561*	0.528	0.926***	0.232
	(0.806)	(0.837)	(0.265)	(0.224)
GF[+7p]	2.452**	−0.064	0.523**	0.354
	(1.099)	(0.741)	(0.254)	(0.235)
Controls	Yes	Yes	Yes	Yes
Industry×Year FE	Yes	Yes	Yes	Yes
State Trend	Yes	Yes	Yes	Yes
Obs	48,859	48,859	48,859	48,859
R-Squared	0.465	0.295	0.145	0.192

2.6 Conclusion

This paper examines the role of employment protection in corporate R&D investment with a focus on the financial frictions firms face. In particular, we identify the operating leverage channel through which employment rigidity affects R&D investment by using an exogenous shock to firing costs.

We establish that state courts' decisions to recognize the good-faith exception in wrongful termination litigation induce a permanent 15 to 20% increase in the operating leverage of the firms headquartered in the corresponding states. We find that there is a large heterogeneity in the magnitude of the adoption's impact on R&D investment, and it depends on the financial constraints firms face. R&D investment of the firms that are not financially constrained is rarely affected, but firms in the highest financial constraint quintile reduce R&D investment up to 3 to 4%p, which is substantial compared to the average R&D intensity of 7.6%. We also document evidence of amplified R&D procyclicality among financially constrained firms. We link the adoption's effect on operating leverage and R&D investment by showing that the adoption generates larger responses in both of them in industries that are expected to be more exposed to the shock. R&D-intensive firms tend to accumulate more cash to counteract the increased uncertainty in financial resources even though holding cash is generally costly to the firms.

This paper's findings suggest that employment protection generates unintended consequences through its interaction with frictions in the financial market. Employment protection may increase the volatility of firms' operating cash flow and thwart many profitable R&D opportunities that could have ultimately led to productivity growth, a primary source of economic growth in developed countries.

We conclude by providing some policy remarks. First, R&D tax credits and subsidies, the most widely accepted forms of policy measures designed to incentivize firms to undertake more R&D investment, only affect marginal factor prices and do not reduce the cash flow volatility firms assume under stronger employment protection. Therefore, they fail to reduce the distortions generated by employment protection. Instead, procyclical payroll tax schedules may reduce the rigidity of wage bills and the volatility in internal financial resources. Second, more broadly, the question of the optimal degree of employment protection is closely related to the question of who assumes more business cycle risks. Employment protection provides insurance for workers, but simultaneously generates negative pressure to corporate R&D investment and the intensity of innovation in the economy, casting doubts on the welfare gains it generates. The expansion of the unemployment insurance market, and the presence of risk sharing in the financial market in general, may reduce the necessity of employment protection, but they also suffer from a high degree of information and agency problems. Therefore, decisions about the optimal level of employment protection, or the optimal allocation of business cycle risks between firms and workers, requires a general equilibrium framework to capture the regulation's effects on both firms and households under the financial market incompleteness.

Chapter 3

Borrowing Frictions and Severance Payments

3.1 Introduction

There is a strong negative relationship between the generosity of severance payments and the per capita income level of a country. And an absence of government administered social security programs, such as unemployment benefits, is often considered to be the key factor contributing to the relationship (Holzmann and Vodopivec, 2011). This paper provides an additional explanation for the importance of severance payments in low income countries. Workers in developing economies face higher private borrowing costs than those in developed economies. According to World Bank Global Findex 2017 report, borrowers in high-income countries reported formal borrowing as the main source while those in developing economies reported family and friends as the main source for borrowing (Demirguc-Kunt *et al.*, 2018). But funding from family and friends can be costly. In fact, even though people in developed economies can get funding at lower rates from their families and friends, they still choose to borrow from third-party intermediaries because of high shadow costs of capital from families and friends (Lee and Persson, 2016). Furthermore, informal lenders in low-income countries charge high rates for the loans they provide. In a survey conducted in Pakistan from 1980 to 1981, Aleem (1990) finds that the average annual rates charged to the borrowers by noninstitutional lenders were 78.7%, even though the borrowers seldom default on their loans, whereas they would have been 12% if the banks provided the loans. These imply that limited access to formal funding sources in developing economies may lead their people to face higher private costs of borrowing than those in developed economies. Using an incomplete market model framework, we show that if the workers face higher private borrowing costs relative to the market interest rates, severance payments can be used to transfer the downside business cycle risk from the workers to the firms and improve welfare.

We modify the infinite period model in Cozzi and Fella (2016) to build two versions of a model where workers face higher private borrowing costs relative to the equilibrium interest rates. The first version is a simple finite period model and we use it to derive partial equilibrium results on the effect of severance payments in the presence of higher worker borrowing costs. Then, we introduce an infinite period model and numerically compute the steady state equilibrium of the model to illustrate the general equilibrium effects of severance payments under different borrowing costs regimes. In each version of the model, we assume that it is more costly for the bank to monitor workers until they pay back their debts than to monitor firms. If the market is incomplete and workers cannot cross insure each other against business cycle risks, a negative firm productivity shock that leads to worker termination becomes more costly for the workers as the monitoring costs increase. Without any form of unemployment benefits, workers save more to avoid borrowing too much upon losing their jobs. Thus, saving in all states increases. When severance payments are introduced, contracted spot wages fall and this becomes more costly for the workers who are saving more. However, with less borrowing and consumption upon job loss, receiving severance payments also becomes more beneficial. We illustrate these competing forces in a partial equilibrium using the finite period model and show analytically that in net, ex-ante marginal benefits of severance payments are greater when the worker private borrowing costs are higher. In a general equilibrium, additional forces are at work which make the net effects of severance payments unclear both with and without debt monitoring costs. At a moderate level, severance payments increase equilibrium interest rates as workers reduce their precautionary savings. With higher costs of capital, the firm's output falls and wages decrease further. At the same time, those who have assets enjoy greater returns to savings while borrowers suffer more. We replicate the findings in the literature that severance payments are welfare neutral in incomplete market general equilibrium settings without firing taxes or job tenure. However, we find that when workers' private borrowing costs become greater than equilibrium interest rates due to debt monitoring costs, severance payments can improve their welfare.

Alvarez and Veracierto (2001) and Cozzi and Fella (2016) also study the welfare consequences of severance payments in augmented versions of Aiyagari (1994)'s incomplete market general equilibrium framework. Alvarez and Veracierto (2001) show that the welfare improvement with severance payments comes in the form of reduced social separation costs in the presence of wage-rigidity. If wages are inflexible, too many workers are terminated in equilibrium and social costs accumulate through worker search costs. Severance payments can save these costs by penalizing firms for worker termination which they call firing taxes. Even though the new economy with severance payments exhibits lower aggregate productivity, lower total assets, and more variable consumption, they find that total employment increases and the unemployment rate falls as fewer workers are laid off and workers more eagerly search for jobs. This justifies having some degree of severance payments. Cozzi and Fella (2016) show welfare benefits of severance payment using a different setting. In their model, wages increase with job tenure but worker termination resets the tenure which drastically decreases current income as well as new wages upon re-employment. Holding fixed separation and job search probabilities constant, they show that severance payments improve welfare through the provision of enough insurance against the loss of tenure and long-term expected wages. This paper builds on their works and shows an additional welfare benefit of severance payments in the presence of asymmetric borrowing costs. Severance payments become an efficient device that allocates the business cycle risks to the agents with lower borrowing frictions and a higher risk tolerance. This paper also provides an alternative explanation for the observed negative cross-country correlation between the magnitude of severance payments and the log GDP per capita.

In section 3.2, we provide a three-period incomplete market model to illustrate the partial equilibrium relationship between the expected benefit of severance payments and worker private borrowing costs. In section 3.3, we extend this model to an infinite period setting and present numerically computed steady-state general equilibrium results. Section 3.4 concludes.

3.2 Finite Period Model

We present a model in which workers face borrowing frictions unlike firms and show that, under the presence of only the extensive margin of labor, the benefit of severance payments increases with the degree of frictions. The model framework and ingredients are borrowed from Cozzi and Fella (2016) with modifications to incorporate worker borrowing frictions and enable finite period analysis.

3.2.1 Model Setup

Workers: the economy is populated by a measure one of workers who are either employed or unemployed in each period. All workers have identical labor endowment of 1. We assume a separable utility function with a differentiable strictly concave utility of consumption and a linear search cost η. To abstract away from the effect of severance payments on job search and separation and to make the model tractable, we assume that job finding and job separation probabilities are given exogenously. Employed workers pay labor income tax at a tax rate of τ while unemployed workers receive a basic income, T_t, from the government. Separated workers receive a severance payment $s_1 = \phi w_0$ in Period 1 but we simplify the problem and assume that there is no severance payment for separated workers in Period 2. The government balances its budget each period. Workers can either save in deposits at interest rate r_t or borrow from the bank at an interest rate of $r_t + \alpha$. α represents the premium the bank charges to the workers for costs associated with gathering information on its borrowers and monitoring them to pay back the debt.

Firms: There are a large number of firms in the economy that employ a single worker each and borrow capital without friction from the bank for production. Production follows a constant returns to scale function. It is also a concave function of capital. Capital depreciates at rate δ each period. Each firm faces the risk of being hit by an idiosyncratic negative productivity shock with probability θ_s which makes any worker unproductive. This induces the firm to separate its worker.

Markets: The final goods market is competitive. The asset market is intermediated by a competitive bank which owns all the firms and capital in the economy. It accepts deposits from workers and pays interests r_t on them and lends its capital to firms at the interest rate of r_t. The bank also lends to workers but incurs monitoring cost α per the amount lent.

Timeline: The economy runs for three periods, and everyone is employed before the economy begins and holds an endowment of a_0. In Period 0, no one gets separated from her match. Each worker-employer pair bargains on spot wages, given other prices and parameters, and production ensues. At the end of Period 0, saved endowments grow in value, wages are paid out, and workers then consume and save for the next periods. At the beginning of Period 1, θ_s of employed workers lose their jobs due to idiosyncratic separation risk and receive severance payments s_1. Separated workers can participate in the job search but matching does not happen until Period 2. The workers who keep their jobs bargain with their employers for their spot wages and production follows. At the end of Period 1, saved deposits grow in value, wages are taxed first and then paid out, and workers consume and save. Unemployed workers get some transfers T_1 from the government and every worker may still borrow from the bank at the rate $r_2 + \alpha$. In Period 2, matched pairs from Period 1 separate with probability θ_s while previously unemployed workers who searched for jobs find their matches with probability θ_f. All matched pairs, including those who keep their jobs, decide on wages through Nash-bargaining and production follows as before. Finally, workers consume everything and the economy ends. Borrowing by the workers is not possible in Period 2. We solve for equilibrium consumption and savings using backward induction.

3.2.2 Equilibrium

Period 2

Employed worker's problem:

$$V_2^e(a_2) = \max_{c_2} U(c_2)$$

$$\text{subject to} \quad c_2 \leq \begin{cases} (1+r_2)a_2 + (1-\tau)w_2 & \text{if} \quad a_2 \geq 0, \\ (1+r_2+\alpha)a_2 + (1-\tau)w_2 & \text{if} \quad a_2 < 0. \end{cases}$$

Unemployed worker's problem:

$$V_2^u(a_2) = \max_{c_2} U(c_2)$$

$$\text{subject to} \quad c_2 \leq \begin{cases} (1+r_2)a_2 + \mathrm{T}_2 & \text{if} \quad a_2 \geq 0, \\ (1+r_2+\alpha)a_2 + \mathrm{T}_2 & \text{if} \quad a_2 < 0. \end{cases}$$

Firm's problem:

$$H_2(a_2) = \max_{k_2} \; f(k_2) - w(a_2) - (r_2+\delta)k_2.$$

Wage bargaining:

Cozzi and Fella (2016) use a Nash-bargaining framework for wage determination in their model with the assumptions described below. Justifications for these assumptions can be found in Section 5 of their paper. We adopt their framework and assumptions.

When bargaining fails, the worker is unemployed and the firm gets 0 payoff. Thus,

$$w_2(a_2) = \arg\max \; (V_2^e(a_2) - V_2^u(a_2))^{\xi} \, H_2(a_2)^{1-\xi}.$$

We assume that worker has all the bargaining power ($\xi \to 1$), which essentially leaves firms with zero bargaining surplus. Also, we assume that even in Period 1, severance payment does not enter as a threat point in the bargaining. Then, from $H_2(a_2) = 0$,

$$w_2 = f(k_2) - (r_2 + \delta)k_2.$$

We require that $(1-\tau)w_2 \geq T_2$ to prevent workers from voluntarily separating which is not central to the role and discussion of severance payments.

Market-clearing and balanced budget:

1) Asset market-clearing condition:

$$r_2K_2 + (r_2 + \alpha)\left|A_2^-\right| - \alpha\left|A_2^-\right| - r_2\left|A_2^+\right| = r_2K_2 - r_2A_2 = 0,$$

where K_2 is aggregate capital stock, A_2^+ and A_2^- represent total assets saved and borrowed, respectively, and $-\alpha\left|A_2^-\right|$ represent total monitoring costs in Period 2. This implies that

$$K_2 = A_2.$$

K_2 and A_2 can be written as follows:

$$K_2 = \int_{a_2} k_2^*(a_2)(1-\theta_s)f(a_2,1)da_2 + \int_{a_2 \in \mathrm{A}_2^f} k_2^*(a_2)\theta_f f(a_2,0)da_2$$
$$A_2 = \int_{a_2} a_2 f(a_2)da_2,$$

where e_1 in $f(a_2, e_1)$ is an indicator of previous employment status, $f(a_2) = f(a_2,1) + f(a_2,0)$ for all a_2, and A_2^f is the set of assets at which unemployed workers participate in job search in Period 2.

2) Balanced budget:

$$T_2\left(\int_{a_2}\theta_s f(a_2,1)da_2 + \int_{a_2\in \mathrm{A}_2^f}(1-\theta_f)f(a_2,0) + \int_{a_2 \notin \mathrm{A}_2^f} f(a_2,0)\right)$$
$$= \int_{a_2}\tau w_2(a_2)(1-\theta_s)f(a_2,1)da_2 + \int_{a_2\in \mathrm{A}_2^f}\tau w_2(a_2)\theta_f f(a_2,0)da_2.$$

We can simplify the above conditions by noticing that there can only be two possible states for the workers until Period 1: employed in Period 1 or separated in Period 1. This is because everyone is employed in Period 0 such that there is no worker heterogeneity until the beginning of Period 1. Thus, every unemployed (separated) employee from Period 1 is identical to each other; they either all participate in the job search in Period 1 or all remain unemployed in Period 2.

