Venture Capital, Entrepreneurship and Labor Market Adjustments[1]

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This version: November 30, 2015

Abstract This paper analyzes the impact of labor market frictions and bankruptcy costs on venture capitalist' financing decisions. We build a two-period dynamic model in which start-up firms with heterogeneous managerial skills need to obtain funding from venture capitalists. These firms face a total factor productivity (TFP) shock at the beginning of each period, and thus need to adjust labor accordingly subject to a labor adjustment cost. We show that both labor adjustment cost and a high bankruptcy cost discourage entrepreneurships. Furthermore, we show that, given a certain government budget, a government policy consisting in only lowering labor adjustment costs or only in lowering bankruptcy costs is dominated. A higher amount of entrepreneurships is achieved by a decrease in labor adjustment costs accompanied by a decrease in bankruptcy costs given the same government expenditure. We illustrate with a numerical example the effects of increasing labor adjustment and bankruptcy costs and show the complementarity between lowering labor adjustment costs and lowering bankruptcy cost.

JEL Classification: G24, M13, J32, K31, K35

Keywords: Venture Capital, Entrepreneurship, Labor Market Adjustments, Bankruptcy

1. INTRODUCTION

Start-up firms are considered as a main source of job creation (Haltiwanger, Jarmin and Miranda, 2013). However, start-up firms have limited access to bank credit, in particular, the ones in high-tech industries, due to opaque information or lack of tangible assets as collateral. Venture capitalists (VCs), unlike banks, play an important role in startup finance. Specifically, VCs are often considered as value-adding investors to the start-up

[1]We are very grateful to Pedro Bom, Monika Merz and Paul Pichler, as well as to participants in the Macro Breakfast Seminar at University Vienna for helpful suggestions on an earlier draft of the paper. Rachinger gratefully acknowledges financial support by the Hardegg Foundation.

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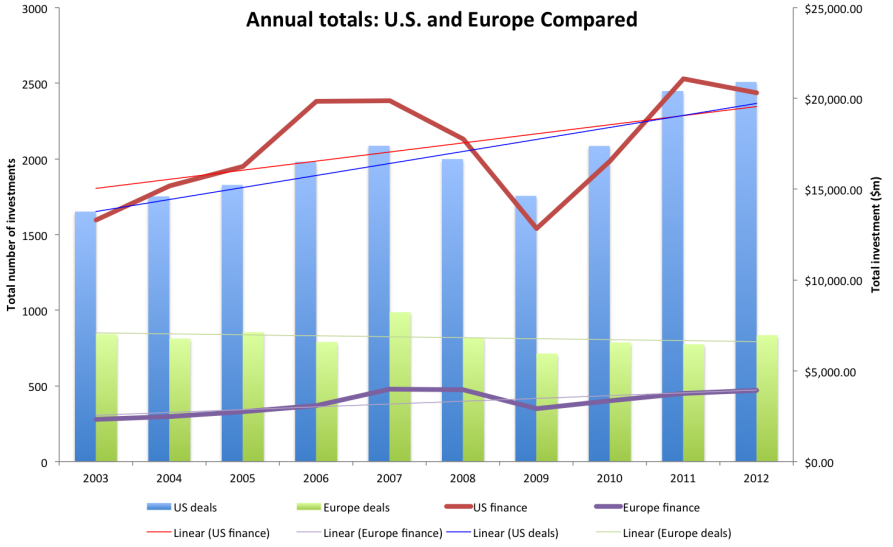
FIG. 1 Total VC investment and total number of deals: US vs Europe



Source: Wall Street Journal

firms since VCs provide other supportive services to increase the value of the firms. Kaplan and Stroemberg (2001, 2004) show that VCs expect to professionalize the firms. Lerner (1995), Baker and Gompers (2003), and Hochberg (2004) find that VCs play an important role in determining the composition of the board of directors. This evidence confirms the VCs' role in supporting the firms to increase the firms' value.

Empirical evidence shows that there exist significant differences in VC investment, as well as the number of entrepreneurships, between the US. and European countries (see Figure 1). This huge gap could be attributed to the different institutions in the US and Europe. In particular, we concentrate on the differences in labor market regulation and bankruptcy proceedings. Over the last decades, labor market rigidities have decreased in most OECD countries. The dispersion among the countries, however, is still large. Furthermore, there exists a wide variation in the success of countries in promoting entrepreneurship across the OECD. VCs, being a crucial determinant of promoting entrepreneurship, are particularly sensitive to labor market rigidities. It is shown that larger labor market rigidities dampen VC investment and hamper entrepreneurship. European countries tend to substitute between employment protection regulation (EPR) and labor market expenditure (LME) (Bozkaya and Kerr, 2009). EPI varies widely across countries. In the US, the EPI from 2004 to 2013 is 0.26 while in Germany, it is 2.87 (see Table 1). In Germany, workers are better protected and have

TABLE 1
OECD Employment protection, 2013

Country	Employment Protection Index (EPI)
US	0.26
UK	1.18
Germany	2.87
France	2.42
(0 to 4, 0 being the lowest)	

Source: OECD

TABLE 2
OECD firing costs

Country	Firing costs (%)
US	0
UK	7.9
Germany	23
France	14
(% on average annual wage income per worker)	

Source: OECD

higher job security. Similarly, Table 2 shows big differences in the firing costs as % on average annual wage. Labor market well-being is one of the major concerns in the OECD countries. However, as noted in Micco and Pagés (2006), a labor market with higher employment protection is more prone to experience lower job creation and a higher unemployment rate. This might instead lead to a worse outcome in workers' well-being.

Besides labor market regulation, bankruptcy costs vary across OECD countries as well. In the US, start-up firms are applied to personal bankruptcy law and the cost of bankruptcy is low compared to other continental European countries, such as Germany and France. A high bankruptcy cost hampers start-up firms and VCs downside return and thus disincentivizes

TABLE 3
OECD Bankruptcy Efficiency Score and Bankruptcy Costs (%)

Country	Bankruptcy Efficiency Index	Bankruptcy Costs Index
US	85.8	14.2
UK	92.3	7.7
Germany	57	43
France	54.1	45.9
Italy	45.3	54.7

Source: Djankov et al (2008)

VCs' funding decisions. When bankruptcy cost is high, it discourages the entry and makes it more difficult for firms to exit. In Table 3, we present bankruptcy efficiency scores (bankruptcy cost = 1- efficiency score) for several OECD countries.

