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Financing Decision and Productivity Growth for the Venture Capital Industry in Taiwan

Chih-Nan Chen
Department of Economics, National Taipei University
151, University Rd., San Shia, Taipei, 237 Taiwan
cnchen@mail.ntpu.edu.tw

Tai-Hsin Huang
Department of Money and Banking, National Chengchi University
No. 64, Sec. 2, ZhiNan Rd., Wenshan District, Taipei City 11605, Taiwan
thuang@nccu.edu.tw

Chien-Hsiu Lin*
Department of Money and Banking, National Chengchi University
No. 64, Sec. 2, ZhiNan Rd., Wenshan District, Taipei City 11605, Taiwan
clin@nccu.edu.tw

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This paper attempts to characterize the production technology of venture capital (VC) firms in Taiwan, whilst taking into account the simultaneity problem that arises from the correlation between inputs and unobserved productivity. The estimates of scale economies from OLS are found to be much higher than those obtained from our preferred approach. The paper also explores how the capital structure of those firms was adjusted to increase their productivity when faced with the institutional change that occurred in the VC markets of Taiwan and what we can learn from this. There is evidence that financing mix was irrelevant to firms' productivity growth when tax incentives were issued by the government to stimulate equity financing, whereas they were able to benefit from increased financial leverage after these tax incentives were discontinued, which suggests that the effect of the policy termination was stronger than its initiation, in terms of productivity. Firms that chose to invest in the internet and bio-related industries emerged as placing higher financing decision importance on productivity growth

*Corresponding author.

than those with other investment preferences, thus implying that the financing decision for those firms investing in these sectors is much more critical in determining the growth of the firm.

Keywords: Financing decision; venture capital industry; productivity; simultaneity problem.

JEL Classification: G32, G24, D24

1. Introduction

Traditional theories of corporate finance always focus on how a firm's characteristics influence the demand for capital. These theories, in general, can be classified in terms of: trade-offs, agency problems, and asymmetric information, which can be verified empirically using industry or firm-level data. The trade-off theory of capital structure claims that debt can increase firm value by reducing the government share, but too much debt would cause the direct costs of bankruptcy and the indirect costs of inefficient operations, leading into bankruptcy (Kraus and Litzenberger, 1973; Liu and Hsu, 2006). Proponents of agency and incomplete contracts theory, by contrast, assert that debt or the associated control rights of creditors and shareholders can discipline management, thereby increasing firm value. (Jensen and Meckling, 1976). Finally, under asymmetric information theory it is argued that corporate financial decisions would credibly reveal managers' views about firm value to outside investors, and the signaling effect might lead firms to carry extra slack or issue debt rather than equity, thereby avoiding new, outside equity capital and the negative signal that comes with it. See, for example, Shyam-Sunder and Myers (1999), Frank and Goyal (2003), and Fama and French (2002). The mutual presumption of the above three theories is that a firm's characteristics would determine the nature and mix of financing decisions.

Corporate finance theories, to date, have mainly focused on how a firm's demand for capital influences its financing decisions and the supply effects in this regard have drawn much less attention in the literature. However, as corporate finance decisions should reflect both the demand and supply of a firm's capital, traditional corporate finance theories implicitly assume that the supply of capital is perfectly elastic. This assumption allows a researcher to concentrate on the demand side of the market. Notwithstanding this, in reality, there are many potential supply effects relating to capital, such as regulation change or investor sentiment, that can influence capital flow and make the capital supply channels not perfectly competitive. However, there

are few studies analyzing the implication of the sources of funds available to the corporate sectors when these channels are not perfectly competitive.

In this paper, we explore how the factors of capital supply affect the financing decision of a firm and its performance. In this regard, to maximize a firm's profit, subject to its funding sources by the legal and institutional traditions of economies, managers choose the optimal financial structure for the firm and the resultant capital structure definitely influences the firm's performance thereafter. This study mainly focuses on the impact of the capital supply factor. More specifically, this work aims to investigate the effects of the changes in regulations regarding the firms' financing mix and productivity in the venture capital (VC) industry of Taiwan. Gompers and Lerner (1999) define VC as a type of financial intermediary that specializes in the financing of entrepreneurial companies and Taiwan's VC market is known as the most successfully engineered in the world. In fact, prior to 1983, VCs did not exist in Taiwan, but by the early to mid-1990s its VC market had already established itself as an integral force in promoting its domestic technology related industries, such as that of electronics (Hu and Chan, 2002).