Given that all unemployed workers in Period 1 face the same problem, we assume away the choice of job search and assume that everyone searches for a Period 2 job when they become unemployed in Period 1. Observe that all wages in Period 2 are identical given the full worker bargaining power. Then, we can simplify the above conditions to:

1) Asset market-clearing conditions:

$$K_2 = k_2^*(r_2)(1-\theta_s)^2 + k_2^*(r_2)\theta_f\theta_s$$
$$A_2 = a_2^e(1-\theta_s) + a_2^u\theta_s,$$

such that $K_2 = A_2$ condition yields

$$k_2^* = \frac{a_2^e(1-\theta_s) + a_2^u\theta_s}{(1-\theta_s)^2 + \theta_f\theta_s}. \tag{3.1}$$

2) Balanced budget:

$$T_2\left((1-\theta_s)\theta_s + \theta_s(1-\theta_f)\right) = \tau w_2\left((1-\theta_s)^2 + \theta_s\theta_f\right),$$

which yields

$$T_2 = \tau w_2 \frac{(1-\theta_s)^2 + \theta_s\theta_f}{(1-\theta_s)\theta_s + \theta_s(1-\theta_f)}. \tag{3.2}$$

Every equilibrium variable in Period 2 can be written as a function of a_2^e and a_2^u. In particular, from the asset market-clearing condition, we observe that when either a_2^e or a_2^u increases, k_2^* increases as r_2 falls. This result is intuitive given that higher savings drive down the equilibrium interest rates.

Period 1

All workers enter Period 1 with homogeneous savings a_1. Because A_1 needs to be positive for the production to occur, which we will observe through the Period 1 asset market-clearing condition, we take it as given that $a_1 > 0$.

Employed worker's problem:

$$V_1^e(a_1) = \max_{c_1,a_2} U(c_1) + \beta\left((1-\theta_s)V_2^e(a_2) + \theta_s V_2^u(a_2)\right)$$

$$\text{subject to} \quad \begin{cases} c_1 + a_2 & \leq (1+r_1)a_1 + (1-\tau)w_1, \\ a_2 & \geq -\dfrac{T_2}{1+r_2+\alpha}. \end{cases}$$

Letting λ^e be the Lagrangian multiplier in front of the natural borrowing constraint, we can obtain the Euler equation from the employed worker's problem:

$$\begin{aligned} U'(c_1^e) = & \left(\beta(1+r_2)\left((1-\theta_s)U'(c_2^{e;a_2^e\geq 0}) + \theta_s U'(c_2^{u;a_2^e\geq 0})\right)\right)\mathbb{I}_{a_2^e\geq 0} \\ & + \left(\beta(1+r_2+\alpha)\left((1-\theta_s)U'(c_2^{e;a_2^e<0}) + \theta_s U'(c_2^{u;a_2^e<0})\right) + \lambda^e\right)\mathbb{I}_{a_2^e<0}. \end{aligned}$$

The above Euler condition provides basic intuition behind the optimal savings decision conditional on fixed market prices. At $a_2 = 0$, if the LHS is greater than the RHS, the worker should borrow from the bank to consume more in Period 1 until either the marginal utilities are equalized or the borrowing limit is reached with positive λ^e. But if the RHS is greater than the LHS at $a_2 = 0$, she should give up some consumption in Period 1 and save for Period 2.

Unemployed workers in Period 1 get severance payments as some percentage of Period 0 wage (ϕw_0).

Unemployed worker's problem:

$$V_1^u(a_1, w_0) = \max_{c_1,a_2,h_1} U(c_1) - \eta h_1 + h_1\beta\left(\theta_f V_2^e(a_2) + (1-\theta_f)V_2^u(a_2)\right) + (1-h_1)\beta V_2^u(a_2)$$

$$\text{subject to} \quad \begin{cases} c_1 + a_2 & \leq (1+r_1)a_1 + \phi w_0 + \mathrm{T}_1, \\ a_2 & \geq -\dfrac{T_2}{1+r_2+\alpha}, \end{cases}$$

where h_1 is worker's job search decision that takes either 0 or 1. As we discussed above, we assume that everyone searches for a job when they become unemployed ($h_1 = 1$).

Firm's problem:

$$H_1(a_1) = \max_{k_1} \ f(k_1) - w(a_1) - (r_1 + \delta)k_1 + \frac{1}{1+r_2}\left((1-\theta_s)H_2(a_1)\right).$$

From Period 2, $H_2 = 0$. Thus,

$$H_1(a_1) = \max_{k_1} \ f(k_1) - w(a_1) - (r_1 + \delta)k_1.$$

Wage bargaining:

$$w_1(a_1) = \arg\max \ \left(V_1^e(a_1) - V_1^u(a_1, 0)\right)^{\xi} H_1(a_1)^{1-\xi}.$$

As before, $\xi \to 1$ implies that $H_1 = 0$. Then,

$$w_1 = f(k_1) - (r_1 + \delta)k_1. \tag{3.3}$$

Market-clearing and balanced budget:

1) Asset market-clearing condition:

$$K_1 + \Pi_1/r_1 = A_1,$$

where Π_1 is the total firm profits from Period 1. K_1, Π_1, and A_1 can be written as follows:

$$\begin{aligned} K_1 &= k_1^*(1-\theta_s), \\ \Pi_1 &= (1-\theta_s)\cdot 0 - \theta_s \phi w_0 = -\theta_s \phi w_0, \\ A_1 &= a_1. \end{aligned}$$

Thus, we get

$$k_1^* = \frac{a_1 + \theta_s \phi w_0 / r_1}{1-\theta_s}. \tag{3.4}$$

All capitals come from consumer savings and because all consumers have homogeneous savings a_1 at the beginning of Period 1, $a_1 > 0$ for any production to occur.

2) Balanced budget:

$$T_1\theta_s = \tau w_1(1-\theta_s),$$

which implies

$$T_1 = \tau w_1(k_1^*)\frac{1-\theta_s}{\theta_s}. \tag{3.5}$$

Every choice variable and equilibrium price in Period 1 and 2 can now be expressed as a function of a_1 and w_0 using the above conditions and the optimality conditions from each agent's problem.

Period 0

All workers are employed without separation in Period 0 and they are all endowed with a_0. Employed worker's problem:

$$V_0^e(a_0) = \max_{c_0,a_1} U(c_0) + \beta\left((1-\theta_s)V_1^e(a_1) + \theta_s V_1^u(a_1, w_0)\right)$$
$$\text{subject to} \quad c_0 + a_1 \leq (1+r_0)a_0 + w_0.$$

We can show that the solution to the worker's problem must satisfy the following Euler condition:

$$U'(c_0^e) = (1+r_1)\beta\Big((1-\theta_s)U'(c_1^e) + \theta_s U'(c_1^u)\Big) \quad \text{(Euler condition)},$$
$$c_0^e = (1+r_0)a_0 + w_0 - a_1^e.$$

Firm's problem:

$$H_0(a_0) = \max_{k_0} f(k_0) - w(a_0) - (r_0+\delta)k_0 + \frac{1}{1+r_1}\left((1-\theta_s)H_1(a_0) - \theta_s\phi w(a_0)\right).$$

From Period 1, $H_1 = 0$. Thus,

$$H_0(a_0) = \max_{k_0} f(k_0) - w(a_0) - (r_0+\delta)k_0 - \frac{1}{1+r_1}\left(\theta_s\phi w(a_0)\right).$$

This is where we can see the difference in costs between workers and firms in times of a negative productivity shock. Because all firms in the economy are owned by the bank, their risks are cross-insured through the bank, which justifies the use of discounted expected profit maximization. When firms get a negative productivity shock in the future, they will pay out $\phi w(a_0)$ to the separating workers and end up with negative profits. But unlike the workers who smooth consumption through borrowing even in the face of high borrowing costs, firms are cross-insured and are not averse to the risk of realizing negative profits. Because they do not borrow to make their individual spot cash flows positive and because they are not subject to the same borrowing frictions when renting capital, as we will show later, severance payments, which are the insurance provided by the firms that protect workers against separation risks, become more beneficial as the worker borrowing costs increase.

Wage bargaining:

Similar to before, as $\xi \to 1$, $H_0 = 0$. Thus,

$$\begin{aligned} w_0 =& f(k_0) - (r_0 + \delta)k_0 - \frac{1}{1+r_1}\theta_s s_1 \\ =& \Big(f(k_0) - (r_0 + \delta)k_0\Big)\left(1 + \frac{\theta_s \phi}{1+r_1}\right)^{-1}. \end{aligned} \tag{3.6}$$

Wages are privately determined through bargaining given the exogenous separation probability. Thus, the severance payments directly affect wages and firm's layoff decision is not a function of severance payments. Following Cozzi and Fella (2016), we use this setting to make severance payments work as actuarially fair insurance and to abstract away from the firing tax component of severance payments, which Alvarez and Veracierto (2001) found to be welfare enhancing. In particular, one unit increase in severance payments is accompanied by a $\theta_s/(1+r_1)$ unit decrease in spot wages.[1] That is, the insurance premium is exactly the discounted expected value of the insurance compensation. We show in Proposition 5 that, because severance payments make such actuarially fair insurance possible, risk-averse workers benefit from more severance payments in a partial equilibrium as long as their consumption in the unemployed state is lower than that in the employed state.

[1] Using data from Colombia, Kugler (2005) documents that wages do fall with severance payments if there is no agency problem.

Market-clearing:

Asset market-clearing condition:

$$K_0 + \Pi_0 / r_0 = A_0,$$

where

$$K_0 = k_0^*$$

$$\Pi_0 = \pi_0^* = f(k_0^*) - w_0 - (r_0 + \delta) k_0^*,$$

$$A_0 = a_0.$$

as no one gets separated in Period 0. Thus,

$$k_0^* = a_0 - \pi_0^* / r_0. \tag{3.7}$$

If we combine all the market-clearing, balanced budget, and optimality conditions from all three periods, we can fully characterize every equilibrium variable as a function of a_0.

We now present a few propositions.

Proposition 5 *When prices* $(\mathbf{r}, \mathbf{T})$ *are given, severance payment increases the ex-ante expected utility of individual worker if and only if* $c_1^e > c_1^u$. *That is,*

$$\frac{\partial V_0^e(a_0)}{\partial \phi}\Big|\mathbf{r}, \mathbf{T} \geq 0 \quad \textit{if and only if} \quad c_1^e \geq c_1^u.$$

Proof. Please refer to Appendix C.1.2. ■

One simple and intuitive case that guarantees $c_1^e \geq c_1^u$ is the combination of $(1-\tau)w_1 \geq \phi w_0 + T_1$ and $(1-\theta_s) \geq \theta_f$: spot income in $t = 1$ and the probability of employment in $t = 2$ for the employed in $t = 1$ are greater than or equal to those of the unemployed in $t = 1$. Then, the overall expected wealth of an employed person in Period 1 is higher than or equal to that of an unemployed person. Combined with consumption smoothing, it leads to $c_1^e \geq c_1^u$. This proposition shows that when prices are assumed to be fixed and when the consumption of the employed is greater than the consumption of the unemployed in Period 1, a worker prefers to transfer some of her wealth in Period 0 (lower w_0) to the unemployed state in Period 1 (higher severance payments). Increasing wealth in the unemployed state reduces the income spread in Period 1 and lowers the risk. As long as the price for the risk reduction is lower than the risk premium, the worker is willing to pay the price and reduce the risk. In our setup, firms work as mediums that deliver and price the wealth transaction. Because firms act as if they have a risk-neutral preference, the cost of this wealth transfer is lower than the worker's required risk premium.

Proposition 6 *Let c_1^e be greater than or equal to c_1^u. Then, the following holds:*

$$\frac{\partial V_0^e(a_0)}{\partial\phi\partial\alpha}\Big|\Big(\mathbf{r},\mathbf{T},a_2^e>0,a_2^u>0\Big)=0,$$
$$\frac{\partial V_0^e(a_0)}{\partial\phi\partial\alpha}\Big|\Big(\mathbf{r},\mathbf{T},a_2^e>0,a_2^u<0\Big)>0.$$

Proof. Please refer to Appendix C.1.3. ■

The above proposition illustrates the additional marginal benefit of severance payments when borrowing becomes more costly for the worker. When the worker's optimal decision is to save both when employed and unemployed, there is no additional benefit of severance payments at the margin as borrowing costs increase. But when the worker needs to borrow from the bank in case she gets separated, severance payments provide extra benefits to the worker ex-ante as borrowing becomes more expensive. As we can see from the proof in Appendix C.1.3, when the worker's borrowing cost α increases, both the marginal utility loss in Period 0 through a lower wage and the marginal utility gain in the unemployed state of Period 1 through higher severance payments become greater in their magnitude. When borrowing becomes more expensive in Period 1, a worker saves more in Period 0 while reducing borrowing in the bad state of Period 1. Given the negative second derivative of our utility function, greater savings in Period 0 make the marginal utility loss from a lower wage in Period 0 more costly. At the same time, in the unemployed state of Period 1, the marginal reduction in borrowing is greater than the marginal increase in accumulated wealth from Period 0. As a result, the marginal utility gain from a higher severance payment in Period 1 becomes larger. Our result holds because the increase in the size of the marginal utility gain is greater than the increase in the size of the marginal utility loss, which in net delivers a greater marginal benefit of ϕ as α increases. In order to derive the results of our propositions, we assumed that prices are given and fixed. But we also relied on the restrictions implied by the asset market-clearing condition. For instance, we ruled out the case where a_2^e and a_2^u are both negative. In the next section, we extend our simple model to a fully dynamic one and numerically solve for steady state general equilibrium prices and policy functions under different severance payment and borrowing cost regimes.

3.3 Infinite Period Model

In this section, we introduce an infinite period dynamic version of our model with its market-clearing conditions and its steady state law of motion of worker measures. The model framework and ingredients are taken from Cozzi and Fella (2016) with a few modifications. Because we want to stress the role of insurance provided by severance payments under different borrowing cost regimes, we simplify the age distribution and do not consider job tenure in our model. Furthermore, because we are studying the need for severance payments in the absence of government administered unemployment benefits, we do not consider them either. In the model setup that follows, prices are assumed to be stationary since we will be using the steady state equilibrium for our analysis.

3.3.1 Model Setup

Workers: The economy is populated by a measure one of workers. Non-retired workers are either employed, unemployed, or out of labor force. Job finding and job separation probabilities are given exogenously. Unemployed workers bear some utility cost η for job searching and find employers with probability θ_f. Separated workers receive a one-time transfer of ϕw from their employers. Workers are also either young or old in terms of age. We denote workers in each group as y and o, respectively. Young workers have 0 probability of retirement while old workers have a probability $\theta_\rho(o)$ of retirement. Retired workers die with probability θ_d and new young workers are born as unemployed with an initial wealth of a_n. Employed workers pay labor income tax at rate τ and this tax revenue finances basic income T given to those without jobs. Workers can either save in deposit at the interest rate r or borrow from the bank at interest rate $r + \alpha$. α represents the premium the bank charges to the workers for costs associated with gathering information on their borrowers and monitoring them to pay back the debt. Borrowing is limited to $-B_i$.

