Review of Pacific Basin Financial Markets and Policies
Vol. 9, No. 1 (2006) 67–95

Financial Structure, Corporate Finance and Growth of Taiwan's Manufacturing Firms

Wan-Chun Liu*
Department of International Trade
Takming College
56, Huan Shan Road, Sec. 1, Taipei 114, Taiwan
shane@takming.edu.tw

Chen-Min Hsu
Department of Economics
National Taiwan University
21, Hsu-Chow Road, Taipei 100, Taiwan
chenmin@ntu.edu.tw

The purpose of this paper is to examine the determinants of Taiwan's manufacturing firm growth, in particular, the effects of financial structure, corporate financing choices and Taiwanese outward FDI in China on firm growth in different industries besides other physical factors discussed in the literature. We construct an unbalanced dynamic panel data using 280 listed and OTC manufacturing firms over the period 1991–2002. The empirical method utilized is the generalized method of moments (GMM) proposed by Arellano and Bond (1991). Our results find that (1) the growth rates of firms are positively related to firm size, age, capital intensity, lagged R&D, export ratio, investment ratio, and profits; (2) high debt-to-equity ratio is associated with low corporation growth, while high return on total assets is associated with high corporation growth, which reflects that a firm with a relatively sound financial structure will facilitate their growth; (3) higher liquidity of stock market relative to the banking sector lead to higher growth of firms. However, larger size of stock market relative to the banking sector leads to lower the firm's growth, i.e., the smaller the indirect finance, the lower the firm growth; (4) firms engaged in FDI toward China might be hollowing-out; (5) individual firms that could be financed more from either bank or equity market will enjoy higher rates of growth compared to others in the same industries, but, those effects on traditional and basic industries are weaker; (6) high bank-financing ratio and internal financing are associated with higher firm growth, while firms using more bonds or

*Corresponding author.

equity financing tend to experience lower growth. However, the net positive effects of equity financing on traditional and basic firm growth are significantly greater.

Keywords: Financial structure; corporate finance; firm growth; outward FDI; GMM estimation.

JEL Classification: C33; D92; F23

1. Introduction

Taiwan's financial system was deregulated slowly and gradually until the mid-1980s. As a consequence of financial liberalization, internationalization and diversification, there has been a significant structural change in the Taiwan's financial system. According to financial statistics data, the share of intermediary financing dropped from 90.87% in 1990 to 71.25% in 2003. In contrast, the share of direct financing from the financial market rose from 9.13% to 28.75% during the same period. This indicates that the dependence on intermediary financing for Taiwanese firms has been declining. And they have significantly shifted from intermediary financing to direct financing, i.e., from bank loans to financial market issues.

In addition, due to the deregulation of equity market in 1988 and gradual capital account openness since 1987, the number of listed firms increased quickly in the past decade. For example, in comparison with the situation of 203 listed and over-the-counter (OTC) companies prior to 1990, there are 1092 listed and OTC companies in 2003. Also, the ratio of total par value of listed shares to total loans of financial institutions changed drastically from 10.93% in 1990 to 37.75% in 2003. The share of corporate bond issues have increased and been substituted for the loans from financial institutions since 1996. It appears that corporate finance channels are different. These data show that financial structure has been alternated. It is thus interesting to see whether the effects of financial structure change and corporate financing patterns on the growth of Taiwanese firms are significant. This is due to the fact that through the financial channels, financial structure and corporate finance would influence corporate investment, resource allocation and the growth of firms, and hence the economic growth.

Most of the literature on the determinants of firm growth have mainly focused on the relationship between initial firm-specific conditions and firm growth. For example, Singh and Whittington (1975) examined the relationship between the size of firms and their growth for nearly 2000 British firms in 1948–1960 and found that firm size had a significant positive effect on firm growth. Later, based on the profit maximization problem, Jovanovic (1982) established a theoretical model of firm learning to analyze the survival of firms. He showed that firm age and size were important factors in determining the survival of firms. Also, smaller firms grew faster, but were more likely to fail than large firms.

Evans (1987a, 1987b), Hall (1987) and Dunne *et al.* (1989) applied the theoretical model of Jovanovic (1982) to test the relationships among the US manufacturing firm growth, firm size, and firm age. They found that firm growth decreased with firm age and firm size. The inverse relationship between growth and age is consistent with Jovanovic (1982). Variyam and Kraybill (1992) and Dunne and Hughes (1994) also obtained similar results using the US manufacturing, sales and service firms data and the UK manufacturing data, respectively.

Some studies on firm growth started to focus on the elements of innovation and R&D in the mid-1990s. For example, Audretsch (1995) showed that the post-entry performance of new firms and technological conditions were closely related. Specifically, they found that higher innovative environment was associated with higher survival and growth. Audretsch and Mahmood (1995) also found that R&D intensity was positively correlated with firm's survival. Lee and Shim (1995) showed that the relationship between firm growth and R&D expenditure was significantly positive using the high-tech firm data from US and Japan. Griliches and Mairesse (1983), Hall and Mairesse (1995), Raut (1995) and Yang and Chen (2002) also examined the relationship between R&D and productivity growth of firms.

The relationship between outward foreign direct investment (FDI) and firm growth was also under investigation. For example, Chen and Ku (2000) used the firm-level data and estimated the effect of FDI on the growth performance of FDI firms from Taiwan. They found that FDI would strengthen rather than weakening the viability and competitiveness of domestic industries. Furthermore, by employing 271 data from British firms during 1976–1982, Paul *et al.* (1997) found that the current period growth rates and a natural measure of changes in current expectations about long run profitability (namely, changes in the stock market valuation of the firm) are robustly positively correlated.