Different to other countries where large companies dominate the markets, the enterprises in Taiwan comprise many small and medium-sized enterprises (SMEs). During the early 1980s, the government set the new direction of policy to promote more technology-intensive and capital-intensive industries and the typical SME did not have access to the large amounts of capital necessary for developing technology. Moreover, SME entrepreneurs often had little or no managerial skills or marketing expertise. Therefore, the government decided to create the legal basis for the existence of venture capitalists, thereby not only fulfilling the need of SMEs but also channeling capital available due to previous economic growth to potentially high-risk, emerging technology companies. More specifically, in order to support the early-stage VC market and make a contribution to the next generation of entrepreneurs and venture capitalists, the government became involved in three ways:

(1) Participation — it directly invested in VC funds and participated in their management as a shareholder and board member; (2) regulation — it issued the Regulations Governing Venture Capital Investment Enterprises on Nov. 24, 1983, that coerced VC funds to invest in high-tech companies; and (3) subsidization — it encouraged the private sector to invest in VC funds through tax incentives.

There is a growing literature focusing on the heterogeneity in the VCs' quality or reputation in explaining the persistence in the VCs' returns

(Hellmann and Puri, 2002; Hochberg *et al.*, 2007; Hsu, 2004; Kaplan and Schoar, 2005; Chemmanur *et al.*, 2007; Bottazzi *et al.*, 2008; Sorensen, 2007; Gompers *et al.*, 2008; Zarutskie, 2010; Bengtsson and Sensoy, 2011). Generally, it states that more experienced VCs may be better at monitoring and managing companies, for they may have access to larger networks to draw on a greater number of contracts with: suppliers, consumers, and potential managers. Moreover, the reputation of an experienced VC may communicate unobserved qualities about the company to the market, thereby increasing its market value. Another strand of research investigates the impact of overall macroeconomic conditions and the degree of competition in the VC industry on the valuation of VCs (Gompers and Lerner, 1998; Gompers and Lerner, 2000; Füss and Schweizer, 2012). This paper, however, investigates the influences of VCs' productivity from another perspective, their financing decisions.

The intended contributions of the current paper are as follows. First, the regulations authorized Taiwan's VC industry became a medium through which the government chose to control VC funds and this control raises certain concerns. That is, if the success of VC in the United States is attributable to the ability of the investors and fund managers to order their relationships and decide the fate of their funds, then any regulatory attempt to limit their ability to engage in such private ordering could adversely affect the efficiency and prospects of the VC markets (Gilson, 2003). However, the promise of tax breaks and government investment was a powerful incentive for VC funds to enlist voluntarily in the government regulatory regime. In this study, the institutional change in Taiwan's VC markets provides us with an opportunity to examine whether the tax incentive policy imposed by the government has improved the VC industry's performance or not. There has been a major institutional change in the Taiwanese VC industry over the last two decades. In 1983, the Regulations Governing Venture Capital Investment Enterprises and the Statute for Encouraging Investment were issued by the government to promote VC markets and high-tech industries in Taiwan and the statute permitted equity holders in VC enterprises to receive a tax deduction of up to 20% of their investment.[1] This tax incentive

[1] In addition, the statute also provided investors with other tax advantages: companies that invested in VC enterprises were allowed to exclude from their income 80% of their revenue from investments in VC funds, and investors in VC funds were not required to include the funds' capitalized retained earnings in their income for tax purposes. However, investors in VC funds were not eligible for these tax incentives unless their investing fund was registered under the regulations and subject to all the restrictions.

regulation did successfully channel much equity capital to the VC firms. It was terminated in 1999 and with the dotcom bubble that occurred in 2001, both of these events led to deterioration in the conditions regarding the raising of money for VCs in Taiwan. Second, this study will provide implications for a VC firm's financing decision when experiencing difficulty in raising money. More specifically, through investigating the relationship between institutional change caused by government policy and productivity growth in the VC industry, we can thoroughly examine the optimal capital structure when the tax incentive policy is ceased.

In order to fulfill the purpose of this work, we first estimate the production function of the VC industry, and then using the parameter estimates to compute productivity growth for the sample firms. We pay particular attention to the effect of the institutional changes on the firm's financing decision and productivity performance. Because a firm's decision on the employment of input quantities depends highly on its efficiency, which is known to the firm and may be measured by output per unit of inputs consumed, and the efficiency of the given firm is possibly autoregressive (Olley and Pakes, 1996), we have to deal with the simultaneity problem raised by Marschak and Andrews (1944), to obtain consistent parameter estimates of the production function. To do so, we follow the procedure proposed by Levinsohn and Petrin (2003), who build on ideas developed in Olley and Pakes (1996) to control for correlation between input quantities and the unobserved firm-specific productivity process. Moreover, because there was only minimal entry and exit regarding Taiwan's VC industry during the sample period, in the current paper we ignore the selection problem, as discussed by Olley and Pakes (1996).