Firms: There are a large number of firms producing a numeraire good. Job creation is exogenous such that a fraction θ_f of searching unemployed workers find jobs. Each firm employs one worker, borrows capital from the bank, and produces using a Cobb-Douglas production function with capital share κ. Capital depreciates at rate δ each period. In each period, every firm faces a risk of being hit by an idiosyncratic negative productivity shock with probability $\theta_s(m)$ where $m \in \{y, o\}$ indicates the employee age group. This renders any worker unproductive and leads to employer-worker separation.

Markets: The final goods market is competitive. The asset market is intermediated by a competitive bank in the economy which handles lending and borrowing. It also owns all capital in the economy. It accepts deposits from the workers and pays interests r_t on them and lends its capital to the firms at an interest rate of r_t. The bank also lends to the workers at interest rate $r_t + \alpha$ but incurs a monitoring cost α per the amount lent. Finally, the bank owns all the firms such that firms share their risks cross-sectionally.

Timeline: At the beginning of each period, $\theta_\rho(o)$ of all old workers retire and θ_d of retirees die. At the same time, some firms are hit by a negative productivity shock and their workers are separated from their jobs. Also, $\theta_o(y)$ of young workers become old. Remaining employer-employee pairs negotiate spot wages through Nash-bargaining and produce output. At the same time, θ_f of job searchers are matched with idle firms, bargain for spot wages, and begin their jobs. After production, pre-tax wages are paid, tax revenues are collected, and workers earn after-tax wages. Also, freshly unemployed workers, continuing unemployed workers, fresh retirees, and surviving retirees all receive basic income T from the government. Freshly unemployed workers additionally receive after-tax severance payments from their most recent employers. All workers collect / pay interest on their saved / borrowed assets and determine their level of consumption and new level of savings

/ debts. Unemployed workers additionally make a decision about whether to search for jobs. In each period, asset markets and goods markets all clear, and government balances its budget.

3.3.2 Equilibrium

Worker's problems

An employed worker's problem can be represented by the following value function:

$$V^e(a,m) = \max_{c,a'} U(c) + \beta(1-\theta_\rho(m))\left(\sum_{m'}\theta_{m'}(m)\left((1-\theta_s(m))V^e(a',m') + \theta_s(m)V^u(a',m',s=m)\right)\right) + \beta\theta_\rho(m)V^\rho((1-\theta_d)a') \tag{3.8}$$

subject to

$$c + a' \leq \begin{cases} (1+r)a + w^\tau(m) & \text{if} \quad a \geq 0, \\ (1+r+\alpha)a + w^\tau(m) & \text{if} \quad a < 0, \end{cases}$$

$$a' \geq -B(e,m),$$

where $U(c) = \frac{c^{1-\gamma}-1}{1-\gamma}$, $m \in \{y,o\}$ indicates the age group of the worker, $w^\tau(m) = (1-\tau)w(m)$ is wage after labor taxes, and s is an indicator of the severance payment entitlement, the amount of which depends on the previous wage. We assume that $\theta_\rho(y) = 0$ and $\theta_o(o) = 1$. We denote an employed worker's consumption and savings policy functions by $c^e(a,m)$ and $a^e(a,m)$, respectively. In the next period, a young employed worker either stays as a young worker or gets old. At the same time, she either gets to stay with her employer or be exogenously separated and receive severance payments. Old employed workers may also exogenously retire in which case they do not receive any severance payments.

Similarly, we can write the value of being an unemployed worker in state (a, m, s) as:

$$V^u(a,m,s) = \max_{c,a',h\in\{0,1\}} U(c) - \eta h + \beta(1-\theta_\rho(m))\left(\sum_{m'}\theta_{m'}(m)\left(\left(\theta_f V^e(a',m') + (1-\theta_f)V^u(a',m',s=0)\right)h + V^u(a',m',s=0)(1-h)\right)\right) + \beta\theta_\rho(m)V^\rho((1-\theta_d)a') \tag{3.9}$$

subject to

$$c + a' \leq \begin{cases} (1+r)a + \mathrm{T} + \mathbb{I}_{s=y}\phi w^\tau(y) + \mathbb{I}_{s=o}\phi w^\tau(o) & \text{if} \quad a \geq 0, \\ (1+r+\alpha)a + \mathrm{T} + \mathbb{I}_{s=y}\phi w^\tau(y) + \mathbb{I}_{s=o}\phi w^\tau(o) & \text{if} \quad a < 0, \end{cases}$$

$$a' \geq -B(u,m),$$

where h is worker's job search decision that takes either 0 or 1. There is a utility cost η of job search. We denote an unemployed worker's consumption, savings, and job-search policy functions by $c^u(a,m,s)$, $a^u(a,m,s)$, and $h(a,m,s)$, respectively.

Finally, we can represent a retiree's problem as:

$$V^\rho(a) = \max_{c,a'} U(c) + \beta(1-\theta_d)V^\rho(a') \tag{3.10}$$

subject to

$$c + a' \leq \begin{cases} \dfrac{1+r}{1-\theta_d}a + \mathrm{T} & \text{if} \quad a \geq 0, \\ \dfrac{1+r+\alpha}{1-\theta_d}a + \mathrm{T} & \text{if} \quad a < 0, \end{cases}$$

$$a' \geq -B(\rho),$$

We assume that at any given level of assets a, retirees who survive evenly split the savings and debts of those who pass away. Thus, the risk-free savings interest rates become $(1+r)/(1-\theta_d)$ while the risk-free interest rates on debt become $(1+r+\alpha)/(1-\theta_d)$ for retirees. We denote a retiree's consumption and savings policy functions by $c^\rho(a)$ and $a^\rho(a)$, respectively.

Firm's problem

Firms are homogeneous and can flexibly open and close at zero cost. Furthermore, firm idiosyncratic risks are shared across the firms through the bank which owns the portfolio of firms. Thus, each firm maximizes its discounted expected profits. Wages are determined through Nash-bargaining once a worker and a firm have been exogenously matched. We assume that the worker possesses all bargaining power to avoid the dependence of wages on the worker's assets. However, wages still depend on the worker's age even though all workers have identical labor endowment and productivity regardless of their ages. This is because wages depend on the expected cost of severance payments which is a function of the retirement probability. Hence, the value function of a firm matched to a worker of age group m is:

$$H(m) = \max_k f(k) - w(m) - (r+\delta)k + \frac{1-\theta_\rho(m)}{1+r}\Bigg((1-\theta_s(m))\sum_{m'}\theta_{m'}(m)H(m') \tag{3.11}$$

$$- \theta_s(m)\phi w(m)\Bigg). \tag{3.12}$$

Solving for k^* yields,

$$f'(k^*) = r+\delta. \tag{3.13}$$

Wage bargaining

Similar to the framework used in the previous section, we assume that wages are determined through Nash-bargaining and severance payments are not considered in the bargaining as threat points even for the continuing firm-worker pairs. Thus,

$$w(a,m) = \arg\max\ (V^e(a,m) - V^u(a,m,s=0))^\xi H(a,m)^{1-\xi}. \tag{3.14}$$

But because we also assume that the worker gets all the bargaining power ($\xi \to 1$), the wages no longer depend on the worker's asset level and $H(m)$ converges to 0, the firm's threat point, as $\xi \to 1$. Then, from the firm's value function, we can solve for the equilibrium wages,

$$w(m) = (f(k^*) - (r+\delta)k^*)\left(1 + \frac{(1-\theta_\rho(m))\theta_s(m)\phi}{1+r}\right)^{-1}. \tag{3.15}$$

Worker measures

Let $\mu^e(a,m)$, $\mu^u(a,m,s)$, and $\mu^\rho(a)$ be the time invariant measures of employed, jobless, and retired workers across different states. Given prices and optimal policy functions, each measure satisfies the following:

$$\begin{aligned} \mu^e(a',m') = &\int_{a,m:a^e(a,m)=a'} (1-\theta_\rho(m))\theta_{m'}(m)(1-\theta_s(m))d\mu^e(a,m) \\ &+ \int_{a,m,s:a^u(a,m,s)=a'} (1-\theta_\rho(m))h(a,m,s)\theta_f d\mu^u(a,m,s), \end{aligned} \tag{3.16}$$

$$\begin{aligned} \mu^u(a',m',s') = &\int_{a,m:a^e(a,m)=a'} (1-\theta_\rho(m))\theta_{m'}(m)\theta_s(m)d\mu^e(a,m)\mathbb{I}_{s'=m} \\ &+ \int_{a,m,s:a^u(a,m,s)=a'} (1-\theta_\rho(m))(1-h(a,m,s)\theta_f)d\mu^u(a,m,s)\mathbb{I}_{s'=0} \\ &+ \int_a \theta_d d\mu^\rho(a)\mathbb{I}_{a'=a_n,m'=y,s'=0}, \end{aligned} \tag{3.17}$$

$$\mu^\rho(a') = \int_{a:a^e(a,o)=a'} \theta_\rho d\mu^e(a,o) + \int_{a,s:a^u(a,o,s)=a'} \theta_\rho d\mu^u(a,o,s) + \int_{a:a^\rho(a)=a'} (1-\theta_d)d\mu^\rho(a), \tag{3.18}$$

where we have applied the assumption that $\theta_\rho(y) = 0$ and have simplified $\theta_\rho(o)$ to θ_ρ.

Market-clearing and balanced budget

In equilibrium, the goods and asset markets clear and the government balances its budget. In particular, in the steady-state equilibrium which will be introduced shortly, aggregate assets do not grow further. Thus, the goods market clearing condition is

$$C + \delta K + \alpha|A^-| = \int_{a,m} f(k^*)d\mu^e(a,m), \tag{3.19}$$

where C is the aggregate consumption, K is the aggregate capital stock, and A^- is the aggregate worker's debt. They are given by

$$
\begin{aligned}
C &= \int_{a,m} c^e(a,m)d\mu^e(a,m) + \int_{a,m,s} c^u(a,m,s)d\mu^u(a,m,s) + \int_a c^\rho(a)d\mu^\rho(a), \\
K &= \int_{a,m} k^* d\mu^e(a,m), \\
A^- &= \int_{a,m} a^e(a,m)\mathbb{I}_{a^e(a,m)<0}d\mu^e(a,m) + \int_{a,m,s} a^u(a,m,s)\mathbb{I}_{a^u(a,m,s)<0}d\mu^u(a,m,s) \\
&\quad + \int_a a^\rho(a)\mathbb{I}_{a^\rho(a)<0}d\mu^\rho(a).
\end{aligned}
$$

The market-clearing condition in the asset market is

$$
K + \frac{\int_{a,m}\left(f(k^*) - w(m) - (r+\delta)k^* - (1-\theta_\rho(m))\theta_s(m)\phi w(m)\right)d\mu^e(a,m)}{r} - A^- = A^+. \tag{3.20}
$$

We can rewrite this as a capital market clearing condition:

$$
K = A - \frac{\int_{a,m}\left(f(k^*) - w(m) - (r+\delta)k^* - (1-\theta_\rho(m))\theta_s(m)\phi w(m)\right)d\mu^e(a,m)}{r}, \tag{3.21}
$$

where A stands for the aggregate net savings and is given by

$$
A = \int_{a,m} a^e(a,m)d\mu^e(a,m) + \int_{a,m,s} a^u(a,m,s)d\mu^u(a,m,s) + \int_a a^\rho(a)d\mu^\rho(a).
$$

Finally, the government's balanced budget condition is

$$
\begin{aligned}
&\tau\left(\int_{a,m} w(m)d\mu^e(a,m) + \int_{a,m}(1-\theta_\rho(m))\theta_s(m)\phi w(m)d\mu^e(a,m)\right) \qquad (3.22)\\
&= T\left(\int_{a,m,s} d\mu^u(a,m,s) + \int_a d\mu^\rho(a)\right).
\end{aligned}
$$

We can now define the steady state equilibrium of this economy.

Definition 7 *A steady state equilibrium is defined as a set of constant prices $\{r, w(m), \tau\}$, a set of policy functions $\{a^e, a^u, a^\rho, c^e, c^u, c^\rho, h, k\}$, a set of value functions $\{V^e, V^u, V^\rho, H\}$, and a set of time-invariant measures $\{\mu^e, \mu^u, \mu^\rho\}$ that satisfy the following conditions:*
(1) Given $\{r, w(m), \tau\}$, the value functions $\{V^e, V^u, V^\rho\}$ and the policy functions $\{a^e$, a^u, a^ρ, c^e, c^u, c^ρ, $h\}$ solve the worker's problems (3.8), (3.9), and (3.10).

(2) Given $\{r, w(m)\}$, the value function H and the policy function k solve the firm's problem (3.11).

(3) Wages $w(m)$ solve the bargaining problem (3.14) and satisfy the bargaining solution (3.15).

(4) The time-invariant measures $\{\mu^e, \mu^u, \mu^\rho\}$ satisfy equations (3.16), (3.17), and (3.18).

(5) The goods market and the asset (or capital) market clear so that conditions (3.19) and (3.20) hold.

(6) The balanced budget condition (3.22) holds.

Appendix C.2 describes the computation of the steady state equilibrium defined above.

3.3.3 Numerical Exercise

We study the general equilibrium welfare implications of severance payments under different borrowing cost regimes by using the U.S. economy as a benchmark. Thus, we choose and calibrate the model parameters to match the observed data in the U.S. economy. Furthermore, we set the parameters assuming that each time period of our model corresponds to two calendar months. The calibration steps largely follow those described in Alvarez and Veracierto (2001) and Cozzi and Fella (2016). To begin with, we adopt the CRRA consumption utility function and set the risk aversion parameter γ to 2, as in the Handbook of Macroeconomics (Attanasio, 1999). κ and δ are chosen to match the annual capital-output ratio of 1.7 and investment-output ratio of 0.15, respectively, both of which are taken from Alvarez and Veracierto (2001). This gives $\kappa = 0.218$ and $\delta = 0.0153$. Our youth group includes people younger than 45 with zero probability of retirement. If one's youth begins at the age of 16, this gives $\theta_o \approx 0.0057$. From 2016 Current Population Survey (CPS), the ratio for the youth group civilian noninstitutional population was 0.48. Also, the ratio of retirees was 0.15. We set the retirement and death probability to match these figures, with the condition that the measures of the young, the old, and retirees sum up to 1. Then, we get $\theta_\rho = 0.0075$ and $\theta_d = 0.018$. From CPS, average monthly earnings were \$3531 in 2016. Because persons with no job get the government benefit in our economy, we use the maximum SNAP one can get, which is \$194 currently, as a reference point, and set the government transfer T to be 5.5% of the average monthly earnings in our model. We then adopt the natural borrowing limit of retirees as the borrowing limit for all workers. $\theta_s(o)$, the separation rate for the old generation, is calibrated so that the median job tenure of old workers matches the CPS average median job tenure of workers age 45 or above from 1996 to 2016. This is 10.1 years or about 60 model periods. Then, we match the median job tenure of all workers in our model to the average median job tenure of all employees of 4.3 years or 26 model periods by calibrating $\theta_s(y)$. To compute the population and age specific median job tenures, we simulate 120,000 workers for 1000 periods. If some individuals die during the simulation, we let them be reborn as unemployed youth with zero wealth and simulate the rest of the periods. In the 1000th period, the median job tenure is computed as the median of employment duration of the simulated workers. The job finding probability, θ_f, is calibrated to match the average unemployment rate from 1996 to 2016 of 5.94%. Following Cozzi and Fella (2016), the job search cost, η, is set such that the ratio of those not seeking jobs to job seekers among the jobless in the model becomes 14% which is the CPS average of the ratio of marginally attached less discouraged workers to unemployed workers from 1996 to 2016. Finally, β is calibrated to match the annual interest rate of 4%. The calibrated parameter values are $\theta_s(y) = 0.045$, $\theta_s(o) = 0.007$, $\theta_f = 0.4927$, $\eta = 6.343$, and $\beta = 0.9838$.