Corporate finance theory suggests that market imperfections, as well as information and incentive problems raise the cost of external finance, especially due to underdeveloped financial and legal systems. These may constrain firm's ability to fund investment projects. (See Myers and Majluf, 1984.) By utilizing firm-level data, Demirgüc-Kunt and Maksimovic (1998) showed the importance of the financial system and the rule of law for relaxing firms' external financial constraints and facilitating growth. Rajan and Zingales (1998) used industry-level data to show that industries that are dependent on external finance grow faster in countries with a developed financial system. Beck *et al.* (2002) employed firm-level survey data for 54 countries, to investigate whether financial, legal and corruption obstacles affect firm growth. They showed that underdeveloped financial and legal systems and higher corruption could obstruct firm growth. Greenwood and Jovanovic (1990), Beck *et al.* (2000), Levine *et al.* (2000) and Christopoulos and Tsionas (2004) showed that financial system would enhance the investment efficiency and productivity. Particularly, financial development will enhance fund liquidity and risk dispersion.

Further, Levine (2000) and Beck *et al.* (2001) examined the relationship between financial structure and economic development and found that the effect of bank finance and equity finance on corporate growth was ambiguous. Beck *et al.* (2001) also showed that firm growth was primarily affected by internally generated funds and short-term debts, while it was less affected by the cost of external finance. It reveals that sources of finance and firms growth are closely related. It is true that financial development creates more financing channels and reduces the gap between external and internal costs of funds to firms and make firm investment more efficient, promoting firm growth. Thus, corporate financing choices have significant effects on firm growth.

The purpose of this paper is to investigate the determinants of manufacturing firm growth. Although the existing literature has already provided many physical elements on the effects of firm growth, some important financial factors are still unexplored, for example, financial structure changes and corporate financial patterns.

In this paper, we take Taiwan as an example to explore the role of financial factors in the firm growth process. It is noteworthy that Taiwan has experienced a dramatic economic structural change since 1986. The share of industrial sector in GDP gradually fell, while the share of service sector increased rapidly. In the meantime, the percentage of GDP originating from manufacturing fell from the peak 39.35% in 1986 to 25.85% in 2002. Furthermore, as Taiwanese firms making substantial outward foreign direct investment in Southeast Asia and China since the late 1980s, the manufacturing structure had remarkably changed. The traditional industry as a fraction of manufacturing GDP shows a decreasing trend, while technology-intensive industry exhibits a growth trend. According to the Taiwan national income statistics data, the traditional industries (including food and beverage processing, tobacco, textile, garment and footwear, leather and fur products, lumber and bamboo products, and paper products and printing) have dropped from 28.72% of manufacturing GDP in 1990 to 14.90% in 2002. In contrast, the share of technology-intensive industries (including machinery equipment, electrical, electronic machinery and repairing, transport equipment, and precision instruments) in manufacturing GDP rose from 30.47% to 42.65% during the same period. Likewise, the share of technology-intensive industry in manufacturing GDP has surpassed that of traditional industry since 1990, and the technology-intensive industry has been continuously growing in 1990s. Clearly, technology-intensive industry has played a critical role in the process of Taiwan's economic development.

Due to remarkable shifts in manufacturing industries and the continuous growth in Taiwanese foreign direct investment (FDI) toward China, our study also aims further to analyze whether the effects of corporate financing choices and Taiwanese outward FDI in China on firm growth in different industries are crucial.[1] We construct an unbalanced dynamic panel data using 280 listed and OTC manufacturing firms in the Taiwan Stock Exchange Corporation (TSEC) over the period 1991–2002. The empirical method utilized is the generalized method of moments (GMM) proposed by Arellano and Bond (1991).

The rest of the paper is organized as follows. Section 2 describes the empirical model and data. Section 3 presents and summarizes the estimation results. Section 4 concludes the paper.

2. Empirical Model and Data Description

2.1. *Empirical model and method*

In this section, we examine the determinants of firm growth by extending the work in Gallego and Loayza (2001) to include indices of financial structure, outward FDI and corporate financing sources. The empirical model could

[1]The FDI flows from Taiwan to China increased dramatically from $174 million in 1991 to $4.59 trillion in 2003. In fact, China had become the major destination of outward foreign direct investment from Taiwan since 1993.

be expressed as follows:

$$Y_{it} = \alpha_0 + \alpha_1 Y_{it-1} + \beta' X_{it} + \gamma FDI_{it} + \pi' F_{it} + \lambda' Z_t + \sum_{j=1}^{2} \vartheta_j \, IND_j \times FDI_{it} + \sum_{j=1}^{2} \vartheta_j \, IND_j \times F_{it} + \mu_i + \varepsilon_{it}, \quad i = 1, \ldots, n; \;\; t = 1, \ldots, T, \qquad (1)$$

where the subscripts i and t refer to firm and time respectively. Dependent variable Y is the firm growth. Explanatory variable X stands for the variables capturing firm-specific characteristics, including firm age, firm size, firm's capital-intensity, R&D ratio, export ratio, investment ratio and profitability. *FDI* captures the effect of firm's FDI toward China. F stands for the factors capturing individual firm's financing sources and the credit degree of individual firm in bank sector and stock market. Z captures the macroeconomic variables, which only vary with time but not across firms, including business fluctuations, financial development and structure variables. *IND* is the industry dummy variable to catch the growth differences across industries. We also incorporate the interaction of financing source with the industry dummy in our model to test whether the effects of corporate financial choices on firm growth in traditional, basic, and technology-intensive industries are different. μ_I and ε_{it} are the firm-specific fixed effect and error terms.