Our paper aims at analyzing the joint effect of labor adjustment costs and bankruptcy costs on VCs' funding decisions and the survival rate of start-up firms in their early stages. Furthermore, we aim at finding the optimal government policy in order to promote entrepreneurships and increase their survival rates. Specifically, we compare three types of government policy under the same government expenditure: (a) the government only subsidizes bankruptcy costs but not labor adjustment costs, (b) the government only subsidizes labor adjustment costs, but not bankruptcy costs, and (c) government subsidizes both labor adjustment and bankruptcy costs at a certain lower degree.

In order to find the optimal policy, we build a two-period (period 0 and 1) dynamic model of endogenous labor decisions of start-up firms in the presence of exogenous bankruptcy costs and labor adjustment costs. We introduce labor adjustment costs arising from EPR as a barrier for firms when adjusting the labor once idiosyncratic total factor productivity (TFP) shocks are realized at the beginning of period 1.

We first study a benchmark economy and show that, if there are neither labor adjustment nor bankruptcy costs, whether a start-up firm obtains funding depends on its distribution of TFP shocks, as well as its managerial ability. The more left-skewed the TFP distribution is in a certain industry, the higher managerial skill is needed to obtain funding. However, if the labor adjustment and bankruptcy costs are positive, we find that compared to the benchmark case, a start-up with the same managerial ability is less likely to obtain funding. In particular, the number of firms obtaining funding decreases as labor adjustment costs increase or bankruptcy costs increase. This shows that both costs hamper entrepreneurships *ex-ante*. As for the aggregate survival rate of funded firms, we find that a positive labor adjustment cost alone and zero bankruptcy cost cause too many bankruptcies but a zero labor adjustment costs together with a positive labor adjustment cost results in too few bankruptcies relative to optimal bankruptcies in the benchmark model.

Finally, we conduct a numerical exercise in order to obtain the optimal government policy when considering the following three different policies: (a) A high labor adjustment cost together with a low bankruptcy cost, (b) a low labor adjustment cost together with a high bankruptcy cost, and (c) a mediate labor adjustment cost together with a mediate bankruptcy cost.

We assume the government has a fixed budget and thus each policy should cost the same to the government no matter which policy is chosen. We show that policy (c) dominates the other two policies under the same government budget.

Our paper complements previous literature by integrating labor market regulation into the analysis, and demonstrates a complementarity effect between reducing labor adjustment costs and bankruptcy costs on entrepreneurships as well as the survival rate of the start-up firms. Armour and Cumming (2008) show that the bankruptcy law has a significant impact on entrepreneurships in North America and Europe. More recently, Lee, Yamakawa, Peng and Barney (2011) show that lenient, entrepreneur-friendly bankruptcy laws are significantly correlated with the level of entrepreneurship development in terms of the entry rate of new firms. Besides, Kanniainen and Vesala (2005) find that labor market institutions, such as unemployment compensation, union power, and labor protection significantly affect the new enterprise formation across 19 OECD countries during 1987-1998. Bozkaya and Kerr (2014) further show that VCs are especially sensitive to the labor adjustment costs arising from employment protection regulations. Our paper combines these two literature and further emphasizes the complementarity effect and thus provides some indication on which policies can enhance entrepreneurship.

The outline of this paper is the following: In Section 2, we describe the environment and the agents. In Section 3 and 4, we first analyze the benchmark model. Afterwards, we consider the case with positive labor adjustment costs and bankruptcy costs and characterize the equilibrium funding decisions as well as the start-up firms' survival rate. In Section 5 we conduct a numerical exercise and compare the effectiveness of three different government policies. Finally, we conclude in Section 6.

2. ENVIRONMENT

2.1. Agents and timeline

2.1.1. Start-up Firms

We assume that the economy is populated by two types of firms, established firms and start-up firms. Established firms are with known managerial ability and for simplicity, we assume that they have constant productivity[4]. On the other hand, start-up firms' (entrepreneurs') managerial abilities are unknown to outside investors.

[4] As will be seen later, the model would allow variation in the productivity as long as it is lower than the variation of the shocks to the new entrepreneurs.

Start-up firms live up to two periods (period 0 and 1). After period 1, surviving start-up firms become established firms. Therefore, their managerial abilities become publicly observable and are not subject to TFP shocks. Thus, these two periods reflect the firm's early-stage. There is a continuum of entrepreneurs of unit mass in each stage. Potential entrepreneurs differ initially in their managerial ability M_i. Heterogenous managerial skills $M_i \in (\underline{M}, \overline{M})$, which is uniformly distributed with $E(M_i) = M$. Managerial abilities are observable by VCs since they have expertise and monitor the start-up firms closely[5].

There is also a firm-specific TFP shock denoted by A_t. For simplicity and without loss of generality, we assume A_0 is the same for all firms and $A_1 \in \{A_l, A_0, A_h\}$, with $A_l < A_0 < A_h$. The firm's productivity is determined as $A_t \frac{M_i}{M}$. Thus, the productivity in period 1 depends on the one in period 0.[6]

The distribution of A_1 is:

$$A_1 = \begin{cases} A_l & \text{w.p. } q \\ A_0 & \text{w.p. } (1 - q - q') \\ A_h & \text{w.p. } q' \end{cases}$$

Finally, A_1 is observed by VCs and by firms (and firms can adjust the labor accordingly). (q, q') represents different industries with a different TFP distribution. In consequence, start-up firms are sorted by three dimensions: $\frac{M_i}{M}$, q and q'.

When potential entrepreneurs enter the market, they generate their business ideas, which can be expressed as their managerial abilities and they apply for funds from venture capitalists (VCs). Each potential entrepreneur demands a fixed fund K as capital investment.

Once the start-up firms obtain the fund, they start their business. At the beginning of period 0, the firms determine their labor L_0 given their initial productivity A_0 and a given wage w as well as the known distribution of the future TFP shock. At the beginning of period 1, entrepreneurs' new productivity A_1 is realized. Firms adjust their labor L_0 to L_1 according to the new productivity A_1. Entrepreneurs can freely increase the amount of hired workers and fire workers by paying a labor adjustment cost per unit of labor f_L, which is assumed to be a constant proportion of the wage,

$$f_L = aw, \text{ where } 0 < a < 1.$$

[5] VCs spend on average a considerable time in managing start-up firms. As shown in Gorman and Salman (1989), a venture capitalist typically devotes 80 hours of on-site time and 30 hours of phone time per year in direct contact with each company.

[6] Once an entrepreneur produces her initial business idea at the seed stage (period 0), her productivity in the subsequent periods (period 1) would depend on the initial business idea as well as her idiosyncratic shock.