Welfare implications of severance payments without private borrowing costs

In a general equilibrium, severance payments have additional effects on welfare as equilibrium prices respond to the policy. A moderate level of severance payments induces the workers to lower their precautionary savings, bringing up equilibrium interest rates. With higher capital costs, firm production, wages, and government transfers all fall which hurts every worker in the economy. But welfare implications for savers and borrowers in the new equilibrium differ; due to higher equilibrium interest rates, savers gain while borrowers lose. The net effect of severance payments depends on the relative magnitudes of these general equilibrium effects. In Table 3.1, we report the effects of severance payments when there are no private borrowing costs ($\alpha = 0$). Unemployment rate is reported for the counterfactual economy while the others are ratios of the focal variable in the counterfactual economy to the variable in the benchmark economy. In particular, we measure the welfares in two different but related ways. Similar to Rogerson and Schindler (2002) and Chatterjee *et al.* (2007), welfare measurement for workers in a given state begins with computing the percentage change in consumption in all future states over time required to make the workers ex-ante indifferent between living in the benchmark economy and the counterfactual economy. For example, for an employed worker in state (a, m), we measure the welfare improvement / loss using the following formula:

$$100\left(\frac{V^{e,new}(a,m)}{V^{e,base}(a,m)}\right)^{1/(1-\gamma)}.$$

Then, we measure the welfare improvement / loss either by picking only the percentage change in consumption of the newborn in the economy as in Cozzi and Fella (2016) or by taking the expected value of the required change in consumption using the measure of workers in the counterfactual economy as in Alvarez and Veracierto (2001).

Consistent with the findings of others, severance payments in the basic setup do not lead to welfare improvements. With a severance payment of only one month of wages, standard deviation of consumption falls slightly while welfare stays about the same. But for a severance payment equivalent to six months of wages, average welfare decreases slightly and the standard deviation of consumption rebounds as the old generation with a low separation probability is over-insured and they actually save when separated in order to support the future consumption in employed states. Thus, positive partial equilibrium benefits of severance payments are canceled out by the general equilibrium effects. To justify the need for severance payments in a general equilibrium, Alvarez and Veracierto (2001) stress the firing tax role of severance payments. They show that even though the unemployment insurance role of severance payments is negligible, severance payments do improve welfare through their firing tax role. With downward wage rigidity, firms cannot lower wages and have to lay workers off when productivity shocks hit. Then, in equilibrium, the total volume of separations is inefficiently high and severance payments can improve welfare by preventing some separations. Cozzi and Fella (2016), on the other hand, focus on the unemployment insurance role of severance payments. The lack of unemployment insurance benefits of severance payments is due to the small costs of job loss in the usual job search models calibrated to the U.S. economy. Thus, they introduce wages that depend on the worker's job tenure which drastically drop once she gets separated. Under this setting, severance payments provide sufficient insurance against a job loss, which is beneficial beyond a partial equilibrium. We also focus on the unemployment insurance role of severance payments. In the next section, we show that severance payments improve welfare when the costs of job loss are high due to the debt monitoring costs.

Table 3.1: *Effects of severance payments when $\alpha = 0$*

Months of wages	No severance payment	1 month	6 months
Unemployment rate	5.9%	5.9%	5.9%
Employment	100.0	99.7	98.9
Output	100.0	99.7	98.9
Assets	100.0	99.2	98.1
Consumption	100.0	100.0	99.8
S.D. Consumption	100.0	99.4	99.8
Welfare (new born)	100.0	100.0	100.0
Welfare (average)	100.0	100.0	99.9

Welfare implications of severance payments with private borrowing costs

According to Proposition 6, because a worker's marginal utility of consumption is high, the marginal benefit of severance payments becomes greater in a partial equilibrium when the private borrowing costs get higher. In a general equilibrium, higher interest rates not only hurt borrowers but also hurt workers in general as wages and transfers fall further. We show that despite the negative effects stemming from price changes, the partial equilibrium effects still survive and deliver net positive welfare benefits of severance payments in the presence of debt monitoring costs.

In order to show that severance payments under high private borrowing costs improve welfare, we repeat the same exercise we did in the previous section with $\alpha = 0.0033$ which is equivalent to a 2% annual rate. Table 3.2 reports the results of this numerical exercise with severance payment amounts equal to one month and six months of wages.

Table 3.2: *Effects of severance payments when* $\alpha = 0.0033$

Months of wages	No severance payment	1 month	6 months
Unemployment rate	5.9%	5.9%	5.9%
Employment	100.0	99.8	99.0
Output	100.0	99.6	98.8
Assets	100.0	99.1	97.7
Consumption	100.0	100.0	99.7
S.D. Consumption	100.0	99.5	99.5
Welfare (new born)	100.0	100.8	104.7
Welfare (average)	100.0	100.6	103.6

Overall, with additional private borrowing costs, both the welfare of the newborn in the economy and the average welfare increase with severance payments. Workers greatly reduce precautionary savings when severance payments equal to six months of wages are provided. This shifts the asset distribution to the left. However, even though total consumption falls in the counterfactual economy with high severance payments, the average of the ratio of consumption in each worker state actually increases. Also, compared to the case without private borrowing costs, the standard deviation of consumption does not rebound with higher severance payments. Combined with the results in Table 3.1, the results presented here show that Proposition 6 also holds in a general equilibrium. Thus, there is room for welfare improvement with severance payments when the workers face high private borrowing costs relative to the firms.

3.4 Conclusion

This paper shows that when workers face private borrowing costs that are higher than the equilibrium interest rates, severance payments can be used to improve welfare by transferring the downside business cycle risks from the workers to the firms. The partial equilibrium intuition behind the result is shown through a simple finite period model. Holding fixed the equilibrium interest rates and transfers, the benefit of severance payments increases as private borrowing costs increase and as a worker's precautionary savings motive increases. This result holds even if the contracted wages fall with severance payments. To extend the result to a general equilibrium setting, we numerically run policy experiments using an Aiyagari-type incomplete market model calibrated to the U.S. economy. In the absence of private monitoring costs, we reproduce the well-known welfare neutrality of severance payments. This neutrality breaks down once monitoring costs are introduced. As the costs of job loss become higher with additional private borrowing costs, severance payments become beneficial. These results provide an additional explanation of why severance payments are more generous in low per capita income countries compared to high income economies.

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Appendix A

Appendix to Chapter 1

A.1 Appendix Tables

Table A.1: *Product Introduction and Cash during the Financial Crisis (SIC 3-digit)*

The following table reports the coefficient estimates and their standard errors from the baseline regression (1.2) *described in section 1.4. The sample only includes the firms who have product introduction announcement records present in CIKD from 2006:Q3 to 2008:Q2. Each sample period begins in 2006:Q3 and ends in the quarter reported in each column. The dependent variable is the natural logarithm of one plus the number of product launch announcements. FC is a dummy variable equal to 1 from 2007:Q3. Cash is the quarterly average of cash reserves (cheq) over total assets (atq) from 2005:Q3 to 2006:Q2. ROA is operating income before depreciation (oibdp) over lagged total assets (atq_{t-1}). Q is Tobin's Q computed as the market value of assets over their book value. Size is the natural logarithm of total assets. Standard errors are clustered at the firm level. Industries are classified at the SIC 3-digit level for industry-quarter fixed effects.*

	Dependent variable:		
	ln(1 + Product launch announcements)		
	(1)	(2)	(3)
FC	0.050***	0.052***	0.047***
	(0.015)	(0.014)	(0.013)
FC x Cash	−0.103**	−0.102**	−0.104***
	(0.044)	(0.041)	(0.038)
ROA_{t-1}	0.179	−0.010	−0.087
	(0.325)	(0.261)	(0.213)
Q	−0.001	0.002	0.005
	(0.010)	(0.009)	(0.008)
Size	0.120***	0.087***	0.100***
	(0.041)	(0.030)	(0.024)
End Quarter	2008:Q2	2008:Q4	2009:Q2
Firm FE	Yes	Yes	Yes
Industry x Quarter FE	Yes	Yes	Yes
Observations	9,596	11,798	13,902
R^2	0.679	0.670	0.665
Note:			*p<0.1; **p<0.05; ***p<0.01

Table A.2: *Product Introduction and Cash during the Financial Crisis with interacted controls*

The following table reports the coefficient estimates and their standard errors from the baseline regression (1.2) *described in section 1.4 modified to include interaction term of financial crisis dummy and pre-crisis firm size. The sample only includes the firms who have product introduction announcement records present in CIKD during the sample period. The dependent variable is the natural logarithm of one plus the number of product launch announcements. FC is a dummy variable equal to 1 from 2007:Q3. Cash (pre-FC), ROA_{t-1} (pre-FC), Q (pre-FC), and Size (pre-FC) are the standardized quarterly average of each variable from 2005:Q3 to 2006:Q2. Cash is cash reserves (cheq) over total assets (atq). ROA is operating income before depreciation (oibdp) over lagged total assets (atq_{t-1}). Q is Tobin's Q computed as the market value of assets over their book value. And Size is the natural logarithm of assets. Standard errors are clustered at the firm level.*

	Dependent variable:		
	ln(1 + Product launch announcements)		
	(1)	(2)	(3)
FC	0.027***	0.028***	0.022**
	(0.010)	(0.010)	(0.009)
FC x Cash (pre-FC)	−0.023*	−0.023**	−0.023**
	(0.012)	(0.011)	(0.010)
FC x ROA_{t-1} (pre-FC)	0.003	0.002	0.004
	(0.011)	(0.010)	(0.010)
FC x Q (pre-FC)	0.017	0.015	0.017
	(0.012)	(0.011)	(0.011)
FC x Size (pre-FC)	0.008	0.009	0.010
	(0.010)	(0.009)	(0.009)
ROA_{t-1}	0.199	−0.087	0.014
	(0.312)	(0.247)	(0.190)
Q	−0.003	0.0001	0.005
	(0.010)	(0.009)	(0.008)
Size	0.095**	0.076**	0.087***
	(0.043)	(0.031)	(0.025)
End Quarter	2008:Q2	2008:Q4	2009:Q2
Firm FE	Yes	Yes	Yes
Industry x Quarter FE	Yes	Yes	Yes
Observations	9,276	11,389	13,407
R^2	0.669	0.661	0.657
Note:			*p<0.1; **p<0.05; ***p<0.01

Table A.3: *Product Introduction, Innovation, and Net Short-term Debt during the Financial Crisis*

The following table presents estimates from the baseline regression described in section 1.4 with net short-term debt ratio instead of cash ratio.[a] *All dependent variables are the natural logarithm of one plus the underlying counts. The count variable underlying AN is the number of product launch announcements. PT represents the transformed number of total patent applications. Radical PT and Typical PT represent the transformed number of potentially radical patents applied and the transformed number of potentially typical patents applied, respectively, classified using the index developed by Eggers and Kaul (2018). TM is the transformed number of new trademarks first used and TMf is the transformed number of intent-to-use trademark applications. FC is a dummy variable equal to 1 from 2007:Q3. Net Short-term Debt is the quarterly average of short-term debts net of cash (dlcq - cash) over total assets (atq) from 2005:Q3 to 2006:Q2. ROA is operating income before depreciation (oibdp) over lagged total assets (atq_{t-1}). Q is Tobin's Q computed as the market value of asset over their book value. Size is the natural logarithm of total assets. Standard errors are clustered at the firm level.*

	Dependent variable:					
	AN	PT	Radical PT	Typical PT	TM	TMf
	(1)	(2)	(3)	(4)	(5)	(6)
FC	0.047***	−0.023***	−0.021***	−0.020**	−0.011	−0.004
	(0.013)	(0.009)	(0.008)	(0.009)	(0.010)	(0.013)
FC x Net Short-term Debt	0.098**	−0.066*	−0.091***	−0.018	−0.021	−0.023
	(0.040)	(0.037)	(0.032)	(0.035)	(0.028)	(0.041)
ROA_{t-1}	0.273	0.266	0.089	0.416**	0.072	−0.117
	(0.307)	(0.224)	(0.184)	(0.206)	(0.216)	(0.251)
Q	−0.003	0.025**	0.019**	0.018**	0.013	0.026**
	(0.010)	(0.010)	(0.009)	(0.009)	(0.009)	(0.013)
Size	0.099**	0.083**	0.036	0.078**	0.081***	0.114***
	(0.041)	(0.037)	(0.028)	(0.033)	(0.028)	(0.039)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Industry x Quarter FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	9,529	9,529	9,529	9,529	9,529	9,529
R^2	0.668	0.931	0.888	0.917	0.688	0.721
Note:						*p<0.1; **p<0.05; ***p<0.01

[a] Duchin *et al.* (2010) use net short-term debt ratio as a measure of liquidity instead of cash ratio for robustness test. We also find that our results are robust to the use of the alternative measure.

Appendix B

Appendix to Chapter 2

B.1 Description of Sampling Procedure

We first construct the Whited-Wu index by closely following the procedure described in Whited (1992) and Whited and Wu (2006). We first exclude regulated industries with SIC codes 4900-4999 or 6000-6999. In order to compute the annual Whited-Wu index, we take quarterly arithmetic averages for flow variables such as cash flow, firm sales growth, and industry sales growth, while we use annual variables for stock variables such as total assets and total debt. Following Whited and Wu (2006), for the purpose of the index construction, we use 3-digit SIC codes for industry sales growth. We compute replacement costs of assets as in Whited and Wu (2006) and deflate the variables used for the index construction.