Our empirical results show that the termination of tax incentive policy did not have a significant negative effect on VC industry's productivity, suggesting the government's tax break policy did not effectively increase the productivity of VC industry in Taiwan. In contrast to the stated goal given by the policy makers, our empirical results show that the introduction of a financing mix proved irrelevant to a firm's productivity performance during the periods when tax incentives were granted by the government to stimulate equity financing. However, the results suggest that firms were able to benefit by increasing their financial leverage after tax incentives ceased, which implies that the effect of policy discontinuation was stronger than when it was in place. The results also imply that under a market with abundant capital, corporate finance decision-making is allowed to ignore safely productivity growth. In contrast, the finance decision becomes a

critical factor in determining firms' productivity growth when capital supply is constrained. Next, we take three groups of firms in terms of their investment preference, classified as: general, internet, and bio-related companies, and find that the internet and bio-related investment firms show high financing decision importance on productivity, suggesting that for high-risk investment projects, such as these, the financing decision is much more critical in determining the productivity growth of the firm.

The rest of the paper is organized as follows. Section 2 addresses the methodology, including the econometric model and output elasticities. Section 3 briefly introduces the data and related variables. Section 4 presents and analyzes the empirical results and Sec. 5 contains the conclusion to the paper.

2. Methodology

2.1. *Estimation of the production function*

When estimating the production function of the VC industry, we face the simultaneity problem caused by the association between inputs hiring and unobserved productivity shocks. For a highly pro-cyclical industry like the VC industry, this problem is likely to be amplified, for when firms encounter a large positive productivity shock they may respond by increasing inputs usage, leading to the ordinary least squares (OLS) estimates of the production function being biased, which in turn yields biased estimates of total factor productivity.

To disentangle the simultaneity problem, we follow the procedure proposed by Olley and Pakes (1996) and Levinsohn and Petrin (2003). In this regard, the log production function with the Cobb−Douglas technology can be written as:

$$y_{it} = \beta_0 + \beta_l l_{it} + \beta_k k_{it} + \beta_a a_{it} + \omega_{it} + \eta_{it}, \tag{1}$$

where y_{it} is the log of gross output of firm i in year t, l_{it} is the log of labor input, k_{it} is the log of the firm's capital stock, a_{it} is the firm's age, ω_{it} is the unobserved productivity, and η_{it} is the measurement error. Both ω_{it} and η_{it} are unobserved, with the former being a state variable in the firm's decision-making process affecting input hiring decisions, whereas the latter is a statistical noise independent of the explanatory variables.

Labor is assumed to be a variable input and the remaining two inputs, capital and age, are fixed factors dependent upon the distribution of ω_{it} conditional on information at time $t-1$ and all past values of ω. Unlike the

traditional input items for other industries, here, VC age is included as an input to capture the critical factor, reputation or quality, in the VC industry. VC age can be a good proxy for VCs' reputation or quality as old VC firms are suggested to have more investment experiences and better ability to monitor and intervene with their portfolio companies.[2] Our input setting is the same as that defined in Olley and Pakes (1996) for the telecommunication industry in the US, which uses a firm's age as an input to capture the innovation of technology.

The aforementioned simultaneity problem happens because input choices are partially determined by a firm's beliefs about ω_{it}. When those inputs will be used and if there is a serial correlation in ω_{it}, inputs in period t will be positively correlated with it. OLS or any procedure that overlooks the unobserved productivity differences will be inclined to obtain upwardly biased estimates of the input coefficients [see, e.g., Marschak and Andrews (1944) and Griliches (1957)]. It is anticipated that the more volatile the inputs, the more greatly the inputs will be correlated with current values of ω_{it}, because of their ease of adjustment in response to the versatile market conditions and present business cycles.