The production technology follows the form of a Cobb-Douglas production function, and is assumed to be:

$$Y = f\left(A_t, K, L_{t,i}, M_i\right) = A_t \frac{M_i}{M} L_{t,i}^{\alpha} K^{\beta}$$

Capital investment K is exogenously given and is fixed for any firm at the early stage. For simplicity, we assume $K = 1$ for each entrepreneur[7].

Expected profit for a start-up firm is :

$$E_0\pi_{start-up} = \left(A_0 \frac{M_i}{M} L_0^{\alpha} - wL_0 - r_i\right) + E_0\left(A_1 \frac{M_i}{M} L_1^{\alpha} - wL_1 - f_L\left(L_0 - L_1\right)_+ - r_i\right).$$

where the second term is the expected profit in period 1, at period 0, r_i is the returns to the VC at each period and $(f)_+$ denotes the positive part of f.

2.1.2. Venture Capitalists

We further assume VCs have unlimited fund supply and can refinance themselves at an interest rate $\overline{r}$. In other words, the investors of VCs require at least $\overline{r}$ as a rate of return. Since outside investors can either choose to invest in an established firm or a start-up firm, the refinancing cost $\overline{r}$ is the required rate of return if investors invest in the established firm. Moreover, VCs offer start-up firms take-it-or-leave-it contracts and are able to extract rents from firms ($E_0\pi_{start-up} = 0$) because start-up firms do not have outside options in obtaining fund. VCs fund if and only if their expected profit from the funding is not negative. VCs' expected profit from each start-up firm i is described as the following:

$$E_0\pi_{VC} = 2\left(r_i - \bar{r}\right) = \left(A_0 \frac{M_i}{M} L_0^{\alpha} - wL_0\right) + E_0\left(A_1 \frac{M_i}{M} L_1^{\alpha} - wL_1 - f_L\left(L_0 - L_1\right)_+\right) - 2\bar{r}$$

Besides funding decisions, venture capitalists decide whether to let the firms continue operating or liquidate them at the end of period 0. VCs liquidate the firm only if VCs' loss from period 1 (after observing a low TFP A_1) is higher than the bankruptcy cost, *i.e.* VCs liquidate the firm at the end of period 0 if

$$A_1 \frac{M_i}{M} L_1^{\alpha} - wL_1 - f_L\left(L_0 - L_1\right)_+ - r_i \leq -C_{br}$$

and allow the firm to continue if

$$A_1 \frac{M_i}{M} L_1^{\alpha} - wL_1 - f_L\left(L_0 - L_1\right)_+ - r_i > -C_{br},$$

where C_{br} is the bankruptcy cost.

[7] Since we are mostly interested in the impact of labor market rigidities on VCs' funding decisions, we assume that capital investment for each entrepreneur is fixed.

2.2. Financial Market

VCs obtain investment from investors. These investors are equity holders of VCs. Equity holders require a certain rate of return and only invest in VCs if the return rate is at least as high as their outside option. We consider that the outside option of investors is the return rate $\overline{r}$ from investing in established firms.[8] We define this return rate as VCs' refinancing rate. In other words, in order to attract investors, VCs need to offer a return rate $r \geq \overline{r}$.

2.3. Labor Market and Bankruptcy Proceedings

We assume that the labor market is competitive, and workers are price takers. Thus, w equals the workers' reservation wage $\overline{w}$, which is an established firm's marginal product of labor. $\overline{w}$ satisfies

$$\begin{aligned} \overline{w} &= \alpha A_0 \frac{M_i}{M} L_0^{\alpha-1} \\ &= \alpha A_0 L_0^{\alpha-1}, \end{aligned}$$

where $M_i = M$ for any established firm. Since the labor market is competitive, labor supply is perfectly elastic and thus equilibrium wage equals to the reservation wage $\overline{w}$ for every worker.

As for bankruptcy law, we assume a firms files for bankruptcy and is liquidated if the VC decides to do so. Thus, we consider involuntary bankruptcies instead of voluntary bankruptcies which are initiated by the firms themselves.

2.3.1. ***Labor adjustment costs***

Start-up firms are subject to TFP shocks at the beginning of period 1. Thus, they have to adjust their labor accordingly. If the firms continue staying in the market and adjust the labor, we assume that the firing cost per worker is $f_L = aw$, where $0 \leq a \leq 1$. Clearly, entrepreneurs in a country with a stricter EPR face potentially higher labor adjustment costs (higher a) if these costs are borne by firms. Alternatively, the government could bear at least partially the labor adjustment costs by adopting LME regulation. In this case, firms only partially bear labor adjustment costs.

2.3.2. ***Bankruptcy costs***

When entrepreneurs suffer negative productivity shocks, they might not be able to continue their business and would have to involuntary exit the

[8] VCs are price takers in the financial market because VC investments account only for a small percentage of the total investments.

market. Once the bankruptcy is filed, the bankruptcy cost has to be borne by the venture capitalist since the entrepreneur's liability is limited. Bankruptcy costs C_{br} consist of C, a direct administrative cost, of filing for bankruptcy and commissions to the lawyers together with an indirect cost such as time spent during the procedure, and the waiting time for a fresh start. In addition, there is a labor dismissal cost bL_0 included in the bankruptcy costs. Thus

$$C_{br} = C + bL_0.$$

We assume $b < a$ since in the case of bankruptcy labor dismissal is considered justified.

2.4. Government policy

The government's objective is to promote entrepreneurship and increase start-up firms' survival rate at their early stage. It may consider several different policies in order to achieve the goal. We consider three types of government policy on both labor adjustments and bankruptcy: (a) A high labor adjustment cost together with a low bankruptcy cost, (b) a low labor adjustment cost together with a high bankruptcy cost, and (c) a mediate labor adjustment cost together with a mediate bankruptcy cost. We assume the government has a fixed budget and thus each policy should cost the same to the government no matter which policy is chosen.

In policy (a), the government partially subsidizes bankruptcy cost, and does not subsidize labor adjustment costs. Start-up firms bear the entire labor adjustment costs. Thus the total cost for government to implement policy (a) is

$$TC_a = \phi C \times \text{proportion of bankrupt firms at period 1.}$$

In policy (b), the government instead partially subsidizes labor adjustment cost φf_L and does not subsidize bankruptcy costs. The total cost of policy (b) is

$$TC_b = \varphi f_L \times \text{ proportion of laid-off worker at period 1.}$$

Finally in policy (c), the government partially subsidizes both labor adjustment costs and bankruptcy costs, and the total cost of policy (c) is

$$\begin{aligned} TC_c \;\; = \;\; & \phi' C \times \text{proportion of bankrupt firms at period 1} \\ & + \varphi' f_L \times \text{ proportion of laid-off worker at period 1,} \end{aligned}$$

where $\phi' < \phi$ and $\varphi' < \varphi$. And $TC_a = TC_b = TC_c$.