To eliminate the firm-specific effect that might cause the biases of estimators, we estimate first-differences of Eq. (1). Since the variables may be endogenous, using OLS estimates will lead to inconsistency. We employ a dynamic panel, generalized method of moment (GMM) estimator proposed by Arellano and Bond (1991).[2] They have shown that the consistency of the GMM estimator depends on the validity of the instruments and the assumption that the differenced error terms do not exhibit second order serial correlation. To test these assumptions, they proposed a Sargan test of overidentifying restrictions, which tested the overall validity of the instruments by analyzing the sample analog of the moment conditions used in the estimation procedure. Besides, they also tested the assumption of no second-order serial correlation. Failure to reject the null hypotheses of both

[2]To obtain a consistent estimator, most researches take the first difference of a dynamic panel model, and then use instrumental variables to do estimation. See, for example, Anderson and Hsiao (1982), Hsiao (1986), Holtz-Eakin *et al.* (1988), and Arellano and Bond (1991). Among them, Arellano and Bond (1991) proposed a GMM procedure that is more efficient than the Anderson and Hsiao (1982) estimator. We hence use the methods of Arellano and Bond (1991). See also the discussion in Baltagi (2001).

tests gives support to our estimation procedure. (Please see the Appendix for the detailed discussion of the Arellano-Bond GMM estimation method.)

All regressors are treated as strictly exogenous except the lagged dependent variables, R&D ratio, export ratio and investment ratio which are endogenous. Therefore, we conduct the analyses with lagged independent variables dated $t-2$ and earlier together with the lagged changes of endogenous variables, and exogenous variables used as instruments variables.

2.2. *Data*

Since we hope that the sample period is not too short and the sample size is not too small, we construct an unbalanced dynamic panel data using 280 listed and OTC manufacturing firms in the TSEC over the period 1991–2002.

From the total sample, we deleted all the observations that did not have a complete record in the variables included in our analysis. Likewise, we deleted a small number of observations with negative values for the replacement cost. Furthermore, we also eliminated firms that were in sample for less than five years. After adjustments, the companies included in our sample are 280 with 2519 observations.[3] Financial information from annual reports of the firms is drawn from the "*TEJ* (*Taiwan Economic Journal*) *Financial Statement of Listed Companies in TSE Data Bank*" and "*TEJ Production and Sales Data Bank*". Data on the market value of the firm's stock is obtained from "*TEJ Stock Price Data Bank*".

The definitions of dependent and explanatory variables and the associated measurement are discussed below. The dependent variable in the analysis of firm growth is the firm's net sale growth rate. The growth of sale is used as a proxy for that of output. It captures the performance of the firm growth.

The independent variables can be grouped in four different categories: (1) firm-specific characteristics; (2) foreign direct investment; (3) macroeconomic factors and industry effect; (4) firms' financing sources, and the credit degree of individual firm in the banking sector and stock market.

Among the firm-specific characteristics, the first variable is the firm age (*Age*). Firm age is defined as the time period since the date of incorporation. The second variable is the natural logarithm of the quantity of firms' employees as an indicator of firm's size (*Size*). Empirical studies on domestic firms, however, find a mixed relationship between firm size and growth. Some

[3]There are 509 listed and OTC manufacturing firms in the TSEC at the end of 2002.

support a positive relationship (e.g., Singh and Whittington, 1975), but negative relationship seems to dominate the empirical literature (e.g., Evans, 1987a, 1987b; Hall, 1987; Dunne *et al.*, 1989 and Variyam and Kraybill, 1992). The third variable, reflecting firm characteristics, is the capital intensity (*KL*) and is measured by the ratio of capital stock to the number of employees. We use the replacement cost of fixed assets as a proxy of capital stock. To obtain replacement cost, we adopt the method proposed by Chan (2002) to adjust the face values of fixed assets.[4]

The fourth variable is R&D ratio (*R&D*), which is the ratio of R&D expenditure to sale. Theoretically, R&D helps firms upgrade technology and enhances their capability in product innovation. The sign of R&D ratio is expected to be positive. The fifth variable is export ratio (*Export*) and is measured by the exports to the sale ratio. High export ratio reflects better international competition and productivity. We, therefore, expect the export ratio to be positively related to firm growth. The sixth variable is the firm's investment ratio (*Investr*) and is defined as the ratio of firm's investment to revenues. The seventh variable is capturing the firm's leverage and is defined as the debt-to-equity ratio (*Debt*). The index of debt-to-equity ratio was constructed by Schmukler and Vesperoni (2001) to examine the determinant of firm growth. Finally, the return on total assets (*Profit*) is considered to capture the capacity of firm to generate internal resources and is defined as firm's profits after taxes divided by average total assets.

The variable in the second category measures the effect of firm's FDI toward China (*FDI*). Since data on the amount of firm's outward FDI toward China are not available, we use a dummy variable, which is time-invariant and that takes the value one from the moment that a firm has engaging FDI in China, and zero otherwise.

The third category involves macroeconomic factor and industry dummy that affect firm growth. The first variable captures the business fluctuation conditions and is measured by the growth rate of real GDP (*Gdpgr*). The economic boom period, (that is, period with high GDP growth) is associated with a higher level of sale. We expect that the growth rate of real GDP is positively related to the firm growth. The second variable related to macroeconomic factors is the one capturing financial intermediary development. Two indicators of financial intermediary development are constructed. First, we use a broad money stock (M2) to GDP ratio (*M2gdp*) to capture

[4]See Chan (2002), p. 57.

the overall size of the formal financial intermediary sector. This is a typical indicator of financial depth (see King and Levine, 1993). Second, we use bank claims on the private sector divided by GDP (*Private*), which is an indicator of bank activity in the private sector. The measure excludes loans issued to governments and public enterprises. It also excludes credits issued by the central bank. It indicates the share of credit funneled through the private sector.[5]