We assume that investment of firm i at time t, i_{it}, depends on three state variables, i.e.,[3]

$$i_{it} = i_{it}(\omega_{it}, k_{it}, a_{it}). \tag{2}$$

Pakes (1996) has proved that the investment functions of optimizing firms tend to be strictly increasing in the unobserved productivity shock, ω_{it}. With this monotonicity property, we invert $i_{it}(\omega_{it}, k_{it}, a_{it})$ to obtain ω_{it} as a function of investment, capital, and firm age, i.e., $\omega_{it} = \omega_{it}(i_{it}, k_{it}, a_{it})$ and thus one can rewrite (1) as:

$$y_{it} = \beta_l l_{it} + \phi_t(i_{it}, k_{it}, a_{it}) + \eta_{it}, \tag{3}$$

where $\phi_t(i_{it}, k_{it}, a_{it}) = \beta_0 + \beta_k k_{it} + \beta_a a_{it} + \omega_t(i_{it}, k_{it}, a_{it})$.

[2]Other measures of VC reputation or quality in the literatures include the number of historical investments, VC fund size, and the success (IPO) rate of the VC's previous investments.

[3]Since state variable investment is costly to adjust, firms usually make investments in an intermittent pattern. This results in the data, collected from manufacturing industries or service-related industries, containing a large fraction of zero-investment observations that fail to satisfy the required monotonicity condition and thus causes inconsistent parameter estimates. Levinsohn and Petrin (2003) propose that there should be an additional variable input to avoid the problem of zero-investment as much as possible. However, their approach requires imposing the somewhat strong assumptions that input and output prices are common across firms and there is no error in the input demand function.

The estimation procedures take the form of two stages and in each stage the parameters are estimated for the entire sample and for two sub-samples, corresponding to sample periods 1988−1998 and 1999−2001. As pointed out above, in the watershed year of 1999, the tax incentives for investors in VC funds were stopped.

The First Stage

This stage is devoted to estimate consistently the single parameter of labor, β_l. Following Robinson (1988), we adopt the kernel estimation technique and the Nadaraya−Watson kernel estimator (Nadaraya, 1964; Watson, 1964), to estimate the conditional moments of $E_t(y_{it}|i_{it}, k_{it}, a_{it})$ and $E_t(l_{it}|i_{it}, k_{it}, a_{it})$. We then subtract the expectation of (3) conditional on (i_{it}, k_{it}, a_{it}) from (3) to yield:

$$y_{it} - E_t(y_{it}|i_{it}, k_{it}, a_{it}) = \beta_l(l_{it} - E_t(l_{it}|i_{it}, k_{it}, a_{it})) + \eta_{it}, \tag{4}$$

which includes no intercept. Subsequently, regressing the dependent variable $y_{it} - E_t(y_{it}|i_{it}, k_{it}, a_{it})$ on the independent variable of $[l_{it} - E_t(l_{it}|i_{it}, k_{it}, a_{it})]$, we obtain OLS estimates of β_l, $\hat{\beta}_l$, which converges to β_l at the usual parametric rate.

The Second Stage

This stage basically follows the one developed by Levinsohn and Petrin (2003) and aims to identify the remaining two parameters, β_k and β_a.[4] It is suggested that readers refer to the foregoing paper for details. Similar to Olley and Pakes (1996), we assume that ω_{it} follows a first-order Markov process and ξ_{it}, the innovations in productivity over the last period's expectation, can be written as:

$$\xi_{it} = \omega_{it} - E[\omega_{it}|\omega_{it-1}]. \tag{5}$$

Since we assume that capital and age do not immediately respond to ξ_{it}, the population moments are then given by:

$$E[(\xi_{it} + \eta_{it})k_{it}] = E[\xi_{it}k_{it}] = 0, \tag{6}$$

$$E[(\xi_{it} + \eta_{it})a_{it}] = E[\xi_{it}a_{it}] = 0, \tag{7}$$

and re-write Eq. (1) as:

$$y^*_{it} = y_{it} - \beta_l l_{it} = \beta_0 + \beta_k k_{it} + \beta_a a_{it} + E[\omega_{it}|\omega_{it-1}] + \eta^*_{it}, \tag{8}$$

[4]We refer to the program developed by Levinsohn and Petrin, which can be obtained from the website, http://www.econ.umn.edu/∼petrin/research.html, but we modified this by adding one more state variable, a_{it}.

where $\eta^*_{it} = \xi_{it} + \eta_{it}$ denotes a new residual. It can be seen from the following equation that the residual is a function of the two unknown parameters, $\beta^* = (\beta^*_k, \beta^*_a)$,

$$\xi_{it} + \eta_{it}(\beta^*) = y_{it} - \hat{\beta}_l l_{it} - \beta^*_k k_{it} - \beta^*_a a_{it} - E[\omega_{it}|\omega_{it-1}]. \tag{9}$$

To estimate $E[\omega_{it}|\omega_{it-1}]$, we need to use the estimates of ω_{it} obtained from the first stage results and the candidate values (β^*_k, β^*_a).