We use two separate samples for our empirical analysis. The first sample is constructed to perform the regression analysis of the changes in corporate investment after the adoption of wrongful discharge laws. We use the panel of COMPUSTAT public firms for the period 1971 to 1999, excluding the utility industry (SIC codes 4900-4999) and finance industry (SIC codes 6000-6999). We remove firm-year data points with non-positive sales, and construct an industry competition measure defined as the fraction of total industry sales by competitors in the given state and year. This process enables us to more accurately estimate each firm's market share in the corresponding state. Next, we drop the data points with missing information on common shares outstanding, common equity values, end of fiscal year price of common stocks, and net income. We also drop observations with non-positive or missing values for asset, capital stock, depreciation value, and capital investment, and those with negative or missing values for long-term debt, short-term debt, R&D spending, and dividend payment. We then convert all nominal COMPUSTAT and state-level variables into real values in 2009 dollars.

Using the sample we have at this stage, we construct all regression variables and controls following the definition of variables listed in Appendix Table A3. Because the construction of variables entails normalization by total assets at the end of the last fiscal year, some observations have missing values. We drop all data points with missing values. Finally, we winsorize all of the independent variables in the regression analysis at 1% and 99%, and standardize all of the independent variables in order to easily capture the economic magnitude of each variable's impact. The annual industry average R&D and capital investment intensities are computed after dropping observations, for industries with fewer than ten firms in a given year. This is to make sure that we have enough observations to get reliable estimates of industry averages. For each industry, we also estimate the industry layoff elasticity to the industry business cycle. This process generates our final panel dataset that are used for the regression analysis of corporate investment.

The second sample is constructed for analysis of operating leverage, earnings, and cash holding. To begin with, we sample firm-year data between 1971 and 1999 with positive sales and capital expenditure, excluding the utility industry and finance industry. We also require that the values of cash stock, interest expenses, income taxes, dividends, working capital, long-term debt, current debt liabilities, and acquisitions are not missing and non-negative. Because we need data on the price of equity and common shares outstanding to measure the market value of a firm, we also drop observations with missing values for these variables. Because R&D investment is no longer a dependent variable, following Bates *et al.* (2009), we set missing R&D expenses to zero in order to avoid losing too many data points. The procedures we followed for the construction of regression variables, winsorization, and standardization are identical to the ones we followed for the first sample.

B.2 Description of Whited-Wu Index

Whited and Wu (2006) solve a firm's dynamic optimization problem, which is to maximize the expected present value of a dividend stream subject to debt and equity constraints. Then, taking the firm investment Euler equations as moments and setting the multiplier on the external financing constraint (the shadow value of external finance) as a linear function of observable firm characteristics, they use GMM to jointly estimate the model parameters including the coefficients on the variables in the linear function. The empirical measure of a firm's financial constraints is defined as the fitted value of the shadow value of external finance. Using the coefficient estimates documented in Whited and Wu (2006), we compute the index of firm financial constraints as follows.

$$\begin{aligned} \text{FC} = & -0.091 \times \frac{\text{Cash Flow}}{\text{Asset}} - 0.062 \times \text{Dividend Indicator} \\ & + 0.021 \times \frac{\text{Long Term Debt}}{\text{Asset}} - 0.044 \times \log(\text{Asset}) \\ & + 0.102 \times \text{Industry Growth} - 0.035 \times \text{Firm Growth} \end{aligned}$$

We directly use the coefficient estimates from Whited and Wu (2006) given that our sample periods mostly overlap with the sample periods of the samples they used for the estimation.

B.3 Appendix Tables

Table B.1: *Determinants of Aggregate Private R&D Expenditure*

This table reports coefficient estimates from a regression of each OECD country's gross private R&D expenditure as a percentage of GDP on the country's employment protection index from the Indicators of Employment Protection provided by OECD, GDP growth rate, changes in average total working hours (in thousand hours) normalized by population, and gross fixed capital formation normalized by GDP. The standard errors are clustered at country level. Country fixed effects and year fixed effects are included.

Dep.Variable	R&D/GDP (%)
Employment Protection Index	$-0.18*$
	(0.10)
ΔGDP	0.09
	(0.89)
ΔTotal Working Hours	0.30
	(1.18)
ΔCapital	-0.31
	(0.81)
Country FE	Yes
Year FE	Yes
Obs	432
R-squard	0.26

Table B.2: *Average R&D Intensity of Publicly Listed Firms and GF-Adoption Status of Each U.S. State*

The following table shows the time-series average of the annual cross-sectional mean R&D intensity and capital expenditure intensity of the firms in our sample. The time-series median number of firms within each state is also presented. The GF column shows whether each state has been adopted good-faith exception at least for one year in our sample period 1971-1999.

State	R&D	CapEx	Firms	GF	State	R&D	CapEx	Firms	GF
AK	0.1580	0.0044	1	Yes	DE	0.0509	0.0884	5	Yes
VT	0.1402	0.0440	1		MO	0.0481	0.0740	19	
ME	0.1357	0.0577	1		IN	0.0452	0.0713	13	
MT	0.1349	0.0592	1	Yes	CT	0.0451	0.0719	46	Yes
OR	0.1251	0.0878	10		WV	0.0451	0.0374	1	
WA	0.1085	0.0825	15		VA	0.0441	0.0670	30	
CA	0.1062	0.0875	185	Yes	MI	0.0440	0.0800	39	
MA	0.0933	0.0751	83	Yes	SC	0.0440	0.0814	3	
NH	0.0842	0.0684	8	Yes	NC	0.0434	0.0698	20	
MD	0.0761	0.0767	21		AR	0.0434	0.1028	3	
NJ	0.0760	0.0643	78		NV	0.0434	0.1043	3	Yes
MN	0.0734	0.0828	57		IL	0.0407	0.0734	64	
HI	0.0694	0.4005	1		RI	0.0389	0.0619	7	
AZ	0.0683	0.0675	10	Yes	LA	0.0382	0.0714	2	Yes
KS	0.0680	0.0660	7		OH	0.0360	0.0654	47	
SD	0.0647	0.0694	2		WI	0.0325	0.0725	26	
AL	0.0632	0.0683	3		OK	0.0290	0.0995	7	Yes
CO	0.0601	0.1084	27		NM	0.0260	0.0873	1	
FL	0.0598	0.0885	37		ND	0.0229	0.0466	1	
GA	0.0579	0.0854	14		TN	0.0226	0.0658	6	
TX	0.0564	0.1023	72		KY	0.0198	0.0625	4	
PA	0.0531	0.0713	56		IA	0.0195	0.0652	5	
NY	0.0527	0.0662	105		MS	0.0104	0.1693	1	
UT	0.0526	0.0810	11		WY	0.0000	0.1967	1	Yes
ID	0.0512	0.1667	1	Yes					

Table B.3: *Description of Variables (Firm Investment Variables)*

The following table presents the detailed description of firm investment variables, measures of financial constraints, and the control variables we use in the analyses of the impact of the adoption of wrongful discharge laws on firm investment decisions.

Variables	Descriptions	Sources	Range
Exogenous Shock to Labor Rigidity			
WDL	Indicator variables for the adoption status of wrongful discharge laws: Good-Faith (GF), Implied Contract (IC), and Public Policy (PP)	Autor, Kerr, and Kugler (2007)	1971-1999
Discretionary Investment Variables			
XRD	R&D expenditure divided by total assets at the end of last fiscal year	COMPUSTAT	1971-1999
CAPX	Capital expenditure divided by total assets at the end of last fiscal year	COMPUSTAT	1971-1999
Measures of Financial Constraint			
FC	Financial constraint index constructed using the structurally estimated equation from Whited and Wu (2006)	COMPUSTAT	1971-1999
KZ	The measure of financial distress from Kaplan and Zingales (1997)	COMPUSTAT	1971-1999
AGE	Negative value of the number of years since IPO	COMPUSTAT	1971-1999
MKT	Negative value of the log of market equity at the end of the calendar year that overlaps with the fiscal year the most	CRSP	1971-1999
Investment Controls			
TOBINQ	Log of market equity plus book liability divided by book assets	COMPUSTAT	1971-1999
SIZE	Log of the amount of total assets in 2009 dollars	COMPUSTAT	1971-1999
SIZESQ	Squared value of SIZE	COMPUSTAT	1971-1999
COMP	Share of industry total revenue generated by the corporation's industry competitors within the state where its headquarter is located	COMPUSTAT	1971-1999
COMPSQ	Squared value of COMP	COMPUSTAT	1971-1999
SHARE	Industry share of GSP	U.S. BEA	1971-1997
POP	Log of population	COMPUSTAT	1971-1999
UE	Unemployment rate: national (1971-1975), state (1976-1999) level	U.S. BLS	1971-1999
GSP	Log of real gross product within the state where the corporation's headquarter is located in	U.S. BEA	1971-1997
HE	Log of number of institutions for higher education in each state	U.S. Census	1971-1999
EN	Log of enrollment in institutions for higher education in each state	U.S. Census	1971-1999
POL	Political balance: share of democratic seats in state lower house	U.S. Census	1971-1999
TAX	R&D user cost in each state divided by the sum of real interest rate and R&D capital depreciation rate	Wilson (2009)	1971-1999

Table B.4: *Description of Variables (Firm Performance and Capital Structure Variables)*

The following table presents the description of variables representing firm performance and capital structure, and the control variables we use in the analyses of the impact of the adoption of wrongful discharge laws on these variables.

Variables	Descriptions	Sources	Range
Firm Performance Measures			
OIBDP	Operating income before depreciation divided by total assets at the end of last fiscal year	COMPUSTAT	1971-1999
ROA	Income before extraordinary items plus interest expenses divided by total assets at the end of last fiscal year	COMPUSTAT	1971-1999
CF	Income before extraordinary items minus total accruals (defined as the sum of changes in current assets and changes in short-term debt minus the sum of changes in cash, changes in current liabilities, and depreciation expenses) divided by total assets at the end of last fiscal year	COMPUSTAT	1971-1999
PM	Sum of income before extraordinary items, interest expenses, and total income taxes divided by sales	COMPUSTAT	1971-1999
Firm Performance Controls			
PSALE	Sales divided by total assets at the end of last fiscal year	COMPUSTAT	1971-1999
PCAPX	Capital expenditure divided by total assets at the end of last fiscal year	COMPUSTAT	1971-1999
PXRD	R&D expenditure divided by total assets at the end of last fiscal year	COMPUSTAT	1971-1999
PTOBINQ	Log of market equity plus book liability divided by book assets at the end of last fiscal year	COMPUSTAT	1971-1999
PSIZE	Log of total assets at the end of last fiscal year in 2009 dollars	COMPUSTAT	1971-1999
PNWC	Net working capital minus cash and marketable securities divided by total assets at the end of last fiscal year	COMPUSTAT	1971-1999
PCHE	Cash holding divided by total assets at the end of last fiscal year	COMPUSTAT	1971-1999
Capital Structure			
CHE	Cash holdings and marketable securities divided by total assets	COMPUSTAT	1971-1999
DC	Changes in the sum of long-term debt and current liabilities divided by total assets	COMPUSTAT	1971-1999
NEI	Net sales of common and preferred stocks divided by total assets	COMPUSTAT	1971-1999
DIV	Dividends for common and preferred stocks divided by total assets	COMPUSTAT	1971-1999
Firm Capital Structure Controls			
CTOBINQ	Log of market equity plus book liability divided by book assets	COMPUSTAT	1971-1999
CSIZE	Log of total assets in 2009 dollars	COMPUSTAT	1971-1999
CCAPX	Capital expenditure divided by total assets	COMPUSTAT	1971-1999
CXRD	R&D expenditure divided by total assets	COMPUSTAT	1971-1999
CLEV	Ratio of total debt to book assets	COMPUSTAT	1971-1999
CNWC	Net working capital minus cash and marketable securities divided by total assets	COMPUSTAT	1971-1999
CDD	Indicator variable equal to 1 if the firm is paying dividends	COMPUSTAT	1971-1999

Table B.4: *(Continued)*

Variables	Descriptions	Sources	Range
CCF	Earnings before interest and taxes minus interest, taxes, and common dividends divided by total assets	COMPUSTAT	1971-1999
CICF	Mean of the standard deviations of cash flow divided by total assets over 10 years among the firms in the same industry	COMPUSTAT	1971-1999
CACQ	Expenditures on acquisitions divided by total assets	COMPUSTAT	1971-1999

Table B.5: *Industry Layoff Elasticity, Labor Share, and Investment*

The following table provides the complete version of Table 2.10, the list of the estimates of the industry layoff elasticity to the growth rate of the real industry output in a descending order. In the table, Elasticity reports estimated industry layoff elasticity, and Rate, Share, R&D, and CapEx report industry time-series mean and standard deviation of annual layoff rate, labor share, average R&D intensity, and average capital expenditure intensity. Innovation is the number of high technology patents granted to each industry over the sample period, and the brackets show the industry rank of the patent number. All measures are reported in percentage units. For the detailed descriptions of variable construction, see Table 2.10.