The third macroeconomic variable is related to the stock market development. Two indicators are considered. The first is the stock market capitalization ratio (*Marcap*), which is the ratio of the market value of listed shares to GDP. This is a typical measure of stock market size. The second indicator is the total value traded as a share of GDP (*Valtrade*). The index measures the value of stock transactions relative to the size of the economy. It is frequently used as a measure of stock market liquidity.[6]

The last macroeconomic variable captures the financial structure. We use two measures of financial structure, i.e., structure-size (*Structs*) and structure-activity (*Structa*), which were constructed by Demirgüc-Kunt and Levine (2001). *Structs* indicates the size of stock markets relative to the size of the banking sector and is defined as the natural logarithm of *Marcap* divided by *Private*. *Structa* measures the relative importance of bank and stock market finance and is defined as the natural logarithm of *Valtrade* divided by *Private*. A larger stock market relative to banking sector suggests that relatively well-developed stock markets could substitute for bank finance.[7]

In addition, we also include industry dummies variables to reflect the firm growth difference across industries. According to firms' attribution, we divide the firms into three industries — traditional (including cement, foods, glass and ceramics, textiles, paper and pulp), basic (including chemicals, rubber, plastics, steel and iron), and technology-intensive (including electric and machinery, electric appliance and cable, automobile, and electronics) industries.[8] Two dummy variables — *IND1* and *IND2* are created to differentiate these industries. *IND1* is given a value of one for traditional

[5]See Levine *et al.* (2000), Beck *et al.* (2000), and Hsu *et al.* (2003).

[6]See Levine and Zervos (1998) and Hsu *et al.* (2003).

[7]Real GDP is from *National Income in Taiwan Area, ROC.* Bank claims on the private sector is from *Financial Statistics, Taiwan District Republic of China* (*compiled in accordance with IFS format*), *CBC.* The market value of listed shares and total value traded are from http://www.sfc.gov.tw/7-1.htm.

[8]We follow Chan (2002) to classify the industries.

industry, whereas the others possess zero. *IND2* takes one for basic industry, otherwise zero.

The fourth category involves variables that reflect firms' financing sources and the credit degree of individual firm in the banking sector and stock market. Four variables measure firms' financing sources. The first variable is bank-financing ratio (*Bank*), which is used as a proxy for external finance. It is defined as the percentage of firm's financing from banks.[9] The second and third variables are both equity-financing ratio (*Stock*) and corporate bond-financing ratio (*Bond*). They also capture external finance and are defined as the percentage of firm's financing from stocks and corporate bonds issues, respectively. The last variable is internal funds ratio (*Retain*) and is defined as the percentage of firm's financing from retained earnings. Due to the fact that the sum of *Bank*, *Stock*, *Bond* and *Retain* are one, when adding them together in the regression, multicollinearity might be serious. To solve the problem, we use internal financing (*Internal*) as a proxy for internal funds ratio.[10] *Internal* is defined as retained earnings over total liabilities and expresses the importance of internal financing. The index of internal financing was constructed by Schmukler and Vesperoni (2001).

Finally, we use two indicators to measure the credit degree of individual firm in the banking sector and stock market. The first variable is firm's share of bank borrowing (*Sdebt*) and is defined as the ratio of bank borrowings of firm relative to total bank borrowings of the industry.[11] High values of the index reflect that it is easier for a firm to borrow from banks with higher credit degree. The second variable, firm's share of stock market value (*Smar*), is defined as the ratio of firm's stock market value to the total stock market value of the industry. It would provide the share of the firm in a stock market, as a measure of information of stock market size for individual firm relative to other firms in the same industry. The index reflects the degree of stock credit for an individual firm.

2.3. *Basic statistics*

Table 1 presents the number of listed and OTC companies by industry in various years. There are only 106 listed companies in 1991, among them, the

[9]Total funds are composed of bank borrowing, corporate bonds issuing, stock issuing and retained earnings.

[10]The correlation between internal financing and internal funds ratio is high. Hence, we use internal financing index is being substituted for internal funds ratio.

[11]Bank borrowing is calculated as the sum of long-term debt and short-term debt minus nonfinancial institutions debt.

Table 1. Number of firms by industry and year.

Unit: No. of firms

Year	Industry			
	Traditional industry	Basic industry	Technology-intensive industry	Total
1991	47 (44.34%)	31 (29.25%)	28 (26.42%)	106 (100%)
1992	51 (41.13%)	40 (32.26%)	33 (26.61%)	124 (100%)
1993	55 (40.74%)	43 (31.85%)	37 (27.41%)	135 (100%)
1994	60 (39.47%)	45 (29.61%)	47 (30.92%)	152 (100%)
1995	62 (35.84%)	49 (28.32%)	62 (35.84%)	173 (100%)
1996	65 (32.66%)	53 (26.63%)	81 (40.7%)	199 (100%)
1997	68 (29.57%)	57 (24.78%)	105 (45.65%)	230 (100%)
1998	72 (25.71%)	62 (22.14%)	146 (52.14%)	280 (100%)
1999	72 (25.71%)	62 (22.14%)	146 (52.14%)	280 (100%)
2000	72 (25.71%)	62 (22.14%)	146 (52.14%)	280 (100%)
2001	72 (25.71%)	62 (22.14%)	146 (52.14%)	280 (100%)
2002	72 (25.71%)	62 (22.14%)	146 (52.14%)	280 (100%)

Note: Figures in parentheses are percentages.
Source: Computed by author from data in Taiwan Economic Journal.

largest share is the traditional industry followed by the basic industry. The number of listed and OTC companies in the traditional industry was still the largest share and accounted for 39.47% of our sample in 1994. The number of firms in technology-intensive industry continued to grow. By 1995, it was the largest industry in our sample. The number of technology-intensive firms was only 62 in 1995, but had reached 146 and accounted for 52.14% of our sample in 1998.