We include an additional over-identifying condition using l_{it-1} as the instrumental variable, yielding in total three population moment conditions given by the vector of expectations:

$$E[(\xi_{it} + \eta_{it})Z_{it}], \tag{10}$$

where Z_{it} is the vector of chosen instruments given by $Z_{it} = \{k_{it}, a_{it}, l_{it-1}\}$. Finally, estimates $(\hat{\beta}_k, \hat{\beta}_a)$ can be obtained by minimizing the generalized method of moments (GMM) criterion function:

$$Q(\beta^*) = \min_{\beta^*} \sum_{h=1}^{3} \left(\sum_i \sum_{t=Ti0}^{Ti1} (\xi_{i,t} + \eta_{i,t}(\beta^*)) Z_{i,ht} \right)^2,$$

where i indexes firms, h indexes the three instruments, and $Ti0$ and $Ti1$ corresponds to the second and last period of firm i.

2.2. *Total factor productivities*

After estimating the parameters of the production function, we can calculate the total factor productivity measure, p_{it}, for each firm by the following formula:

$$p_{it} = \exp(y_{it} - \hat{\beta}_l l_{it} - \hat{\beta}_k k_{it} - \hat{\beta}_a a_{it}), \tag{11}$$

where $\hat{\beta}_l$, $\hat{\beta}_k$, and $\hat{\beta}_a$ are the estimates derived from the above subsection. Next, we examine how the institutional change and financing decisions made by firms might affect the productivity of VC firms. Instead of modeling a particular mechanism, we attempt to check whether there is evidence supporting the supposition that the productivity growth in this industry differed under the two regulation regimes.

The following regression is estimated:

$$\Delta \log p_{it} = \alpha_t + (\gamma_1 + \gamma_2 D_t)\Delta(d_{it}/e_{it}) + \beta_1 D_t + \beta_2 R_{\text{nasqt}} + \beta_3 R_{\text{mt}} + \varepsilon_{it}, \tag{12}$$

where Δ is the first difference operator, d_{it}/e_{it} is debt-to-equity ratio of firm i at time t, and D_t is a dummy variable with $D_t = 1$ corresponding to the

period after 1999 (tax incentives discontinuation period) and $D_t = 0$ (tax incentives issuing period) otherwise. Control variables of Nasdaq market return (R_{nasqt}) and the equity market return in Taiwan (R_{mt}) are included to capture the influences of the US high-tech industry and local macroeconomic conditions.[5] ε_{it} denotes a standard random error.

The measure of debt-to-equity ratio reflects the importance of the financing decision in the VC industry of Taiwan. If the financing decision is critical to the performance of VC firms, then we would expect the productivity measure to be significantly affected by the variable. The use of the dummy variable is intended to examine whether productivity growth can be explained by the enforcement of tax incentives. More specifically, parameters β_1 and γ_1 represent the productivity growth purely entailed by the institutional change and the financing decision change, respectively, such that the productivity growth is unrelated to the interaction between the two. In contrast, γ_2 identifies the productivity growth in relation to both the financing decision change and deregulation. Since VCs are dedicated to providing both financial and nonfinancial resources to high-tech ventures, we add the control variable, R_{nasqt}, to capture the comovement between the performance of the US high-tech industry and the productivity growth of VC firms in Taiwan. In addition, we include the control variable R_{mt} in Eq. (12), for two reasons. First, it is able to pick up the influence of the business cycles in Taiwan on productivity growth and second, should it be excluded from Eq. (12), it becomes a part of the error term, which would result in inconsistent parameter estimates, unless it is uncorrelated with the institutional change and financing mix measures. Variable R_{mt} represents the return on capital investment in publicly listed firms, while a VC firm's productivity performance reflects the growth of start-up firms before public listing. It follows that if R_{mt} is relatively high, then equity might flee from the VC industry to pursue higher returns in the stock market, especially after tax incentives are discontinued.

3. Data Description

We compile data on Taiwanese VC firms taken from the Securities & Futures Institute (SFI Online) database, which is publicly accessible and includes accounting statements for publicly traded companies, as required

[5] Variables R_{nasqt} and R_{mt} are computed on the basis of the Nasdaq Index and the Taiwan Stock Exchange Weighted-price Index, respectively.

by law. The unbalanced sample covers a major portion of the VC industry in Taiwan.[6] Starting from 2001, VC firms in Taiwan have not had to report their financial statements to the SFI and because of this regulation change many such firms have disappeared from the database. Therefore, our sample period is limited to being from 1988 to 2001.