3. THE MODEL

3.1. Established firms

In this section, we first consider established firms in order to derive the refinancing cost $\overline{r}$ for VCs, as well as the wage $\overline{w}$ for each worker.

Established firms are assumed to have a known managerial ability M and are not subject to TFP shocks. Therefore, the objective function for an established firm is:

$$\max_{L_0} A_0 \frac{M}{M} L_0^{\alpha} - wL_0 - r.$$

Since established firms do not suffer TFP shocks, $A_0 = A_1$. For simplicity, we assume $A_0 = 1$. Labor market is assumed to be competitive and workers are homogeneous. Thus, in equilibrium, the benchmark wage is equal to a worker's marginal productivity. That is,

$$\overline{w} = \alpha A_0 L_0^{\alpha-1} = \alpha L_0^{\alpha-1}$$

Finally, we derive the repayment to VC $\overline{r}$, where $\overline{r}$ is such that the established firm has zero profit. Therefore,

$$\overline{r} = (1-\alpha) A_0 L_0^{\alpha} = (1-\alpha) L_0^{\alpha}$$

We assume $L_0 = 1$ for an established firm, and obtain the equilibrium wage for a worker and the benchmark repayment for a VC:

$$\overline{w} = \alpha,$$

$$\overline{r} = 1 - \alpha.$$

3.2. Start-up firms

The crucial differences between start-up firms and established firms are: (1) start-up firms face TFP shocks, and (2) their managerial abilities are heterogeneous and not publicly observable. VCs have expertise in funding start-up firms and they closely monitor them. Therefore, we assume that start-up firms' managerial abilities are only observable to VCs.

A start-up firm's objective function is written as:

$$\max_{L_0} \{\pi_0 + E_0 \pi_1\},$$

where

$$\begin{aligned}
\pi_0 &= \frac{M_i}{M} L_0^{\alpha} - \overline{w} L_0 - r_i, \\
E_0 \pi_1 &= E_0 \left(A_1 \frac{M_i}{M} L_1^{\alpha} - \overline{w} L_1 - f_L \left(L_0 - L_1 \right)_+ - r_i \right) \\
&= q \left(A_L \frac{M_i}{M} L_1^{\alpha} - \overline{w} L_1 - f_L \left(L_0 - L_1 \right)_+ \right) \\
&\quad + q' \left(A_H \frac{M_i}{M} L_1^{\alpha} - \overline{w} L_1 - f_L \left(L_0 - L_1 \right)_+ \right) \\
&\quad + \left(1 - q - q' \right) \left(\frac{M_i}{M} L_1^{\alpha} - \overline{w} L_1 - f_L \left(L_0 - L_1 \right)_+ \right) - r_i
\end{aligned}$$

where r_i is the repayment to the VC.

We solve the optimal labor $L_1(A_1)$ backwards:

$$L_1(A_1) = \begin{cases} \left(\frac{\alpha A_L \frac{M_i}{M}}{\alpha - f_L} \right)^{\frac{1}{1-\alpha}} & \text{if } A_1 = A_l \\ \left(\frac{M_i}{M} \right)^{\frac{1}{1-\alpha}} & \text{if } A_1 = A_0 \\ \left(A_H \frac{M_i}{M} \right)^{\frac{1}{1-\alpha}} & \text{if } A_1 = A_h \end{cases}. \tag{1}$$

Thus, the optimal labor at period 0 is

$$L_0 = \begin{cases} \left(\frac{\alpha \frac{M_i}{M}}{\alpha + q f_L} \right)^{\frac{1}{1-\alpha}} & \text{if } A_l \frac{M_i}{M} L_1^{\alpha}(A_l) - \overline{w} L_1(A_l) - f_L \left(L_0 - L_1 \right)_+ - r_i \leq -C_{br} \\ \left(\frac{\alpha \frac{M_i}{M}}{\alpha + q b} \right)^{\frac{1}{1-\alpha}} & \text{if } A_l \frac{M_i}{M} L_1^{\alpha}(A_l) - \overline{w} L_1(A_l) - f_L \left(L_0 - L_1 \right)_+ - r_i > -C_{br} \end{cases}. \tag{2}$$

3.3. Venture capitalists

3.3.1. Funding decisions at the beginning of period 0

A VC receives a return r_i if it funds a start-up firm with managerial ability M_i. A VC's objective function can be written as

$$\arg\max 2 r_i = \pi_0 + E_0 \pi_1,$$

where r_i is the repayment of a start-up firm with managerial ability M_i to the VC in each period.

A VC's funding decision depends on whether the return r_i is larger than its refinancing cost $\overline{r}$. Thus, a VC funds if and only if

$$r_i \geq \overline{r} \ \left(= 1 - \alpha \right),$$

for any start-up firm with managerial ability M_i and for any q and $q\prime$.

3.3.2. Liquidation decisions at the beginning of period 1

Besides funding decisions, at the beginning of period 1, VCs decide whether to let the start-up firms continue operating or to liquidate them. If a firm is liquidated, the VC bears a bankruptcy cost C_{br}. VC liquidates a firm if and only if

$$A_1 \frac{M_i}{M} L_1^{\alpha} - \overline{w} L_1 - f_L \left(L_0 - L_1\right)_+ - r_i > -C_{br},$$

where A_1 is the realized TFP at the beginning of period 1. Otherwise, the firm continues operating. That is, a firm is liquidated only if the bankruptcy cost C_{br} is smaller than the firm's profit at period 1. Otherwise, even if the firm is unable to repay the return r_i, it is still allowed to continue operating, i.e.

$$A_1 \frac{M_i}{M} L_1^{\alpha} - \overline{w} L_1 - f_L \left(L_0 - L_1\right)_+ - r_i \leq -C_{br}.$$