Industry Description	Elasticity (%)	Rate (%)	Share (%)	R&D (%)	CapEx (%)	Innovations
Metal mining	6.55	8.42	57.41	0.13	15.76	43 [11]
	(2.60)	(10.62)	(14.28)	(0.16)	(6.59)	
Oil and gas extraction	2.67	5.72	21.95	0.34	19.67	12 [5,134]
	(0.82)	(2.84)	(3.68)	(0.16)	(5.98)	
Furniture and fixtures	1.30	5.12	80.80	0.87	6.82	21 [607]
	(0.73)	(2.65)	(3.90)	(0.16)	(1.72)	
Industrial machinery, equipments	1.14	4.61	75.27	5.11	7.13	3 [65,068]
	(0.32)	(1.88)	(2.86)	(1.49)	(1.32)	
Primary and metal industries	1.07	3.98	75.67	0.73	8.02	16 [3,059]
	(0.57)	(2.70)	(6.47)	(0.35)	(1.21)	
Rubber, miscellaneous plastic products	0.92	3.95	76.25	1.49	8.62	13 [4,409]
	(0.65)	(1.64)	(2.66)	(0.32)	(1.65)	
Railroad Transportation	0.84	2.32	74.88	0.00	9.65	51 [1]
	(0.36)	(1.58)	(4.14)	(0.00)	(2.94)	
Fabricated metal products	0.72	4.63	72.97	1.08	6.51	14 [3,625]
	(0.38)	(1.57)	(4.49)	(0.14)	(0.91)	
Stone, clay, and glass products	0.66	3.78	74.48	0.88	9.73	15 [3,225]
	(0.53)	(2.24)	(6.33)	(0.41)	(2.29)	
Chemicals and allied products	0.65	2.86	53.81	4.00	7.66	1 [94,131]
	(0.27)	(1.23)	(5.70)	(0.70)	(0.84)	
Printing and publishing	0.56	3.24	70.84	0.37	7.32	29 [220]
	(0.34)	(1.20)	(2.42)	(0.29)	(1.37)	
Apparel, other textile products	0.50	6.80	79.14	0.11	4.64	30 [174]
	(0.84)	(2.39)	(3.67)	(0.11)	(1.14)	
Farms	0.46	1.53	16.78	1.88	8.12	18 [900]
	(0.19)	(0.77)	(2.55)	(0.00)	(0.00)	
Amusement, recreational services	0.35	2.52	58.79	0.21	11.64	32 [53]
	(0.26)	(0.98)	(2.12)	(0.23)	(4.01)	
Miscellaneous manufacturing	0.35	5.13	64.11	1.37	6.46	19 [889]
	(0.44)	(1.74)	(6.86)	(0.31)	(0.91)	
Health services	0.29	1.22	75.76	0.35	10.73	26 [242]
	(0.11)	(0.55)	(3.03)	(0.18)	(2.77)	
Motor vehicles and equipment	0.29	3.61	73.25	2.12	7.73	6 [27,409]

Table B.5: *(Continued)*

Industry Description	Elasticity (%)	Rate (%)	Share (%)	R&D (%)	CapEx (%)	Innovations
	(0.48)	(1.63)	(9.29)	(0.64)	(1.47)	
Lumber and wood products	0.26	4.96	61.49	0.22	8.39	25 [342]
	(0.68)	(2.02)	(3.81)	(0.13)	(1.70)	
Other transportation equipment	0.26	4.38	95.77	2.54	6.39	8 [20,683]
	(0.41)	(1.99)	(10.64)	(0.43)	(1.50)	
Textile mill products	0.24	3.98	77.13	0.63	7.86	23 [392]
	(0.50)	(1.79)	(2.77)	(0.18)	(1.72)	
Instrument and related products	0.19	3.81	85.77	6.68	7.12	7 [25,431]
	(0.26)	(1.22)	(9.30)	(1.01)	(1.16)	
Paper and allied products	0.16	2.86	65.64	0.77	9.84	11 [9,984]
	(0.33)	(1.30)	(4.29)	(0.17)	(1.48)	
Transportation by air	0.15	3.03	71.10	0.00	20.45	45 [8]
	(0.43)	(1.87)	(5.04)	(0.00)	(6.88)	
Personal services	0.07	2.25	52.04	0.05	8.40	37 [27]
	(0.20)	(1.48)	(2.89)	(0.00)	(0.00)	
Communications	0.02	2.17	41.97	0.51	9.01	10 [15,080]
	(0.22)	(0.79)	(5.90)	(0.31)	(2.09)	
Business services	−0.02	3.68	63.55	4.50	8.82	4 [51,415]
	(0.31)	(1.21)	(2.50)	(1.94)	(2.27)	
Other services	−0.06	2.75	70.05	1.07	7.13	24 [343]
	(0.17)	(0.72)	(6.61)	(0.67)	(1.67)	
Trucking and warehousing	−0.08	3.34	66.72	0.01	18.14	54 [0]
	(0.36)	(1.25)	(2.50)	(0.03)	(4.15)	
Motion pictures	−0.12	4.02	61.19	0.04	13.19	40 [18]
	(0.58)	(1.78)	(6.94)	(0.07)	(5.28)	
Electronic, other electric equipment	−0.16	4.61	70.31	5.46	8.46	2 [91,007]
	(0.45)	(1.53)	(12.28)	(1.34)	(1.46)	
Petroleum and coal products	−0.18	2.98	47.49	0.68	10.80	9 [18,442]
	(1.38)	(2.86)	(12.02)	(0.30)	(2.55)	
Food and kindred products	−0.23	3.67	58.05	0.35	8.63	17 [1,895]
	(0.49)	(1.20)	(4.69)	(0.09)	(0.97)	
Leather and leather products	−0.42	7.93	71.22	0.43	3.98	38 [26]
	(1.06)	(4.11)	(9.21)	(0.32)	(0.90)	

Table B.8: *Robustness Test for Table 2.3: Fixed Effects and Time Trends*

We replicate Columns (2) and (4) in Table 2.3 using different specifications for fixed effects and time trend. BEA industry classification is used to construct industry-specific time fixed effect dummy variables. Region is the U.S. census regions that group the states by geographic locations.

Dep.Var: Earnings Growth	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Sales Growth	1.527***	1.528***	1.531***	1.528***	—	—	—	—
	(0.024)	(0.026)	(0.026)	(0.026)				
Sales Growth×GF	0.249***	0.272***	0.269***	0.268***	0.201***	0.218***	0.214***	0.214***
	(0.075)	(0.073)	(0.077)	(0.075)	(0.066)	(0.066)	(0.069)	(0.068)
Sales Growth×IC	0.034	0.022	0.021	0.023	0.029	0.016	0.015	0.017
	(0.048)	(0.047)	(0.049)	(0.048)	(0.043)	(0.042)	(0.043)	(0.043)
Sales Growth×PP	−0.033	−0.037	−0.041	−0.037	−0.036	−0.036	−0.039	−0.035
	(0.053)	(0.055)	(0.056)	(0.056)	(0.046)	(0.047)	(0.048)	(0.048)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE, Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry×Year FE		Yes	Yes	Yes		Yes	Yes	Yes
Region×Year FE			Yes				Yes	
State Trend				Yes				Yes
Obs	48,859	48,859	48,859	48,859	48,859	48,859	48,859	48,859
R-Squared	0.312	0.341	0.343	0.342	0.318	0.346	0.348	0.347

Table B.6: *Subsample Descriptive Statistics (Firm Investment Variables)*

The following table shows the descriptive statistics of investment variables, measures of financial constraints, and the control variables we use in the analyses of the impact of the adoption of wrongful discharge laws on firm investment decisions, for each subsample consist of the firms whose industry layoff elasticity is below or above the median. Table B.3 provides the definition of variables.

Layoff Elasticity	Low						High					
Variables	Obs	Mean	Std	Min	Median	Max	Obs	Mean	Std	Min	Median	Max
Discretionary Investment Variables												
R&D/Asset	10,706	0.075	0.101	0.000	0.043	2.736	17,468	0.076	0.136	0.000	0.037	5.727
CapEx/Asset	10,706	0.081	0.092	0.000	0.060	3.283	17,468	0.073	0.083	0.000	0.055	2.756
Total Investment/Asset	10,706	0.156	0.141	0.000	0.120	3.676	17,468	0.150	0.165	0.000	0.109	7.074
R&D/ME	10,706	0.089	0.168	0.000	0.045	5.305	17,468	0.081	0.185	0.000	0.043	10.351
CapEx/ME	10,706	0.115	0.173	0.000	0.070	7.995	17,468	0.117	0.210	0.000	0.065	7.038
Total Investment/ME	10,706	0.204	0.267	0.000	0.138	10.245	17,468	0.198	0.320	0.000	0.130	13.340
R&D/Total Investment	10,706	0.424	0.277	0.000	0.404	0.996	17,468	0.434	0.268	0.000	0.408	0.999
Measures of Financial Constraint												
Whited and Wu (2006)	10,706	−0.232	0.115	−0.533	−0.215	0.007	17,468	−0.242	0.110	−0.533	−0.239	0.007
Kaplan and Zingales (1997)/100	10,706	−0.034	0.081	−1.080	−0.014	0.115	17,468	−0.036	0.086	−1.080	−0.018	0.115
IPO Age/10	10,706	−1.107	0.665	−2.900	−0.900	−0.300	17,468	−1.156	0.679	−2.900	−1.000	−0.300
Market Capitalization	10,706	−4.978	2.251	−11.272	−4.771	0.303	17,468	−5.066	2.060	−11.439	−4.905	0.303
Investment Controls												
dGSP	10,706	0.035	0.030	−0.051	0.037	0.105	17,468	0.033	0.032	−0.051	0.036	0.105
Tobin's Q	10,706	0.402	0.549	−0.874	0.280	2.554	17,468	0.399	0.572	−0.874	0.267	2.554
Size	10,706	5.162	2.205	0.533	4.918	10.783	17,468	5.256	2.070	0.533	5.132	10.761
Competition	10,706	0.738	0.361	0.000	0.947	1.000	17,468	0.783	0.321	0.000	0.954	1.000
GSP Share	10,706	0.025	0.015	0.001	0.024	0.093	17,468	0.024	0.027	0.001	0.016	0.191
Population	10,706	9.131	0.817	6.742	9.282	10.380	17,468	9.071	0.808	6.742	9.133	10.380
Unemployment Rate	10,706	6.450	1.735	3.250	6.233	11.933	17,468	6.522	1.797	3.250	6.242	11.933
GSP	10,706	12.620	0.890	9.987	12.607	14.100	17,468	12.542	0.876	9.987	12.566	14.100
Higher Education	10,706	4.812	0.786	2.303	4.796	5.981	17,468	4.757	0.766	2.303	4.787	5.981
Enrollment	10,706	13.127	0.865	10.646	13.085	14.498	17,468	13.056	0.851	10.646	13.059	14.498
Political Balance	10,706	0.602	0.126	0.277	0.592	0.893	17,468	0.592	0.127	0.277	0.587	0.893
R&D User Cost	10,706	1.333	0.139	1.132	1.302	1.540	17,468	1.346	0.138	1.132	1.373	1.540

Table B.7: *Subsample Descriptive Statistics (Firm Performance and Capital Structure Variables)*

The following table shows the descriptive statistics of variables representing firm performance and capital structure, and the control variables we use in the analyses of the impact of the adoption of wrongful discharge laws on these variables, for each subsample consist of the firms whose industry layoff elasticity is below or above the median. Table B.4 provides the definition of variables.

Layoff Elasticity	Low						High					
Variables	Obs	Mean	Std	Min	Median	Max	Obs	Mean	Std	Min	Median	Max
Firm Performance Measure												
Earnings	18,483	0.197	0.111	0.000	0.179	1.332	19,790	0.194	0.108	0.001	0.177	1.807
Cash Flow	18,483	0.098	0.124	−2.139	0.102	1.297	19,790	0.098	0.120	−2.595	0.102	1.299
ROA	18,483	0.102	0.074	−1.511	0.093	0.963	19,790	0.102	0.073	−2.661	0.094	1.058
Profit Margin	18,483	0.112	0.103	−0.897	0.095	3.724	19,790	0.119	0.100	−1.862	0.102	2.621
Firm Performance Controls												
Sales	18,483	1.634	0.867	0.239	1.472	7.229	19,790	1.491	0.670	0.239	1.425	7.229
Tobin's Q	18,483	0.349	0.510	−0.816	0.248	2.169	19,790	0.265	0.474	−0.816	0.180	2.169
Size	18,483	5.032	1.844	1.156	4.861	9.890	19,790	5.253	1.754	1.156	5.142	9.890
Capital Expenditure	18,483	0.087	0.080	0.003	0.063	0.677	19,790	0.086	0.083	0.003	0.062	0.677
R&D Investment	18,483	0.036	0.055	0.000	0.008	0.324	19,790	0.021	0.039	0.000	0.004	0.324
Leverage	18,483	0.209	0.167	0.000	0.189	0.815	19,790	0.225	0.164	0.000	0.211	0.815
Net Working Capital	18,483	0.207	0.162	−0.162	0.201	0.632	19,790	0.223	0.155	−0.162	0.224	0.632
Cash Holdings	18,483	0.134	0.151	0.000	0.073	0.726	19,790	0.108	0.121	0.000	0.062	0.726
Firm Capital Structure												
Cash Holdings	18,483	0.131	0.150	0.000	0.071	0.972	19,790	0.105	0.120	0.000	0.059	0.985
Net Equity Issuance	18,483	0.010	0.083	−2.365	0.000	0.976	19,790	0.005	0.068	−0.840	0.000	1.424
Dividend Payout	18,483	0.013	0.027	−0.004	0.005	1.440	19,790	0.017	0.047	0.000	0.011	3.093
Changes in Debt Outstanding	18,483	0.011	0.111	−1.855	0.000	1.998	19,790	0.012	0.115	−3.820	0.000	1.851
Firm Capital Structure Controls												
Tobin's Q	18,483	0.327	0.496	−0.794	0.231	2.351	19,790	0.240	0.455	−0.794	0.161	2.351
Size	18,483	5.137	1.825	1.223	4.981	9.970	19,790	5.340	1.740	1.223	5.234	9.970
Capital Expenditure	18,483	0.074	0.060	0.003	0.058	0.421	19,790	0.075	0.062	0.003	0.058	0.421
R&D Investment	18,483	0.032	0.046	0.000	0.008	0.271	19,790	0.019	0.033	0.000	0.004	0.271
Leverage	18,483	0.208	0.167	0.000	0.189	0.848	19,790	0.226	0.164	0.000	0.213	0.848
Net Working Capital	18,483	0.209	0.162	−0.156	0.202	0.616	19,790	0.224	0.155	−0.156	0.223	0.616
Dividend Dummy	18,483	0.515	0.500	0.000	1.000	1.000	19,790	0.624	0.484	0.000	1.000	1.000
Cash Flow	18,483	0.092	0.053	−0.084	0.087	0.283	19,790	0.086	0.050	−0.084	0.082	0.283
Industry Cash Flow Risk	18,483	0.055	0.031	0.012	0.044	0.123	19,790	0.050	0.030	0.010	0.042	0.189
Acquisition	18,483	0.018	0.052	0.000	0.000	0.425	19,790	0.018	0.050	0.000	0.000	0.425

Table B.9: *Robustness Test for Table 2.5: Fixed Effects and Time Trends*

Panel A replicates Columns (2) and (4) in Table 2.5 using different specifications for fixed effects and time trend. BEA industry classification is used to construct industry-specific time fixed effect dummy variables. Region is the U.S. census regions that group the states by geographic locations. Panel B replicates Columns (6) and (8) in Table 2.5.

A. R&D Investment

Dep.Var: R&D/Asset (%)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Good Faith (GF)	−0.185	−0.220	−0.263	−0.320	−1.000***	−1.027***	−1.035***	−0.808***
	(0.182)	(0.179)	(0.228)	(0.193)	(0.257)	(0.254)	(0.300)	(0.260)
FC Index (FC)					−1.775**	−1.802**	−1.846**	−1.804**
					(0.756)	(0.739)	(0.752)	(0.751)
FC×GF					−1.550***	−1.568***	−1.502***	−1.590***
					(0.432)	(0.432)	(0.452)	(0.452)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE, Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry×Year FE		Yes	Yes	Yes		Yes	Yes	Yes
Region×Year FE			Yes				Yes	
State Trend				Yes				Yes
Obs	28,174	28,174	28,174	28,174	28,174	28,174	28,174	28,174
R-Squared	0.021	0.029	0.032	0.032	0.027	0.035	0.038	0.038

B. Capital Investment

Dep.Var: CapEx/Asset (%)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Good Faith (GF)	−0.510	−0.286	−0.175	0.121	−0.584*	−0.380	−0.274	0.020
	(0.399)	(0.308)	(0.363)	(0.308)	(0.326)	(0.268)	(0.371)	(0.300)
FC Index (FC)					−0.527	−0.626*	−0.619*	−0.583*
					(0.337)	(0.337)	(0.336)	(0.335)
FC×GF					−0.125	−0.169	−0.174	−0.325
					(0.306)	(0.289)	(0.290)	(0.267)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE, Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry×Year FE		Yes	Yes	Yes		Yes	Yes	Yes
Region×Year FE			Yes				Yes	
State Trend				Yes				Yes
Obs	28,174	28,174	28,174	28,174	28,174	28,174	28,174	28,174
R-Squared	0.082	0.115	0.118	0.118	0.082	0.115	0.118	0.118

Table B.10: *Robustness Test for Table 2.7: Fixed Effects and Time Trends*

Panel A replicates Columns (2) and (4) in Table 2.7 using different specifications for fixed effects and time trend. BEA industry classification is used to construct industry-specific time fixed effect dummy variables. Region is the U.S. census regions that group the states by geographic locations. Panel B replicates Columns (6) and (8) in Table 2.7.