Table 2 reports the sources of financing by industry in various years. Four forms of financing sources are bank borrowing, stock issuing, corporate

Table 2. Distribution of sources of financing by industry.

		Bank-financing %	Equity-financing %	Bonds-financing %	Internal funds%
1991	Traditional	25.71	64.85	1.63	7.80
	Basic	22.23	67.30	0.94	9.54
	Technology	21.90	60.02	4.08	13.99
1992	Traditional	24.59	67.00	1.66	6.75
	Basic	22.77	67.01	1.34	8.88
	Technology	20.79	63.59	3.40	12.21
1993	Traditional	22.04	70.41	1.55	6.01
	Basic	20.54	68.59	1.07	9.80
	Technology	18.57	63.15	2.91	15.37
1994	Traditional	20.69	67.78	1.69	9.84
	Basic	20.01	65.09	3.04	11.87
	Technology	19.09	60.09	4.67	16.16
1995	Traditional	19.93	71.35	1.44	7.28
	Basic	20.19	64.98	3.79	11.05
	Technology	23.36	71.75	7.03	−2.13
1996	Traditional	17.37	72.81	2.98	6.84
	Basic	18.53	64.74	6.12	10.60
	Technology	18.56	60.95	5.03	15.45
1997	Traditional	19.71	67.96	3.57	8.77
	Basic	23.34	61.08	7.22	8.36
	Technology	19.15	57.97	5.80	17.08
1998	Traditional	23.40	71.59	3.47	1.54
	Basic	22.90	65.13	6.69	5.29
	Technology	20.44	64.36	5.83	9.37
1999	Traditional	25.73	70.78	3.88	−0.38
	Basic	24.54	64.48	6.18	4.80
	Technology	20.46	63.69	5.83	10.02
2000	Traditional	28.23	73.28	4.24	−5.74
	Basic	27.79	65.68	5.18	1.35
	Technology	22.96	63.29	6.87	6.89
2001	Traditional	28.93	72.90	3.51	−5.34
	Basic	28.83	66.85	4.62	−0.31
	Technology	22.78	69.55	8.18	−0.50
2002	Traditional	28.49	71.46	3.36	−3.30
	Basic	27.16	64.95	4.64	3.25
	Technology	21.65	66.42	8.55	3.38

bonds issuing and internal funds.[12] When comparing the difference of financing source, we find that financing through the share of stock issuing is the

[12]Internal funds are the retained earnings.

largest one, accounting for over 60% of total funds. It reflects that firms prefer to rely more on stock as a source of fund. After the shocks of Asian financial crisis and local financial crisis in 1998, the profitability of the listed and OTC companies in Taiwan weakened and therefore the internal funds got reduced further. Especially, the traditional industries, the mean retained earnings over total funds became negative since 1999. As for the bank borrowings, the traditional and basic industries have the highest average bank borrowing share during the study period except in 1995–1996. Regarding the stock issuing, the traditional and basic industries also have a high average stock issuing share except in the year 1995. In addition, the share of corporate bonds issuing in the technology-intensive industry shows a significantly increasing trend from 5.03% in 1996 to 8.55% in 2002, while the traditional industry shows a declining trend. As for the internal funds, the technology-intensive industry has the highest average internal funds ratio (3.27%).

Table 3 shows the summary statistics for major variables. Over the sample period, firms of technology-intensive industry have much higher average growth rates of output, firm size, R&D ratio, export ratio, investment ratio, and rate of return on total assets than the other industries. However, firms in technology-intensive industry have lower average age and debt-to-equity ratio. In addition, bank borrowing and equity issues are the most important financing sources for firms. Technology-intensive industry appears to have more bonds and internal financing as sources of funds. One possible reason may be that technology-intensive firms are newly established with more cash inflows and high market credit.

3. Empirical Results

Table 4 reports the correlations matrix. The cross-correlations are markedly higher in several variables. First, *Gdpgr* is negatively and highly correlated with *M2gdp*, with a correlation coefficient of −0.75. Second, the correlation between *Debt* and *Bank* is 0.76. Third, *Profit* is correlated with *Internal*, with a correlation coefficient of 0.83. Fourth, *Marcap* is positively and strongly correlated with *Structs*, with a correlation coefficient of 0.97. The correlation between *Valtrade* and *Structa* is also extremely high (0.97). Finally, the correlation between *Structa* and *Structs* is 0.63. It appears that these variables are highly correlated over the sample period. Hence, when we add them in each of the regression, multicollinearity might be serious. To overcome the difficulty, only one of them was included in each of the regressions.

Table 3. Descriptive statistics (1991–2002).