From the SFI Online database we identify a single output (y), which is defined as net operating income. We also identify three input categories, i.e., labor, capital, and age inputs (l, k, and a).[7] Control variable total debt can be extracted directly from the database. After data cleaning, our sample consists of 68 VC firms that were active between 1988 and 2001, which covers about 40% of all firms and 54% of total capitalization in the VC industry. Table 1 summarizes the sample statistics for all the variables. The figures reveal that the size of the sample firms tends to be small, but there are considerable variations among them and thus the standard deviations are quite large.

Table 1. Sample statistics.

Variable Name	Full Sample	1988−1998	1999−2001
Output (y)	2524.906	2106.017	3314.684
	(3917.768)	(3015.875)	(5137.549)
Labor (l)	3035.103	2781.458	3513.329
	(2601.579)	(2177.64)	(3213.307)
Capital (k)	5920.192	5159.944	7353.577
	(4623.842)	(3403.855)	(6081.447)
Age (a)	5.051	5	5.135
	(3.581)	(3.581)	(3.606)
Debt Ratio (d/e)	0.044544	0.043877	0.045802
	(0.109856)	(0.118319)	(0.092379)

Note: Sample size: full sample — 277; 1988−1998 — 181; 1999−2001 — 96. The numbers without brackets are sample means, and the numbers with brackets are standard deviations. All numbers except for debt-equity ratio are measured in thousands of New Taiwan Dollars and are deflated by the consumer price index (base year is 2001).

[6] The database includes all mandated public offering companies. The 1981 regulation set out by the Ministry of Economics in Taiwan states that the capitalization of a public offering company must be larger than NT200 million. Due to data limitation, we are unable to include nonpublic offering firms. However, our sample already covers about 40% of all firms and 54% of capitalization in the VC industry in Taiwan.

[7] Please see Appendix A for detailed definitions of the outputs and inputs. All numbers are deflated by the consumer price index of Taiwan (base year is 2001).

4. Empirical Results

Table 2 reports the parameter estimates of the production function for the full sample and two sub-samples, using both the Olley-Pakes (O−P) method and the OLS. The estimated coefficients from the O−P method for the full sample are 0.442, 0.78, and 0.07 for labor, capital, and age, respectively. However, the same estimates for the two sub-samples differ substantially. In 1988−1998, the three parameters are estimated to be 0.456, 0.79, and 0.11 for labor, capital, and age, respectively, whereas for the later period of 1999−2001, the coefficients of capital and age reduce to 0.598 and 0.061, respectively, and become statistically insignificant at the 10% level, whilst the coefficient of labor is relatively stable at 0.433 and remains statistically significant at the 5% level. The outcomes suggest that after the cancellation of tax incentives, capital and age played much less important roles than did labor.

We list the OLS estimates in Table 2 so as to make comparisons easier and similar variations of the three input coefficients are found between the two sub-samples.[8] For the full sample, the implied scale elasticities are 1.292 and 1.447 for O−P and the OLS, respectively. Thus, it emerges that this industry exhibits increasing returns to scale, whereby the sample firms can

Table 2. Parameter estimates of the production function.

	O-P Full Sample	OLS Full Sample	O-P 1988−1998	OLS 1988−1998	O-P 1999−2001	OLS 1999−2001
Labor	0.442***	0.4***	0.456**	0.395***	0.433**	0.479***
	(0.09)	(0.066)	(0.204)	(0.083)	(0.188)	(0.104)
Capital	0.78***	0.869***	0.79**	0.81***	0.598	0.908***
	(0.188)	(0.091)	(0.252)	(0.115)	(0.405)	(0.143)
Age	0.07*	0.178***	0.11***	0.236***	0.061	0.069**
	(0.039)	(0.021)	(0.042)	(0.027)	(0.459)	(0.034)
Scale Elasticity	1.292	1.447	1.356	1.441	1.036	1.456

Note: Figures in parentheses are standard errors. ∗, ∗∗ and ∗∗∗ indicate that the corresponding coefficients are significant at the 10, 5, and 1 percent levels, respectively.