4. EQUILIBRIUM CHARACTERIZATION

4.1. Benchmark: Neither labor adjustment costs nor bankruptcy costs

In this section, we first characterize the equilibrium outcomes in a benchmark economy where there are no labor adjustment costs and no bankruptcy costs. In the benchmark economy, we find the start-up firms that are worthy to obtain funding from VCs. Given $\overline{w}$ and $\overline{r}$, the expected profit of a funded start-up in the benchmark economy is:

$$E_0 \pi_{start-up} = \pi_0 + E_0 \pi_1 \geq 0$$

In other words, a start-up firm which is worth of obtaining funding satisfies the following condition:

$$q' \geq \frac{q\left(1 - A_L^{\frac{1}{1-\alpha}}\right)\left(\frac{M_i}{M}\right)^{\frac{1}{1-\alpha}} - 2\left(\left(\frac{M_i}{M}\right)^{\frac{1}{1-\alpha}} - 1\right)}{\left(A_H^{\frac{1}{1-\alpha}} - 1\right)\left(\frac{M_i}{M}\right)^{\frac{1}{1-\alpha}}}. \tag{3}$$

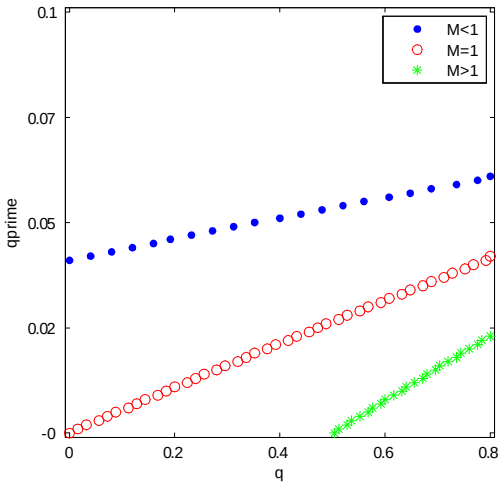
This leads to the following Propositions.

PROPOSITION 1. *In the environment without labor adjustment costs and without bankruptcy costs, start-up firms with a higher probability of the good TFP shock at period 1 or the ones with higher managerial abilities are more likely to obtain funding:*

(a) For a given M_i and q, start-up firms with higher q' obtain funding.

(b) For a given q and q', start-up firms with higher managerial ability M_i are more likely to obtain funding.

FIG. 2 Funding threshold relation q-q' for several M



Proof. Follows immediately from (3). ∎

Figure 3 illustrates that the funding probability increases in q' and M and decreases in q.

PROPOSITION 2. *Venture capitalists' funding decision depends on both the TFP distribution and managerial ability.*

(a) For $M_i = M$, funded start-up firms' TFP distribution must satisfy

$$q\prime \geq \frac{1 - A_L^{\frac{1}{1-\alpha}}}{A_H^{\frac{1}{1-\alpha}} - 1} q.$$

(b) Otherwise, funded start-up firms' TFP distribution must satisfy (3).

Proof. Follows immediately from (3). ∎

As for the survival rate of start-up firms, since there is zero bankruptcy cost, the firms go bankrupt if and only if

$$A_1 \frac{M_i}{M} L_1^{\alpha} - \overline{w} L_1 - f_L \left(L_0 - L_1\right)_+ - r_i < -C_{br},$$

Thus, we can find a threshold $\widehat{r}_i\left(A_1\right)$ such that for any equilibrium $r_i < \widehat{r}_i\left(A_1\right)$, firm i would continue operating. This leads to the following Proposition.

PROPOSITION 3. *Whether a start-up goes bankrupt depends on the TFP shock at period 1 and M_i,*

(a) For any M_i, if $A_1 = A_h$, firms will never go bankrupt
(b) For any M_i, if $A_1 \in \{A_h, A_0\}$, firms go bankrupt iff

$$r_i > \widehat{r}_i(A_1),$$

where $\widehat{r}_i = \left(\frac{M_i}{M}\right)^{\frac{1}{1-\alpha}} \left[(1-\alpha) A_1^{\frac{1}{1-\alpha}} + \frac{\alpha b}{\alpha + qb}\right]$.

Proof. See the supplemental Appendix. ∎

4.2. Positive labor adjustment cost and zero bankruptcy cost

If the labor adjustment cost is positive, a start-up firm obtains funding if and only if its q, q' and M_i satisfy:

$$q' \geq q\left(\frac{\left\{-A_l^{\frac{1}{1-\alpha}} Q(f_L) - A_l^{\frac{1}{1-\alpha}} f_L \left(\frac{\alpha}{\alpha - f_L}\right)^{\frac{1}{1-\alpha}} + f_L \left(\frac{\alpha}{\alpha + q f_L}\right)^{\frac{1}{1-\alpha}} + (1-\alpha)\right\}}{(1-\alpha)\left(A_h^{\frac{1}{1-\alpha}} - 1\right)} - \frac{\left(\frac{M_i}{M}\right)^{\frac{1}{1-\alpha}} Q(f_L) + (1-\alpha)}{\left(\frac{M_i}{M}\right)^{\frac{1}{1-\alpha}} (1-\alpha)\left(A_h^{\frac{1}{1-\alpha}} - 1\right)}\right),$$

where $Q(f_L) = \left(\frac{\alpha}{\alpha - f_L}\right)^{\frac{\alpha}{1-\alpha}} - \alpha\left(\frac{\alpha}{\alpha - f_L}\right)^{\frac{1}{1-\alpha}}$.

LEMMA 1. *a) For a given M_i, $\frac{\partial q'}{\partial f_L} > 0$.*
b) For a given q, $\frac{\partial q'}{\partial M_i} < 0$.

Proof. See the supplemental Appendix. ∎

Therefore, for a given M_i, we show that the q' required for getting funding increases as the labor adjustment cost f_L increases. This tells us that when there is a positive labor adjustment cost, the probability of $A_1 = A_h$ should increase in order to obtain funding. In other words, start-up firms only obtain funding if q' is sufficiently high. In addition, we show that start-up firms with higher M_i do not need to have high q' in order to obtain funding. In sum, we show that when the labor adjustment cost is positive, in any industry, there are less start-up firms obtaining funding.

As for the survival rate, we can see that the bankruptcy condition is such that r_i satisfies the following condition given A_1 and M_i,

$$r_i > A_1 \frac{M_i}{M} L_1^{\alpha}(A_1) - \overline{w} L_1(A_1) - f_L (L_0 - L_1(A_1))_+ + C_{br} = \widehat{r}_i,$$

where

$$r_i = \frac{\left(\frac{M_i}{M}\right)^{\frac{1}{1-\alpha}}}{2} \left\{ \begin{array}{c} (L_0^{\alpha} - \alpha L_0) + q\left(A_l L_1^{\alpha}(A_l) - \alpha L_1(A_l) - f_L(L_0 - L_1(A_l))\right) \\ + q'\left(A_h L_1^{\alpha}(A_h) - \alpha L_1(A_h)\right) \\ + (1 - q - q')\left(L_1^{\alpha}(A_0) - \alpha L_1(A_0)\right) \end{array} \right\},$$

with L_0 and $\mathrm{L}_1(A_1)$ defined in (2) and (1).