A. R&D Investment

Dep.Var: R&D/Asset (%)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Good Faith (GF)	−0.239	−0.270	−0.307	−0.359*	−1.039***	−1.068***	−1.068***	−0.860***
	(0.186)	(0.180)	(0.222)	(0.200)	(0.255)	(0.250)	(0.289)	(0.260)
ΔGSP	0.067	0.075	0.045	0.002	0.055	0.056	0.052	−0.006
	(0.042)	(0.049)	(0.065)	(0.068)	(0.048)	(0.055)	(0.068)	(0.079)
ΔGSP×GF	0.308***	0.312***	0.228**	0.261***	0.268***	0.275**	0.189*	0.232**
	(0.086)	(0.102)	(0.100)	(0.083)	(0.093)	(0.104)	(0.098)	(0.087)
FC Index (FC)					−1.774**	−1.797**	−1.837**	−1.801**
					(0.757)	(0.738)	(0.749)	(0.750)
FC×GF					−1.559***	−1.582***	−1.514***	−1.599***
					(0.436)	(0.436)	(0.455)	(0.456)
FC×ΔGSP					−0.017	−0.019	−0.025	−0.014
					(0.055)	(0.049)	(0.047)	(0.048)
FC×ΔGSP×GF					0.265***	0.291***	0.298***	0.272***
					(0.091)	(0.085)	(0.086)	(0.084)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry×Year FE		Yes	Yes	Yes		Yes	Yes	Yes
Region×Year FE			Yes				Yes	
State Trend				Yes				Yes
Obs	28,174	28,174	28,174	28,174	28,174	28,174	28,174	28,174
R-Squared	0.021	0.029	0.032	0.032	0.027	0.036	0.039	0.039

B. Capital Investment

Dep.Var: CapEx/Asset (%)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Good Faith (GF)	−0.502	−0.301	−0.205	0.102	−0.569*	−0.393	−0.306	0.002
	(0.392)	(0.298)	(0.357)	(0.300)	(0.322)	(0.262)	(0.363)	(0.299)
ΔGSP	0.360***	0.162*	0.194**	0.166	0.374***	0.179*	0.211**	0.185
	(0.123)	(0.093)	(0.090)	(0.110)	(0.124)	(0.096)	(0.092)	(0.111)
ΔGSP×GF	−0.046	0.093	0.153	0.125	−0.086	0.062	0.138	0.096
	(0.087)	(0.104)	(0.122)	(0.114)	(0.088)	(0.107)	(0.120)	(0.118)
FC Index (FC)					−0.524	−0.627*	−0.619*	−0.587*
					(0.339)	(0.341)	(0.340)	(0.339)
FC×GF					−0.137	−0.178	−0.179	−0.330
					(0.294)	(0.281)	(0.282)	(0.259)
FC×ΔGSP					0.069	0.119*	0.125*	0.124*
					(0.057)	(0.068)	(0.070)	(0.068)
FC×ΔGSP×GF					0.101	0.013	0.007	−0.000
					(0.074)	(0.083)	(0.086)	(0.085)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry×Year FE		Yes	Yes	Yes		Yes	Yes	Yes
Region×Year FE			Yes				Yes	

Table B.10: *(Continued)*

Dep.Var: CapEx/Asset (%)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
State Trend				Yes				Yes
Obs	28,174	28,174	28,174	28,174	28,174	28,174	28,174	28,174
R-Squared	0.082	0.115	0.118	0.118	0.082	0.115	0.118	0.119

Appendix C

Appendix to Chapter 3

C.1 Solution of Simple Model

C.1.1 Summary of Equilibrium Conditions

We first summarize equilibrium conditions from each period:

Period 2

Optimality conditions:

1) Workers:

$$\left.\begin{aligned} c_2^e &= (1+r_2)a_2 + (1-\tau)w_2, \\ c_2^u &= (1+r_2)a_2 + T_2, \end{aligned}\right\} \quad \text{if} \quad a_2 \geq 0$$

$$\left.\begin{aligned} c_2^e &= (1+r_2+\alpha)a_2 + (1-\tau)w_2, \\ c_2^u &= (1+r_2+\alpha)a_2 + T_2. \end{aligned}\right\} \quad \text{if} \quad a_2 < 0$$

2) Firms:

$$f'(k_2^*) = r_2 + \delta.$$

3) Wages:

$$w_2 = f(k_2^*) - (r_2 + \delta)k_2^*.$$

Market- and budget-clearing conditions:

$$k_2^* = \frac{a_2^e(1-\theta_s) + a_2^u\theta_s}{(1-\theta_s)^2 + \theta_f\theta_s},$$
$$T_2 = \tau w_2 \frac{(1-\theta_s)^2 + \theta_s\theta_f}{(1-\theta_s)\theta_s + \theta_s(1-\theta_f)}.$$

Period 1

Optimality conditions:

1) Employed workers:

$$0 = -U'(c_1^e) + \beta\left((1-\theta_s)V_2^{e\prime}(a_2^e) + \theta_s V_2^{u\prime}(a_2^e)\right) + \lambda^e,$$
$$c_1^e = (1+r_1)a_1 + (1-\tau)w_1 - a_2^e,$$
$$a_2^e \geq -\frac{T_2}{1+r_2+\alpha} \quad (\lambda^e),$$
$$\lambda^e \geq 0,$$
$$0 = \lambda^e(a_2^e + \frac{T_2}{1+r_2+\alpha}).$$

We can rewrite the first-order condition as:

$$U'(c_1^e) = \left(\beta(1+r_2)\left((1-\theta_s)U'(c_2^{e;a_2^e\geq 0}) + \theta_s U'(c_2^{u;a_2^e\geq 0})\right)\right)\mathbb{I}_{a_2^e\geq 0}$$
$$+ \left(\beta(1+r_2+\alpha)\left((1-\theta_s)U'(c_2^{e;a_2^e<0}) + \theta_s U'(c_2^{u;a_2^e<0})\right) + \lambda^e\right)\mathbb{I}_{a_2^e<0}.$$

2) Unemployed workers:

$$
\begin{aligned}
0 &= -U'(c_1^u) + \beta \left(\theta_f V_2^{e\prime}(a_2^u) + (1-\theta_f) V_2^{u\prime}(a_2^u)\right) + \lambda^u, \\
c_1^u &= (1+r_1)a_1 + \phi w_0 + T_1 - a_2^u, \\
a_2^u &\geq -\frac{T_2}{1+r_2+\alpha} \quad (\lambda^u), \\
\lambda^u &\geq 0, \\
0 &= \lambda^u (a_2^u + \frac{T_2}{1+r_2+\alpha}).
\end{aligned}
$$

Similar to before, the FOC can be expressed as an Euler condition,

$$
\begin{aligned}
U'(c_1^u) = &\left(\beta(1+r_2)\left(\theta_f U'(c_2^{e;a_2^u\geq 0}) + (1-\theta_f)U'(c_2^{u;a_2^u\geq 0})\right)\right) \mathbb{I}_{a_2^u\geq 0} \\
&+ \left(\beta(1+r_2+\alpha)\left(\theta_f U'(c_2^{e;a_2^u<0}) + (1-\theta_f)U'(c_2^{u;a_2^u<0})\right) + \lambda^u\right) \mathbb{I}_{a_2^u<0}.
\end{aligned}
$$

3) Firms:

$$
f'(k_1^*) = r_1 + \delta.
$$

4) Wages:

$$
w_1 = f(k_1) - (r_1 + \delta)k_1.
$$

Market- and budget-clearing conditions:

$$
\begin{aligned}
k_1^* &= \frac{a_1 + \theta_s \phi w_0 / r_1}{1-\theta_s}, \\
T_1 &= \tau w_1(k_1^*) \frac{1-\theta_s}{\theta_s}.
\end{aligned}
$$

Period 0

Optimality conditions:

1) Employed workers:

$$
\begin{aligned}
0 &= -U'(c_0^e) + \beta \left((1-\theta_s) V_1^{e\prime}(a_1^e) + \theta_s V_1^{u\prime}(a_1^e)\right), \\
c_0^e &= (1+r_0)a_0 + w_0 - a_1^e.
\end{aligned}
$$

Recall that using the optimality conditions from Period 1, we can write V_1^e as:

$$V_1^e(a_1) = U(c_1^e) + \beta\left((1-\theta_s)V_2^e(a_2^e) + \theta_s V_2^u(a_2^e, w_1)\right) + \lambda^e\left(a_2^e + \frac{T_2}{1+r_2+\alpha}\right).$$

Then, $V_1^{e\prime}(a_1^e)$ can be derived as:

$$V_1^{e\prime}(a_1^e) = (1+r_1)U'(c_1^e) + \left(-U'(c_1^e) + \beta((1-\theta_s)V_2^{e\prime}(a_2) + \theta_s V_2^{u\prime}(a_2, w_1)) + \lambda^e\right)\frac{\partial a_2^e}{\partial a_1^e}$$
$$+ \lambda^{e\prime}(a_1^e)\left(a_2^e + \frac{T_2}{1+r_2+\alpha}\right).$$

From the FOC from Period 1, the expression in the parentheses of the second term is 0. If the constraint is binding, the expression in the parentheses of the last term is 0 and if it is not binding, it is straightforward to show that $\lambda^{e\prime}(a_1^e) = 0$. Thus,

$$V_1^{e\prime}(a_1^e) = (1+r_1)U'(c_1^e).$$

Similarly,

$$V_1^{u\prime}(a_1^u) = (1+r_1)U'(c_1^u).$$

Hence, the optimality conditions can be re-written as:

$$U'(c_0^e) = (1+r_1)\beta\Big((1-\theta_s)U'(c_1^e) + \theta_s U'(c_1^u)\Big) \quad \text{(Euler condition)}, \tag{C.1}$$
$$c_0^e = (1+r_0)a_0 + w_0 - a_1^e.$$

2) Firms:

$$f'(k_0^*) = r_0 + \delta.$$

3) Wages:

$$w_0 = \Big(f(k_0) - (r_0+\delta)k_0\Big)\left(1 + \frac{\theta_s \phi}{1+r_1}\right)^{-1}.$$

Market-clearing condition:

$$k_0^* = a_0 - \pi_0^*/r_0,$$

where $\pi_0^* = f(k_0^*) - w_0 - (r_0 + \delta)k_0^*$.

C.1.2 Proof of Proposition 5

Because wages are bargained between the firm and the worker, we assume that workers are aware of how the wages change in the bargaining process when the parameters change. To begin with, V_0^e can be expressed as follows:

$$V_0^e(a_0) = U(c_0^e) + \beta\Bigg((1-\theta_s)\Big(U(c_1^e) + \beta((1-\theta_s)U(c_2^e|a_2^e) + \theta_s U(c_2^u|a_2^e)) + \lambda^e\left(a_2^e + \frac{T_2}{1+r_2+\alpha}\right)\Big) \\ + \theta_s\Big(U(c_1^u) + \beta(\theta_f U(c_2^e|a_2^u) + (1-\theta_f)U(c_2^u|a_2^u)) + \lambda^u\left(a_2^u + \frac{T_2}{1+r_2+\alpha}\right)\Big)\Bigg).$$

Then, the total derivative of V_0^e with respect to ϕ, holding the prices $(\mathbf{r}, \mathbf{T})$ fixed, is

$$\frac{\partial V_0^e(a_0)}{\partial\phi}\Big|_{\mathbf{r},\mathbf{T}} \\ = U'(c_0^e)(\frac{\partial w_0}{\partial\phi} - \frac{\partial a_1^e}{\partial\phi}) + \beta\Bigg((1-\theta_s)\Big((1+r_1)U'(c_1^e)\frac{\partial a_1^e}{\partial\phi} \\ + \Big(-U'(c_1^e) + \beta((1-\theta_s)V_2^{e\prime}(a_2^e) + \theta_s V_2^{u\prime}(a_2^e)) + \lambda^e\Big)\frac{\partial a_2^e}{\partial a_1^e}\frac{\partial a_1^e}{\partial\phi} + \left(a_2^e + \frac{T_2}{1+r_2+\alpha}\right)\frac{\partial\lambda^e}{\partial a_1^e}\frac{\partial a_1^e}{\partial\phi}\Big) \\ + \theta_s\Big((1+r_1)U'(c_1^u)\frac{\partial a_1^e}{\partial\phi} + \Big(-U'(c_1^u) + \beta(\theta_f V_2^{e\prime}(a_2^u) + (1-\theta_f)V_2^{u\prime}(a_2^u)) + \lambda^u\Big)\frac{\partial a_2^u}{\partial a_1^e}\frac{\partial a_1^e}{\partial\phi} \\ + \left(a_2^u + \frac{T_2}{1+r_2+\alpha}\right)\frac{\partial\lambda^u}{\partial a_1^e}\frac{\partial a_1^e}{\partial\phi} + \Big(-U'(c_1^u) + \beta(\theta_f V_2^{e\prime}(a_2^u) + (1-\theta_f)V_2^{u\prime}(a_2^u)) + \lambda^u\Big)\frac{\partial a_2^u}{\partial\phi} \\ + \Big(\phi U'(c_1^u)\frac{\partial w_0}{\partial\phi} + w_0 U'(c_1^u)\Big) + \left(a_2^u + \frac{T_2}{1+r_2+\alpha}\right)\frac{\partial\lambda^u}{\partial\phi}\Big)\Bigg).$$

From the wage bargaining, we know that

$$\frac{\partial w_0}{\partial\phi} = w_0\left(-\frac{\theta_s}{1+r_1+\theta_s\phi}\right) < 0.$$