[8] Our OLS estimates do not show a downward bias on the capital coefficient as Marschak and Andrews (1944) and Olley and Pakes (1996) suggested. The difference may be attributed to the following two reasons: First, our data come from the VC industry, instead of that of manufacturing industry, as used by the other researchers and the production characteristics of the two industries are quite different. Second, our production function has three inputs, instead of two, which results in difficulties in relation to the signs of the biases of the OLS coefficients when simultaneity exists.

lower their long-run average costs by expanding the production scale. These findings appear to be in accord with the reality for those VC firms, because their scale of production is not large enough for them to be able to take advantage of specialization and labor division. Given that the O−P method takes into account the simultaneity problem and therefore avoids yielding inconsistent parameter estimates, its parameter estimates are preferable to the OLS outcomes, and are used to produce total factor productivity measures for each firm over time, by applying these to Eq. (11).

Table 3 presents the parameter estimates of Eq. (12), where the figures in Columns 1−3 correspond to the results from the full sample and the two subsamples. It is noteworthy from Column 1 that the coefficient estimate of the interaction term between debt ratio change and the dummy variable of regulation change is equal to 3.895 and this attains statistical significance at the 5% level. This implies that VC firms benefited more from debt financing than from equity financing after the tax incentives policy terminated in 1999. Regarding the estimates of the variables of regulation change and debt ratio change, these are negative. However, they fail to be significant at even the 10% level, owing to their sizeable standard errors. The sign of the debt ratio change coefficient would appear to be consistent with the government's stated policy goal, whereby it was claimed that the release of tax incentives would encourage investors to become equity holders in VC firms and the

Table 3. Estimation results for productivity change.

	Full Sample Period	1988−1998	1999−2001
Intercept	0.3082*	0.4556	0.1492
	(0.1692)	(0.3244)	(0.3033)
Market return	0.4509	0.8463**	0.0105
	(0.2802)	(0.3571)	(0.451)
Nasdaq return	−0.1094	−2.0107	0.6907
	(1.5242)	(3.692)	(1.8756)
Regulation change	−0.0587	—	—
	(0.2048)		
Debt ratio change	−0.3458	−0.3093	3.6143**
	(0.7888)	(0.7207)	(1.6981)
Debt ratio change	3.8953**	—	—
*Regulation change	(1.7112)		
Number of observations	205	123	82
Adjusted R-square	0.0185	0.0257	0.023

Note: Numbers in parentheses are standard errors. ∗, ∗∗ and ∗∗∗ indicate that the corresponding coefficients are significant at the 10, 5, and 1 percent levels, respectively.

subsequent increases in equity financing would result in increases in firm productivity. However, unfortunately, because our finding regarding whether equity financing affects the firm's productivity is insignificant, this would appear to belie this government intention.

Table 3 presents the same parameter estimates for the two sub-samples, which allows us to compare the effect of institutional change on firms' productivity gains. During the period 1988−1998, we observe that market return is significantly and positively associated with the firm's productivity growth, suggesting that the sample firms' productivity grows faster during economic upturns than in economic downturns. However, during the same period, we cannot observe a significant financing mix effect on productivity, which implies that during the period in question the tax incentive policy channeled abundant capital into the VC industry and this relatively elastic supply of capital meant that corporate financing decision-making could safely ignore productivity change. In addition, the influence of the Nasdaq return on productivity is also insignificantly negative, suggesting the global force is not strong enough for the VC industry in Taiwan. By contrast, during the period 1999−2001 evidence is found that the debt ratio change had a significantly positive effect on productivity growth, which is also supported by the full sample results, and shows that increasing debt financing can lead to higher productivity growth. Note that during 1999−2001, the market and Nasdaq returns emerge as insignificantly and positively impacting on productivity growth, thus quite weakly verifying that firms' productivity is positively correlated with the performance of local macroeconomic conditions and of US high-tech industry in the wake of the tax incentive discontinuation.

Next, we hypothesize that the financing mix or institutional change impact may be related to VC firms' industry investment preferences. Our focus in this case is on firms making investments on start-ups in such high risk and high return industries as the bio-related and internet industries, as compared with those that engage in general investment activities. That is, the investment preferences for these three specific groups of firms form our sample categories, almost all of which are involved in investment in start-ups in industries, such as: information, software, electronics, semiconductor, telecommunications, or opto-electronics. We further define firms as belonging to the bio-related group, if they additionally are putting up monies for start-ups into: chemicals and pharmaceuticals, health care, or the biotech industries. Finally, the internet category includes those firms that make specific investments in the internet industry. We select industry investment

Table 4. Parameter estimates for the three groups.