This shows that if the bankruptcy cost is zero, the threshold $\widehat{r}_i$ is low, and thus, the probability of bankruptcy is high, as shown in the following lemma:

LEMMA 2. $\frac{\partial prob(r_i>\widehat{r}_i)}{\partial \widehat{r}_i} > 0$ *since* $\frac{\partial \widehat{r}_i}{\partial C_{br}} > 0$.

Proof. See the supplemental Appendix. ∎

4.3. Positive labor adjustment cost and positive bankruptcy cost

If both labor adjustment and bankruptcy costs are positive, a start-up firm obtains funding if and only if its q, q' and M_i satisfy:

$$q' \geq q\left(\frac{\min\left\{-A_l^{\frac{1}{1-\alpha}}Q(f_L)-A_l^{\frac{1}{1-\alpha}}f_L\left(\frac{\alpha}{\alpha-f_L}\right)^{\frac{1}{1-\alpha}}+f_L\left(\frac{\alpha}{\alpha+qf_L}\right)^{\frac{1}{1-\alpha}}+(1-\alpha), C+b\left(\frac{\alpha}{\alpha+qb}\right)^{\frac{1}{1-\alpha}}\right\}}{(1-\alpha)\left(A_h^{\frac{1}{1-\alpha}}-1\right)}\right.$$
$$\left.-\frac{\left(\frac{M_i}{M}\right)^{\frac{1}{1-\alpha}}Q(f_L)+(1-\alpha)}{\left(\frac{M_i}{M}\right)^{\frac{1}{1-\alpha}}(1-\alpha)\left(A_h^{\frac{1}{1-\alpha}}-1\right)}\right),$$

where $Q(f_L)=\left(\frac{\alpha}{\alpha-f_L}\right)^{\frac{\alpha}{1-\alpha}}-\alpha\left(\frac{\alpha}{\alpha-f_L}\right)^{\frac{1}{1-\alpha}}$.

From the above equation, we show that VCs' funding decision for any given M_i depends negatively on the bankruptcy cost.

LEMMA 3. *For any given* M_i, $\frac{\partial q'}{\partial b} > 0$.

Proof. See the supplemental Appendix. ∎

As for the firms' survival rate, the result follows from the previous Lemma, and thus the survival rate of the firms decreases as the bankruptcy cost increases.

4.4. Continuation Value: Expansion and Established Stages

In this section, we extend the model by including future stages (expansion and established stages) of the life of the entrepreneurs. In particular, in period 2 (expansion stage), the TFP shock variability decreases considerably. For simplicity, we assume there will be no volatility in period 2 and 3, and thus $A_2 = A_3 = A_0$. Table 4 displays the timeline and the TFP shock as well as managerial abilities in the different periods. As firms grow over time, entrepreneurs are still assumed to have heterogeneous managerial abilities M_i in period 2. However, as they approach the established stage (period 3), their ability converges to the average M and stays constant. It is clear that a optimal policy should be the one leading to the more efficient outcome,

TABLE 4
Timeline

	Period 0	period 1	period 2	period 3
Period		early stage	expansion stage	established
TFP shock	A_0	$A_1 \begin{cases} A_l \\ A_0 \\ A_h \end{cases}$	A_0	A_0
Managerial skill	$M_i \in \begin{cases} \underline{M} \\ ... \\ \bar{M} \end{cases}$	$\begin{matrix} \underline{M} \\ ... \\ \bar{M} \end{matrix}$	$\begin{matrix} \underline{M} \\ ... \\ \bar{M} \end{matrix}$	M_i=M
labor choice	L_0	$L_1(A_0, L_0)$	$L_2(A_0, L_1)$	$L_3 = 1$
survive		if $\pi_1(A_1) + \pi_2(A_1) > -C_{br}$	always	always

TABLE 5
Complementarity between labor adjustment and bankruptcy costs

$M_i \setminus A_1$	low	medium	high	efficiency
low	don't survive		survive if bc high	should not survive
medium high	get liquidated if bc is low	survive	survive	should survive

which is the fact that firms with $M_i < M$ should be liquidated and firms with $M_i \geq M$ should survive. Finally, in period 3, firms are established and their labor choice and profit correspond to the ones of established firms. Since their profit equals zero after becoming established, we can abstract from this and potential further periods.

Table 5 illustrates the resulting complementarity arising from reducing labor adjustment costs and bankruptcy costs at the same time. Medium and high managerial skills firms should survive (see fifth column), while low managerial skill firms should not survive. The closer a policy gets to this scheme the more efficient is its outcome and thus the cheaper it is for obtaining the same outcome (more effective given the same government expenditure). In order to illustrate this complementarity, we conduct a numerical exercise in the following section.

5. NUMERICAL ILLUSTRATION

In this Section, we illustrate, with a numerical exercise, the impact of labor market rigidities and inefficient bankruptcy laws on the entrepreneurs' probability of obtaining funds and their survival rates while maintaining workers' well-beings. We consider the values of all variables which characterize the start-up firms, the industries, the labor market, government and

TABLE 6
Parameters

	Parameter	Value
firms		
labor share	α	0.8
TFP in period 0	A_0	1
TFP in period 1	A_1	{0.8,1,1.2}
managerial ability	M	{0.95,0.96,1,1.04,...,1.2}
industries		
probability of negative shock (A_l)	q	{0,0.2,...,0.8}
probability of positive shock (A_h)	q'	{0,0.05,...,0.2}
labor market		
labor supply per firm	L^s	1
government		
labor adjustment cost borne by gov.	f_L^{gov}	0.05
labor adjustment cost to gov. in case of bankruptcy	$f_{L,br}^{gov}$	0.02
bankruptcy cost to gov	bc^{gov}	0.1
unemployment benefit	ub	0.02
frictions		
labor adjustment cost	f_L	{0,0.005,...,0.05}
bankruptcy cost	bc	{0,0.01,...0.1}