Applying the Euler conditions and using the fact that the derivative of the multipliers are 0 when the constraints do not bind, we can simplify the expression to:

$$
\begin{aligned}
&\frac{\partial V_0^e(a_0)}{\partial \phi}\Big|\mathbf{r},\mathbf{T} \\
&= U'(c_0^e)\frac{\partial w_0}{\partial \phi} + \beta\theta_s\left(\phi U'(c_1^u)\frac{\partial w_0}{\partial \phi} + w_0 U'(c_1^u)\right) \\
&= \underbrace{U'(c_0^e)\frac{\partial w_0}{\partial \phi}}_{\text{loss from lower wage in } t=0} \underbrace{+\beta\theta_s U'(c_1^u) w_0\left(\frac{1+r_1}{1+r_1+\theta_s\phi}\right)}_{\text{gain from sev. payment in } t=1}, \\
&= \underbrace{\left(\frac{w_0\theta_s}{1+r_1+\theta_s\phi}\right)\left(-U'(c_0^e) + (1+r_1)\beta U'(c_1^u)\right)}_{\text{net gain/loss through } w_0 \text{ channel}}.
\end{aligned} \tag{C.2}
$$

Once we apply the Euler condition (C.1) to the last expression and substitute out $U'(c_0^e)$, we can conclude that $\frac{\partial V_0^e(a_0)}{\partial \phi}\Big|\mathbf{r},\mathbf{T} \geq 0$ if and only if $c_1^e \geq c_1^u$. ■

C.1.3 Proof of Proposition 6

To begin with, note that our backward induction value maximization problem can be rephrased as a single-period (Period 0) optimization problem. Instead of phrasing a_2^* as a function of a_1, we can restate our Period 0 problem as a maximization over both a_1 and a_2. It is straightforward to show that the optimality conditions from the two approaches coincide. For this proof, we assume that we have taken the latter approach to derive the optimality conditions. Furthermore, we assume that $c_1^e \geq c_1^u$. Taking the derivative of the comparative statics in (C.2) with respect to α, we get

$$
\frac{\partial V_0^e(a_0)}{\partial \phi \partial \alpha}\Big|\mathbf{r},\mathbf{T} = \left(\frac{w_0\theta_s}{1+r_1+\theta_s\phi}\right)\left(U''(c_0^e)\frac{\partial a_1^e}{\partial \alpha} + (1+r_1)\beta U''(c_1^u)\left((1+r_1)\frac{\partial a_1^e}{\partial \alpha} - \frac{\partial a_2^u}{\partial \alpha}\right)\right).
$$

We take the derivative of each optimality condition with respect to α in order to derive $\frac{\partial a_1^e}{\partial \alpha}$ and $\frac{\partial a_2^u}{\partial \alpha}$.

$$\begin{aligned}
-U''(c_0^e)\frac{\partial a_1^e}{\partial \alpha} &= (1+r_1)\beta\Bigg((1-\theta_s)U''(c_1^e)\left((1+r_1)\frac{\partial a_1^e}{\partial \alpha}-\frac{\partial a_2^e}{\partial \alpha}\right) \\
&\quad + \theta_s U''(c_1^u)\left((1+r_1)\frac{\partial a_1^e}{\partial \alpha}-\frac{\partial a_2^u}{\partial \alpha}\right)\Bigg), \\
U''(c_1^e)\left((1+r_1)\frac{\partial a_1^e}{\partial \alpha}-\frac{\partial a_2^e}{\partial \alpha}\right) &= (1+r_2)\beta\Bigg((1-\theta_s)U''(c_2^{e;a_2^e\geq 0})+\theta_s U''(c_2^{u;a_2^e\geq 0})\Bigg) \\
&\quad \cdot\left((1+r_2)\frac{\partial a_2^e}{\partial \alpha}\right)\mathbb{I}_{a_2^e\geq 0} \\
&\quad + (1+r_2+\alpha)\beta\Bigg(\Big((1-\theta_s)U''(c_2^{e;a_2^e<0})+\theta_s U''(c_2^{u;a_2^e<0})\Big) \\
&\quad \cdot\left((1+r_2+\alpha)\frac{\partial a_2^e}{\partial \alpha}+a_2^e\right)+\frac{\partial \lambda^e}{\partial \alpha}\Bigg)\mathbb{I}_{a_2^e<0},
\end{aligned}$$

$$\begin{aligned}
U''(c_1^u)\left((1+r_1)\frac{\partial a_1^e}{\partial \alpha}-\frac{\partial a_2^u}{\partial \alpha}\right) &= (1+r_2)\beta\Bigg(\theta_f U''(c_2^{e;a_2^u\geq 0})+(1-\theta_f)U''(c_2^{u;a_2^u\geq 0})\Bigg) \\
&\quad \cdot\left((1+r_2)\frac{\partial a_2^u}{\partial \alpha}\right)\mathbb{I}_{a_2^u\geq 0} \\
&\quad + (1+r_2+\alpha)\beta\Bigg(\Big(\theta_f U''(c_2^{e;a_2^u<0})+(1-\theta_f)U''(c_2^{u;a_2^u<0})\Big) \\
&\quad \cdot\left((1+r_2+\alpha)\frac{\partial a_2^u}{\partial \alpha}+a_2^u\right)+\frac{\partial \lambda^u}{\partial \alpha}\Bigg)\mathbb{I}_{a_2^u<0}, \\
0 &= \frac{\partial \lambda^e}{\partial \alpha}\left(a_2^e+\frac{T_2}{1+r_2+\alpha}\right)+\lambda^e\left(\frac{\partial a_2^e}{\partial \alpha}-\frac{T_2}{(1+r_2+\alpha)^2}\right), \\
0 &= \frac{\partial \lambda^u}{\partial \alpha}\left(a_2^u+\frac{T_2}{1+r_2+\alpha}\right)+\lambda^u\left(\frac{\partial a_2^u}{\partial \alpha}-\frac{T_2}{(1+r_2+\alpha)^2}\right).
\end{aligned}$$

Using the above second derivatives, we can show that

$$\begin{aligned}
\frac{\partial V_0^e(a_0)}{\partial \phi \partial \alpha}\Big|\mathbf{r},\mathbf{T} = &\left(\frac{w_0\theta_s}{1+r_1+\theta_s\phi}\right)(1+r_1)\beta(1-\theta_s)\Bigg(U''(c_1^u)\left((1+r_1)\frac{\partial a_1^e}{\partial \alpha}-\frac{\partial a_2^u}{\partial \alpha}\right) \\
&- U''(c_1^e)\left((1+r_1)\frac{\partial a_1^e}{\partial \alpha}-\frac{\partial a_2^e}{\partial \alpha}\right)\Bigg).
\end{aligned}$$

To simplify the expressions, let $(1-\theta_s)U''(c_2^{e;a_2^e})+\theta_s U''(c_2^{u;a_2^e})$ be C^e and $\theta_f U''(c_2^{e;a_2^u})+(1-\theta_f)U''(c_2^{u;a_2^u})$ be C^u. Note that $C^e<0$ and $C^u<0$. Then, from the second derivatives, for

$i \in \{e,u\}$,

$$\begin{aligned}
\frac{\partial a_2^i}{\partial \alpha}\bigg|a_2^i > 0 &= \frac{U''(c_1^i)(1+r_1)}{U''(c_1^i)+(1+r_2)^2\beta C^i}\frac{\partial a_1^e}{\partial \alpha},\\
\frac{\partial a_2^i}{\partial \alpha}\bigg|(a_2^i < 0, \lambda^i = 0) &= \frac{U''(c_1^i)(1+r_1)\frac{\partial a_1^e}{\partial \alpha} - a_2^i(1+r_2+\alpha)\beta C^i}{U''(c_1^i)+(1+r_2+\alpha)^2\beta C^i},\\
\frac{\partial a_2^i}{\partial \alpha}\bigg|(a_2^i < 0, \lambda^i > 0) &= \frac{T_2}{(1+r_2+\alpha)^2}.
\end{aligned}$$

We can then observe that when $a_2^e > 0$ and $a_2^u > 0$, $\frac{\partial a_1^e}{\partial \alpha}$ and $\frac{\partial a_2^i}{\partial \alpha}$ are all zero and $\frac{\partial V_0^e(a_0)}{\partial \phi \partial \alpha}\Big|\mathbf{r}, \mathbf{T} = 0$. Now, suppose that $a_2^e > 0$ while $a_2^u < 0$ [1]. Then, we can derive that

$$\begin{aligned}
&\frac{\partial a_1^e}{\partial \alpha}\bigg|(a_2^e > 0, a_2^u < 0, \lambda^u = 0)\\
&= \frac{-(1+r_1)\beta\theta_s U''(c_1^u)\frac{(1+r_2+\alpha)\beta C^u}{U''(c_1^u)+(1+r_2+\alpha)^2\beta C^u}}{U''(c_0^e)+(1+r_1)^2\beta\left((1-\theta_s)U''(c_1^e)\left(\frac{(1+r_2)^2\beta C^e}{U''(c_1^e)+(1+r_2)^2\beta C^e}\right)+\theta_s U''(c_1^u)\left(\frac{(1+r_2+\alpha)^2\beta C^u}{U''(c_1^u)+(1+r_2+\alpha)^2\beta C^u}\right)\right)}a_2^u\\
&> 0.
\end{aligned}$$

and

$$\begin{aligned}
\frac{\partial a_1^e}{\partial \alpha}\bigg|(a_2^e > 0, a_2^u < 0, \lambda^u > 0) &= \frac{(1+r_1)\beta\theta_s U''(c_1^u)\frac{T_2}{(1+r_2+\alpha)^2}}{U''(c_0^e)+(1+r_1)^2\beta\left((1-\theta_s)U''(c_1^e)\left(\frac{(1+r_2)^2\beta C^e}{U''(c_1^e)+(1+r_2)^2\beta C^e}\right)+\theta_s U''(c_1^u)\right)}\\
&> 0.
\end{aligned}$$

We can get a similar expression with the same sign if we had $a_2^e < 0$ and $a_2^u > 0$ instead. In the steady state, which is the benchmark in dynamic models, $w_1 = w_2$ and $\beta = \frac{1}{1+r_2}$ such that it is not optimal for the employed to borrow from Period 2 in Period 1. Thus, we proceed with assuming that $a_2^e > 0$ and $a_2^u < 0$. Now, suppose that $\lambda^u = 0$. Then, further

[1] It is impossible to have both a_2^e and a_2^u be less than 0 for any production to occur in Period 2.

substitutions yield

$$
\begin{aligned}
&\frac{\partial V_0^e(a_0)}{\partial\phi\partial\alpha}\Big|\mathbf{r},\mathbf{T},(a_2^e>0,a_2^u<0,\lambda^u=0)\\
&=\left(\frac{w_0\theta_s}{1+r_1+\theta_s\phi}\right)(1+r_1)\beta(1-\theta_s)\Bigg((1+r_2+\alpha)\beta\Bigg(C^u\left((1+r_2+\alpha)\frac{\partial a_2^u}{\partial\alpha}+a_2^u\right)\Bigg)\\
&-(1+r_2)\beta\Bigg(C^e(1+r_2)\frac{\partial a_2^e}{\partial\alpha}\Bigg)\Bigg)\\
&=\left(\frac{w_0\theta_s}{1+r_1+\theta_s\phi}\right)(1+r_1)\beta(1-\theta_s)\\
&\cdot\Bigg((1+r_2+\alpha)\beta C^u\frac{U''(c_1^u)}{U''(c_1^u)+(1+r_2+\alpha)^2\beta C^u}\Bigg((1+r_2+\alpha)(1+r_1)\frac{\partial a_1^e}{\partial\alpha}+a_2^u\Bigg)\\
&-(1+r_2)\beta C^e(1+r_2)\frac{U''(c_1^e)(1+r_1)}{U''(c_1^e)+(1+r_2)^2\beta C^e}\frac{\partial a_1^e}{\partial\alpha}\Bigg).
\end{aligned}
$$

Substituting $\frac{\partial a_1^e}{\partial\alpha}$ out and cleaning up the expressions again finally gives

$$
\begin{aligned}
&:\ \frac{\partial V_0^e(a_0)}{\partial\phi\partial\alpha}\Big|\mathbf{r},\mathbf{T},(a_2^e>0,a_2^u<0,\lambda^u=0)\\
&=\left(\frac{w_0\theta_s}{1+r_1+\theta_s\phi}\right)(1+r_1)\beta(1-\theta_s)\\
&\cdot U''(c_1^u)\frac{(1+r_2+\alpha)\beta C^u}{U''(c_1^u)+(1+r_2+\alpha)^2\beta C^u}\Bigg(U''(c_0^e)\\
&+(1+r_1)^2\beta\Bigg((1-\theta_s)U''(c_1^e)\left(\frac{(1+r_2)^2\beta C^e}{U''(c_1^e)+(1+r_2)^2\beta C^e}\right)\\
&+\theta_s U''(c_1^u)\left(\frac{(1+r_2+\alpha)^2\beta C^u}{U''(c_1^u)+(1+r_2+\alpha)^2\beta C^u}\right)\Bigg)\Bigg)^{-1}\\
&\cdot\left(U''(c_0^e)+(1+r_1)^2\beta U''(c_1^e)\left(\frac{(1+r_2)^2\beta C^e}{U''(c_1^e)+(1+r_2)^2\beta C^e}\right)\right)a_2^u\\
&=\left(\frac{w_0\theta_s}{1+r_1+\theta_s\phi}\right)(1+r_1)\beta(1-\theta_s)\left(-\frac{1}{(1+r_1)\beta\theta_s}\frac{\partial a_1^e}{\partial\alpha}\right)\\
&\cdot\left(U''(c_0^e)+(1+r_1)^2\beta U''(c_1^e)\left(\frac{(1+r_2)^2\beta C^e}{U''(c_1^e)+(1+r_2)^2\beta C^e}\right)\right)\\
&>0.
\end{aligned}
$$

We can similarly prove that the same result holds for the case when $\lambda^u > 0$. ■

C.2 Equilibrium Computation Procedure

Conditional on the model parameters, we find the steady state equilibrium prices, policy functions, value functions, and worker measures following the steps described in Cozzi and Fella (2016) reproduced below:

1. Choose initial guesses of equilibrium prices $\{r_0, \tau_0\}$.

2. Given the equilibrium prices $\{r_0, \tau_0\}$, solve for equilibrium wages from the equations (3.13) and (3.15).

3. Initialize the vector of values for each worker in each state given a discretized asset grid. Then, find the steady state value functions $\{V^e, V^u, V^e\}$ through value iteration using the equations (3.8), (3.9), and (3.10).

4. Find the policy functions $\{a^e, a^u, a^\rho, c^e, c^u, c^\rho\, h\}$ that are consistent with the computed value functions.

5. Using the optimal policy functions, compute the steady state transition matrix P and time-invariant measures $\{\mu^e, \mu^u, \mu^\rho\}$.

6. From the capital market clearing condition (3.21), compute the capital supply and implied new interest rate, r_{new}. Also, from the balanced budget condition (3.22), compute the new tax rate τ_{new} that balances the government budget.

7. Update the guesses of equilibrium prices through convex combinations of the old guesses and the new derived prices.

8. Repeat steps 2 to 7 until convergence.