Variable (unit)	Total	Traditional industry	Basic industry	Technology-intensive industry
Growth rate of net sales (%)	11.24	4.67	6.78	18.23
	(32.10)	(30.98)	(17.30)	(37.40)
Firm age (years)	25.57	29.18	29.32	20.99
	(10.47)	(9.56)	(8.78)	(10.14)
Number of employees (logarithm)	6.54	6.55	6.31	6.66
	(1.00)	(0.98)	(1.03)	(0.98)
Capital intensity (thousand NT/person)	3602.74	4124.52	5002.03	2463.40
	(3834.36)	(4295.29)	(4605.81)	(2438.60)
R&D ratio (%)	1.58	0.41	1.09	2.65
	(2.47)	(0.65)	(1.76)	(3.08)
Exports ratio (%)	38.29	24.74	29.25	52.62
	(32.48)	(25.20)	(24.07)	(35.12)
Invest ratio (%)	7.96	5.87	8.04	9.34
	(31.56)	(47.59)	(20.32)	(22.20)
Debt-to-equity ratio (%)	45.08	49.74	49.85	39.23
	(46.40)	(54.26)	(48.10)	(38.25)
Internal financing (%)	10.94	6.39	8.15	15.61
	(24.97)	(17.73)	(16.65)	(31.45)
Return on total assets (%)	5.26	3.31	4.55	6.99
	(7.48)	(5.89)	(5.40)	(8.93)
Firm's share of bank borrowing (%)	4.31	5.60	5.69	2.65
	(8.34)	(9.90)	(8.05)	(6.91)
Firm's share of stock market value (%)	5.01	6.67	5.61	3.55
	(9.18)	(11.52)	(7.41)	(7.96)
Bank-financing ratio (%)	22.55	23.86	23.60	21.06
	(19.20)	(17.11)	(18.41)	(20.83)
Equity-financing ratio (%)	66.42	70.45	65.32	64.29
	(25.37)	(16.19)	(18.33)	(32.58)
Bond-financing ratio (%)	4.86	2.87	4.59	6.37
	(10.21)	(5.94)	(8.17)	(12.93)
Internal funds ratio (%)	6.17	2.83	6.49	8.28
	(33.21)	(14.86)	(13.52)	(47.02)

Note: Number in parentheses are standard errors.

Table 5 reports the regression estimation results for the firms' growth.[13] The asterisks ** indicate the error level at 0.05, all in a one-tail test. Almost all one-step GMM estimation results reject the over-identifying restrictions. Table 5 hence shows the two-step GMM estimation results. The last two

[13]The estimation software package used is Stata 8.0.

Table 4. Correlation matrix.

Variables	*Y*	*Age*	*Size*	*KL*	*R&D*	*Export*	*Investr*	*Gdpgr*	*Profit*	*Debt*	*Sdebt*	*Smar*	*Bank*	*Stock*	*Bond*	*Internal*	*Private*	*M2gdp*	*Marcap*	*Valtrade*	*Structa*	*Structs*
Y	1.00																					
Age	−0.22	1.00																				
Size	0.06	0.19	1.00																			
KL	−0.02	0.12	−0.12	1.00																		
R&D	0.05	−0.29	0.10	−0.09	1.00																	
Export	0.15	−0.41	0.11	−0.22	0.26	1.00																
Investr	0.09	−0.07	0.11	0.16	0.13	0.02	1.00															
Gdpgr	0.17	−0.07	0.09	−0.14	−0.10	−0.12	0.04	1.00														
Profit	0.40	−0.22	0.17	−0.14	0.16	0.14	0.09	0.21	1.00													
Debt	−0.06	0.02	0.02	0.23	−0.12	−0.08	0.02	−0.11	−0.41	1.00												
Sdebt	−0.06	0.38	0.37	0.19	−0.11	−0.25	0.04	0.06	−0.04	0.25	1.00											
Smar	−0.04	0.37	0.47	0.05	−0.06	−0.21	0.03	0.11	0.15	−0.09	0.58	1.00										
Bank	−0.02	0.02	0.01	0.18	−0.16	−0.08	0.05	−0.07	−0.39	0.76	0.26	−0.09	1.00									
Stock	−0.17	0.12	−0.23	−0.08	−0.04	−0.06	−0.11	−0.05	−0.33	−0.20	−0.20	−0.10	−0.05	1.00								
Bond	0.00	0.01	0.25	0.07	0.13	0.09	0.03	−0.09	−0.07	0.18	0.10	0.09	−0.05	0.10	1.00							
Internal	0.28	−0.25	0.04	−0.12	0.22	0.14	0.07	0.18	0.83	−0.39	−0.11	0.07	−0.39	−0.16	−0.11	1.00						
Private	0.06	−0.03	−0.03	0.01	0.04	0.05	0.01	−0.02	0.06	−0.01	−0.05	−0.10	−0.05	0.00	0.05	0.08	1.00					
M2gdp	−0.05	0.10	−0.11	0.18	0.12	0.16	−0.07	−0.75	−0.19	0.13	−0.09	−0.17	0.07	0.04	0.12	−0.17	0.25	1.00				
Marcap	−0.03	0.02	−0.07	0.08	0.10	0.11	−0.01	−0.39	−0.05	0.06	−0.08	−0.14	0.00	−0.02	0.09	−0.01	0.49	0.51	1.00			
Valtrade	0.10	−0.01	−0.04	0.03	0.06	0.08	0.01	0.10	0.03	0.02	−0.06	−0.10	0.00	−0.06	0.07	0.06	0.39	0.18	0.59	1.00		
Structa	0.08	0.00	−0.05	0.05	0.07	0.09	0.00	0.01	0.00	0.04	−0.07	−0.11	0.02	−0.05	0.08	0.02	0.23	0.25	0.59	0.97	1.00	
Structs	−0.04	0.03	−0.07	0.09	0.10	0.11	−0.02	−0.44	−0.07	0.07	−0.08	−0.13	0.01	−0.02	0.09	−0.03	0.33	0.55	0.97	0.57	0.63	1.00