the frictions. Table 6 displays the parameters chosen for this exercise. The labor share $\alpha = 0.8$ reflects the high worker's contribution to a start-up firm. We normalized the TFP shock in period 0 (A_0) to 1. The new TFP shock A_1 in period 1 is centered around A_0 but skewed towards bad shocks (A_l). Different probabilities of low and high shocks characterize different industries. In our setup, it is clear that the mean of the shock A_1 increases in $q\prime$ and decreases in q. Further, q and $q\prime$ determine skewness and kurtosis of the TFP shock distribution. In our exercise, we assume that probabilities of q and $q\prime$ vary between 0 and 0.8 and 0 and 0.2 respectively. Thus, $q = q\prime = 0$ and $q = q\prime = 0.5$ imply the lowest and highest variance respectively. There is a constant labor supply $L^s = 1$ available for each firm due to the normalization. The government guarantees to compensate the workers who are not hired initially by a unemployment benefit ub. In addition, the labor market regulation requires a compensation to workers who are hired initially but fired in the process of adjusting the workforce, $\overline{f_L}$, part of which is borne by the firm f_L, and the rest by the government ($\overline{f_L} - f_L$). Similarly, there is a labor adjustment cost $\overline{f_{L,br}}$ in case of bankruptcy, with $\overline{f_{L,br}} < \overline{f_L}$. This cost is entirely born by the firm. Further, there is a maximal bankruptcy cost $\overline{C_{br}}$, borne partially by the firm C_{br} and partially by the government[9]. We start

[9] Here we consider the maximal bankrutpcy cost is fixed, and the government and firms share this cost. However, note that if bankruptcy procedure is improved, the fixed cost of bankruptcy would decrease. Thus, both government and firms would face a lower bankrupty cost.

the exercise by varying the labor adjustment costs $f_L \in \{0, 0.005, ..., 0.05\}$ and bankruptcy costs $C_{br} \in \{0, 0.01, ...0.1\}$ which are borne by the firms. As for the labor cost and capital cost for firms, as analyzed in the model, the equilibrium wage equals α and the VCs' refinancing rate equals $1 - \alpha$. Entrepreneurs act as price takers and are confronted with the wage α and zero profits since VCs have the bargaining power.

In the first part of our exercise, we ignore the government's budget constraint when analyzing the effects of labor market rigidities and inefficient bankruptcy laws on entrepreneurships and firms' survival rates. In the second part of the exercise, in order to evaluate three different government policies, we impose a fixed government's budget constraint to obtain comparable scenarios under different policies.

Different industries are indexed by $q \in \{0, 0.2, ..., 0.8\}$ and $q\prime \in \{0, 0.05, ..., 0.2\}$ with each industry populated by potential entrepreneurs with managerial abilities $M \in \{0.95, 0.96, ..., 1, 1.04, ..., 1.2\}$. Our objective is to vary these three parameters, together with different levels of labor adjustment costs and bankruptcy cost in order to analyze the effects arising from both frictions on funding decisions, survival rates and the proportion of firms that operate despite not being productive (zombies).

Figure 3 illustrates how an increasing labor adjustment cost as well as an increasing bankruptcy cost, shifts the funding threshold respectively for $M \in \{1, 1.004\}$. The blue lines on the right correspond to the funding thresholds for a given M without any frictions. The two further threshold lines correspond to low and moderate labor adjustment cost (a1&b1) as well as low and moderate bankruptcy cost (a2&b2) respectively.

It is clear that the funding threshold move to the left when each of the frictions increases for different M.

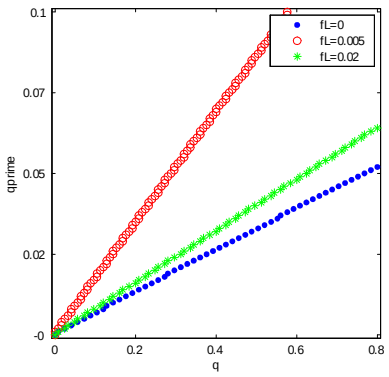
The failure probability is increasing in the labor adjustment and/or bankruptcy costs and thus is higher compared to the optimal bankruptcy in the benchmark case. Moreover, the number of bankruptcy increases as q increases and q' decreases for any M.

In addition, we examine the effect of both frictions on aggregate failure rate. Table 7 displays the percentage of firms being liquidated at the beginning of period 1 as a function of labor adjustment and bankruptcy costs. As expected, failure rates decrease considerably with the bankruptcy costs and slightly react to changes in the labor adjustment costs.

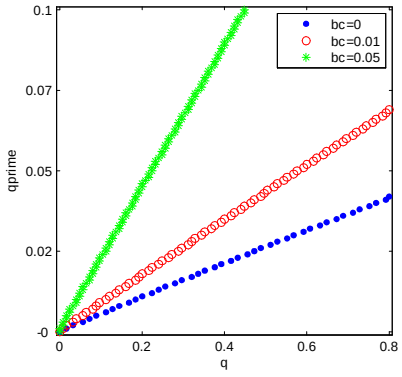
Next, in order to find the optimal government policy in terms of promoting entrepreneurships and the survival rate of firms with high managerial abilities, we consider three different combinations of f_L and C given the

FIG. 3 Funding threshold relation q-q' for different labor adjustment and bankruptcy costs and M

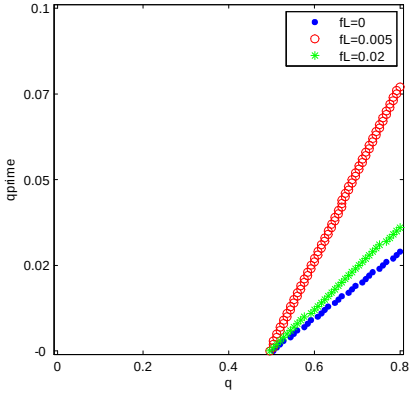
a1) Effect of labor adjustment costs (M_i=M)



a2) Effect of bankruptcy costs (M_i=M)



b1) Effect of labor adjustment costs (M_i>M)



b2) Effect of bankruptcy costs (M_i>M)

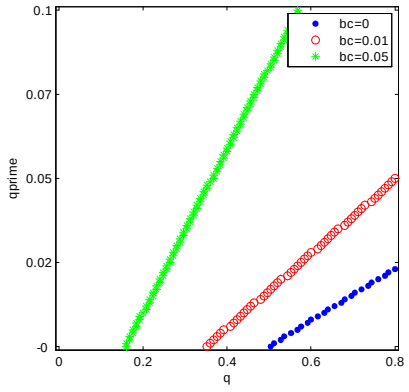


TABLE 7
Failure probabilities in period 1 as function of labor adjustment and bankruptcy costs

$f_L \backslash$bc	0	0.02	0.04	0.06	0.08	0.1
0	23.3	14.4	10.1	4.0	2.7	2.3
0.01	22.3	12.2	7.8	6.3	1.8	1.9
0.02	18.6	8.4	6.0	5.1	4.1	0.6
0.03	13.9	9.8	5.0	4.0	3.2	0.4
0.04	11.7	8.9	4.4	3.2	2.8	1.9
0.05	10.2	7.8	6.7	2.8	2.1	2.1

same amount of government expenditure.