	General	Bio-Related	Internet
Intercept	0.3004	0.3423*	0.313
	(0.3305)	(0.1908)	(0.2041)
Market Return	1.3463**	−0.0256	−0.1998
	(0.6076)	(0.3365)	(0.3326)
Nasdaq Return	−0.9126	−0.7312	−0.1436
	(3.0143)	(1.5592)	(1.704)
Regulation Change	0.4429	−0.1806	−0.1666
	(0.4216)	(0.2228)	(0.2329)
Debt Ratio Change	0.2142	0.2172	2.0722
	(1.3672)	(0.9244)	(1.4269)
Debt Ratio Change	0.6805	11.3549***	12.149***
*Regulation Change	(2.3943)	(3.3922)	(4.0933)
Number of Observations	67	94	110
Adjusted R-square	0.0342	0.084	0.0971

Note: Figures in parentheses are standard errors clustered by firm-year combination. ∗, ∗∗ and ∗∗∗ indicate that coefficients are significant at 10, 5 and 1 percent levels, respectively.

preferences as the criterion splitting the sample firms, because we believe that the industrial type that the VC firms decide to invest in may be a pivotal determinant in their productivity growth.

We re-run Eq. (12) for the three groups of firms and present the results in Table 4 and now, we obtain significant coefficient estimates of the interaction term between debt ratio change and the dummy of regulation change at the 5% level for the bio-related and internet groups, whilst this is not significant for the general group. Moreover, it is noticeable that the estimates for the bio-related and internet group investors are found to be much higher than for the general group and thus one is led to conclude that the financing decision is more closely linked to productivity growth for those VC firms investing in the two foremost industry types than those putting money into the lattermost.

5. Concluding Remarks

Traditional theories of corporate finance tell us that optimal capital structure can be determined by maximizing firms' value based on their demand for capital. However, few researchers have focused on the change of optimal financing strategy in relation to the supply factors of capital, such as institutional change in the capital market. This paper aimed to elicit how the capital structure of VC firms was adjusted in response to institutional

change in the market of Taiwan geared towards enhancing their productivity levels. However, because a firm's choices on input quantities depend on unobserved productivity, we were faced with a simultaneity problem when estimating the production function and to address this we adopted the method developed by Olley and Pakes (1996) and Levinsohn and Petrin (2003).

The parameter estimates have appeared to show the conventional OLS estimates tend to overestimate the measure of scale economies. Furthermore, evidence has emerged that the financing mix was irrelevant to a firm's productivity growth during the period when tax incentives were issued by the government to stimulate equity financing, whereas firms were able to benefit by increasing their financial leverage after these were discontinued. This implies that the effect of the policy termination was stronger than its initiation in terms of productivity. It also implies that during the period 1988−1998, the tax incentive policy channeled abundant capital to the VC industry, thus resulting in a relatively elastic supply of capital, which allowed corporate finance decision-making to safely ignore productivity change. Moreover, firms that chose to invest in the internet and bio-related industries showed higher financing decision importance being placed on productivity growth than those with different investment preferences. This implies that for firms undertaking investment projects in higher risk and higher return industries, such as internet or bio-related ones, the financing decision is much more critical in determining growth.

Appendix A.

Variable definition.

Variables	Definition/Source
Output (y)	Net operating income,[a] from SFI Online Database
Capital (k)	Value of fixed asset and long-term investment,[b] net of depreciation, from SFI Online Database
Labor (l)	Value of total assets, net of Capital (k) defined above,[c] from SFI Online Database
Age (a)	Firm's age, from SFI Online Database
Debt Ratio (d/e)	Ratio of value of total debt to value of total assets, from SFI Online Database
Equity Return (R_{mt})	The equity return of Taiwan Stock Exchange Weighted-price index, from the Taiwan Economic Journal Database (TEJ)
Nasdaq Return (R_{nasqt})	The rate of return of the Nasdaq index, from the Yahoo Finance Database

[a] Net operating income includes the net income from the following sources: securities sale, investment, long-term investment measured by equity method, management fees, interests, and dividends.

[b] We include long-term investment in our calculation of capital, because some firms had zero fixed assets shown on their financial reports. Generally, long-term investment is measured by the equity method if the shareholding of investees is over 20%, and measured by the cost method if the shareholding is less than 20%.

[c] Due to the data limitation, we cannot get firms' employees data. Therefore, we use total assets instead of a firm's employees to define the variable labor (l). However, the overlap between labor and capital would cause incorrect coefficients on inputs when estimating the production function. Therefore, we subtract capital (k) from total assets to represent the variable labor (l).

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