Table 5. Regression results.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Constant	-3.3003^{**}	-1.3100^{**}	-3.2440^{**}	-2.8833^{**}	-3.2799^{**}	-3.4396^{**}	-2.9010^{**}	-2.7643^{**}
	(0.1185)	(0.0905)	(0.1325)	(0.1033)	(0.1218)	(0.1161)	(0.1122)	(0.1175)
$Y[n-1]$	0.0627^{**}	0.0089^{**}	0.0290^{**}	0.0516^{**}	0.0629^{**}	0.0619^{**}	0.0600^{**}	0.0577^{**}
	(0.0016)	(0.0022)	(0.0025)	(0.0012)	(0.0016)	(0.0015)	(0.0014)	(0.0015)
Age	0.1488^{**}	0.0986^{**}	0.1736^{**}	0.1402^{**}	0.1537^{**}	0.1477^{**}	0.1464^{**}	0.1396^{**}
	(0.0050)	(0.0033)	(0.0055)	(0.0047)	(0.0050)	(0.0047)	(0.0048)	(0.0048)
Size	10.4630^{**}	10.1001^{**}	13.5242^{**}	8.9504^{**}	10.8273^{**}	10.1175^{**}	11.2093^{**}	11.4166^{**}
	(0.2608)	(0.2997)	(0.4093)	(0.3641)	(0.2950)	(0.2639)	(0.3377)	(0.3365)
KL	0.0009^{**}	0.0014^{**}	0.0006^{**}	0.0009^{**}	0.0009^{**}	0.0009^{**}	0.0009^{**}	0.0009^{**}
	(0.00004)	(0.0001)	(0.00004)	(0.00004)	(0.00004)	(0.00004)	(0.00004)	(0.00005)
Lagged R&D	2.4488^{**}	3.4911^{**}	3.1380^{**}	2.4227^{**}	2.4345^{**}	2.4332^{**}	2.3404^{**}	2.2606^{**}
	(0.0641)	(0.0812)	(0.1200)	(0.0868)	(0.0776)	(0.0607)	(0.0802)	(0.0894)
Export	0.2646^{**}	0.2467^{**}	0.0206^{**}	0.2710^{**}	0.2470^{**}	0.2675^{**}	0.2743^{**}	0.2547^{**}
	(0.0085)	(0.0139)	(0.0120)	(0.0105)	(0.0082)	(0.0092)	(0.0113)	(0.0110)
Investr	0.0573^{**}	0.0402^{**}	0.0658^{**}	0.0637^{**}	0.0597^{**}	0.0590^{**}	0.0544^{**}	0.0531^{**}
	(0.0037)	(0.0040)	(0.0039)	(0.0037)	(0.0038)	(0.0037)	(0.0042)	(0.0042)
Gdpgr	3.1777^{**}	2.3757^{**}		3.2687^{**}	3.1483^{**}	3.1284^{**}	3.2034^{**}	3.1803^{**}
	(0.0390)	(0.0229)		(0.0434)	(0.0401)	(0.0390)	(0.0375)	(0.0396)
Debt	-0.0357^{**}							
	(0.0026)							
Profit		2.1632^{**}						
		(0.0119)						
M2GDP			-57.6661^{**}					
			(1.6262)					

Table 5. (*Continued*)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Private				37.0750**				
				(0.4294)				
Marcap			−9.5718**					
			(0.2250)					
Valtrade				−0.6984**				
				(0.0437)				
Structs					−5.1666**			
					(0.2480)			
Structa						1.2480**		
						(0.1092)		
FDI							−5.8642**	−7.5423**
							(0.5045)	(0.6292)
FDI × *IND1*								5.4937**
								(1.3076)
FDI × *IND2*								2.7752**
								(0.5086)
Sargan test p-values	0.35	0.59	0.13	0.28	0.32	0.29	0.33	0.32
Second-order serial correlation p-values	0.32	0.67	0.69	0.35	0.31	0.33	0.38	0.39

Note: Numbers in parentheses are standard errors. ** and * indicate significance levels of 5% and 10%, respectively.

Table 5. (*Continued*)

	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
Constant	−3.3196**	−3.3052**	−3.2139**	−1.0080**	−0.9433**	−0.4504**	−0.7727**	−0.5513**
	(0.1419)	(0.1408)	(0.1144)	(0.1398)	(0.1395)	(0.1638)	(0.1466)	(0.1429)
$Y[n-1]$	0.0613**	0.0611**	0.0592**	0.0183**	0.0177**	0.0242**	0.0205**	0.0123**
	(0.0016)	(0.0016)	(0.0015)	(0.0025)	(0.0026)	(0.0027)	(0.0022)	(0.0024)
Age	0.1522**	0.1516**	0.1514**	0.0863**	0.0855**	0.0541**	0.0793**	0.0651**
	(0.0057)	(0.0056)	(0.0047)	(0.0054)	(0.0053)	(0.0063)	(0.0060)	(0.0055)
Size	10.9252**	10.8173**	11.1957**	10.4985**	10.2954**	10.5384**	10.0939**	10.4284**
	(0.4692)	(0.4259)	(0.3840)	(0.4945)	(0.5125)	(0.5730)	(0.4653)	(0.4700)
KL	0.0010**	0.0010**	0.0010**	0.0012**	0.0012**	0.0010**	0.0012**	0.0011**
	(0.00005)	(0.00004)	(0.00004)	(0.00004)	(0.00005)	(0.0001)	(0.0001)	(0.00005)
Lagged R&D	2.5279**	2.5232**	2.6469**	2.7975**	2.7826**	3.1740**	2.9215**	2.9363**
	(0.0718)	(0.0731)	(0.0697)	(0.0691)	(0.0712)	(0.0978)	(0.0637)	(0.0699)
Export	0.2599**	0.2610**	0.2592**	0.2282**	0.2343**	0.2465**	0.2155**	0.2268**
	(0.0109)	(0.0118)	(0.0111)	(0.0138)	(0.0127)	(0.0195)	(0.0104)	(0.0118)
Investr	0.0590**	0.0588**	0.0582**	0.0418**	0.0419**	0.0504**	0.0482**	0.0468**
	(0.0042)	(0.0049)	(0.0035)	(0.0042)	(0.0039)	(0.0041)	(0.0051)	(0.0036)
Gdpgr	3.2242**	3.2253**	3.2268**	2.7017**	2.6979**	2.5875**	2.6893**	2.6551**
	(0.0358)	(0.0382)	(0.0345)	(0.0281)	(0.0278)	(0.0350)	(0.0266)	(0.0355)
Sdebt	0.2389**	0.2014**	0.2709**					
	(0.0366)	(0.0385)	(0.0345)					
Smar	0.8594**	0.8560**	1.5984**					
	(0.0450)	(0.0462)	(0.0667)					