(a) high f_L, low bc

(b) low f_L, high bc

(c) medium f_L, medium bc

The government cost consists of two parts: bearing bankruptcy costs, bearing labor adjustment costs (see Section 2.4). In this exercise, we want to show complementarity between reducing labor adjustment cost and reducing bankruptcy costs. We have first calibrated the parameters so that (a), (b) and (c) lead to the same funding rates, and we compare the government expenditure on these three policies. The optimal policy would be the one with the lowest government expenditure.

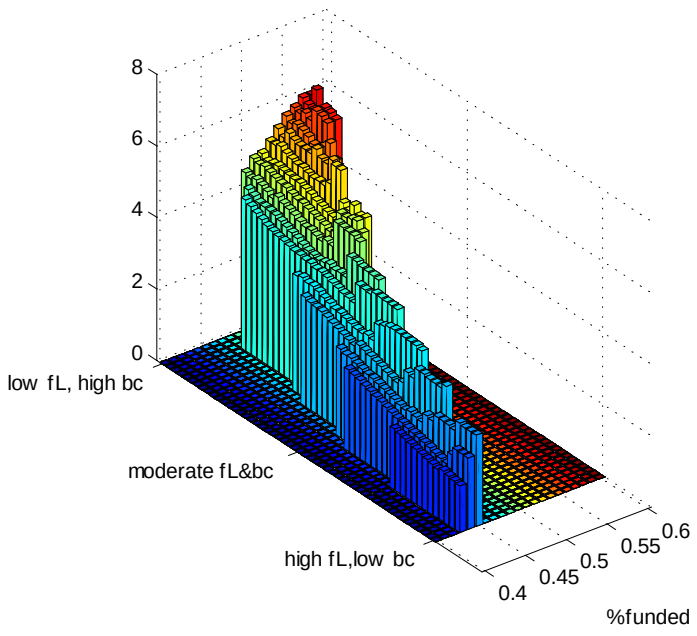
Figure 4 displays the government expenditure from on the different policies (a), (b) and (c) in order to obtain a funding proportion between 40% and 60%. Each color represents the costs for achieving a specific proportion of funding. It can be seen that the government expenditure for each funding target is U-shaped. This indicates that moderate labor adjustment costs together with moderate bankruptcy costs (policy (c)) achieve the same funding object as policy (a) and (b), but with a lower expenditure. Correspondingly, the same expenditure would result in a higher funding proportion. This complementarity can also be seen in Table 5.

In summary, our exercise results point out that if the government is allowed to have a certain level of budget deficit (at least in the short term), reducing labor adjustment costs together with bankruptcy costs are most effective in promoting VC financing especially in high-variance industries. Moreover, this policy leads to a second-best bankruptcy. Our result confirms that there is a complementarity effect arising from reducing both frictions at the same time. This confirms the crucial role of labor market flexibility, as well as a more efficient bankruptcy law, on the development of the venture capital market. In addition, it also provides a policy recommendation to policymakers.

6. CONCLUSION

In this paper, we analyze the effect of labor adjustment costs and bankruptcy costs on VCs' decisions to fund to start-up firms. We develop a two-period model in which entrepreneurs with heterogeneous managerial abilities apply for funds from VCs under TFP shocks. We first study the benchmark model and derive the optimal funding and survival rates of start-up firms when there are neither labor adjustment costs nor bankruptcy costs. We

FIG. 4 Costs for reaching a certain level of funding for policies 1), 2) and 3)



show that VCs' funding decisions depends on the entrepreneurs' managerial abilities as well as the TFP shock in the beginning of period 1.

We further study the respective impact of labor adjustment costs and bankruptcy costs on VCs' funding decisions as well as start-up firms' survival rates. We show that in the case of positive labor adjustment costs and zero bankruptcy cost, less firms obtain funding and the survival rate decreases. Thus, the VC's funding decisions and firms' survival rates are both decreasing in labor adjustment costs. There are more *ex-post* bankruptcies compared to the benchmark. On the other hand, we also examine the effect of a positive bankruptcy costs and derive a similar result in funding decisions but different result in terms of firms' survival rates. In particular, in the case of positive bankruptcy costs and zero labor adjustment costs, less firms obtain funding, but the survival rates of the firms are higher compared to the benchmark. Furthermore, a higher bankruptcy cost results in a higher survival rate of a funded firm. In summary, both labor adjustment costs and bankruptcy costs hamper entrepreneurships *ex-ante* since VCs' profits are sensitive to both frictions. Moreover, in terms of survival rates, both labor adjustment costs and bankruptcy costs result in inefficient bankruptcies, however, in opposite directions. Specifically, a positive labor adjustment

cost together with zero bankruptcy cost causes too many bankruptcies, but a zero labor adjustment costs together with a positive labor adjustment cost results in too few bankruptcies relative to optimal bankruptcies in the benchmark model.

Furthermore, we conduct a numerical exercise and examine three different government policies given the same government's budget with the objective of promoting entrepreneurships as well as reaching second-best bankruptcies. The three policies are: (a) A high labor adjustment cost together with a low bankruptcy cost, (b) a low labor adjustment cost together with a high bankruptcy cost, and (c) a mediate labor adjustment cost together with a mediate bankruptcy cost. Our results show that policy (c) strictly dominates policy (a) and (b) in terms of promoting entrepreneurships and reaching the second-best bankruptcies. This implies that there is a complementarity between reducing both labor adjustment and bankruptcy costs at the same time. Our results are robust regardless of the initial level of both labor adjustment and bankruptcy costs. In particular, in terms of entrepreneurships, all three policies under the same government spending promote first-best level of entrepreneurships. However, under policy (c), bankruptcies are closer to first-best bankruptcies compared to policy (a) and (b). The complementarity is found from improving the bankruptcy efficiency. This result also implies that under policy (c), the labor productivity is the second-best, and thus dominates the other two alternatives.

Our results confirm the crucial role of both labor market flexibility and a more efficient bankruptcy law in promoting start-up firms, thus, providing a policy recommendation for policymakers.

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