Table 5. (*Continued*)

	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
Bank				0.2239**	0.2887**	0.4936**	0.2168**	0.2225**
				(0.0105)	(0.0132)	(0.0111)	(0.0097)	(0.0082)
Stock				−0.0159**	−0.0287**	−0.1586**	−0.0213**	−0.0109**
				(0.0038)	(0.0046)	(0.0085)	(0.0043)	(0.0037)
Bond				−0.1908**	−0.1933**	0.0018	−0.1471**	−0.1621**
				(0.0106)	(0.0101)	(0.0138)	(0.0169)	(0.0105)
Internal				0.5096**	0.5083**	0.5858**	0.5146**	0.6315**
				(0.0062)	(0.0061)	(0.0078)	(0.0064)	(0.0061)
Sdebt × *IND1*		0.1199*						
		(0.0655)						
Sdebt × *IND2*		0.0960						
		(0.0746)						
Smar × *IND1*			−1.2459**					
			(0.0866)					
Smar × *IND2*			−0.9736**					
			(0.0642)					
Bank × *IND1*					−0.1501**			
					(0.0302)			
Bank × *IND2*					−0.1599**			
					(0.0230)			

Table 5. (*Continued*)

	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
Stock × *IND1*						1.3166**		
						(0.0406)		
Stock × *IND2*						0.1437**		
						(0.0245)		
Bond × *IND1*							−0.8854**	
							(0.0537)	
Bond × *IND2*							0.1040**	
							(0.0472)	
Internal × *IND1*								−0.3957**
								(0.0161)
Internal × *IND2*								−0.2489**
								(0.0152)
Sargan test p-values	0.31	0.31	0.32	0.38	0.40	0.39	0.35	0.24
Second-order serial correlation p-values	0.35	0.35	0.35	0.51	0.52	0.64	0.48	0.63

Note: Numbers in parentheses are standard errors. ** and *indicate significance levels of 5% and 10%, respectively.

row shows p-values of the two-step difference for the Sargan test of the overidentifying restrictions. All p-values of the Sargan test cannot reject the null of overidentitying restrictions. Thus, we do not reject the null hypothesis that the instruments are appropriate. The last row reports p-values of the test of second-order serial correlation. The tests indicate that econometric specification and the assumption of no second-order serial correlation cannot be rejected.

As shown in Table 5, the results show a significantly positive relationship between firm age, size, capital intensity, lagged R&D, investment ratio and firm growth.[14] This suggests that larger and older firms have better growth performance than smaller and younger firms. Higher lagged R&D, investment ratio and capital intensity are associated with higher firm growth. The *Export* has a positive and significant effect on firm growth. As Taiwan is a small open economy with a high degree of trade dependency, manufacturing sector is the major exporting sector. Higher export ratio has contributed to higher growth for these firms. Further, the return on total assets has significantly and positively affected on firm growth, while the debt to equity ratio has a negative effect on the growth of firms. The results indicate that if a firm has a relatively sound financial structure, they will enjoy higher growth.

As to the effect of the financial development, columns 3 and 4, include the effects of both bank development and stock market development indicators. We find that the coefficient for *Private* is significantly positively related, while *M2gdp*, *Marcap* and *Valtrade* are significantly negatively related to the firm growth. It is shown that the development of the banking sector is more relevant than that of the stock market for the growth of the firm. These indicate that Taiwan stock market during 1991–2002 is still a underdeveloping and emerging stock market.[15] The results are consistent with previous research documented by Gallego and Loayza (2001), when they studied the case of Chile. Similar results are obtained when we replace the financial

[14]Current R&D has been considered as one of the explanatory variables. But all coefficients are significantly negative. However, all coefficients of lagged R&D dated $t-1$ are significantly positive and are quite robust. The positive impact of R&D on firm growth might be effective one year later. We hence use lagged R&D date $t-1$ in our analysis.

[15]In fact, the liberalization of stock market in Taiwan was slowly and gradually during the past decade. The participation of foreign investors in the Taiwan stock market is also allowed to increase gradually. Until 2003, the government has pushed for greater liberalization of the stock market. QFIIs were permitted to invest up to 100% in most listed firms in Taiwan, while the qualification requirement for each QFII was abolished.

development by financial structure in columns 5 and 6. In column 5, the estimated coefficient of structure-size (*Structs*) has a negative and significant effect on the growth rate of firms, while in column 6, the estimated coefficient of structure-activity (*Structa*) is significantly positive. It reflects that larger activity of the banking sector and stock market lead high growth of firms.

To capture the effect of outward FDI toward China on firm growth, in columns 7 and 8, we add the FDI dummy variable. The results indicate that firm investment in China has a negative effect on firm growth. This reflects that outward FDI toward China has a substitution effect on firm's domestic output. In addition, to further examine whether the relation between outward FDI toward China and firm growth differs across industries, we consider the interaction term of FDI and industry dummies in our regression. The results indicate that the growth of firm is positively related to both the interaction terms $FDI \times IND1$ and $FDI \times IND2$. That is, it seems that the substitution effects on sales growth in the traditional or basic industrial firms engaged in FDI toward China are smaller. However, it should be noted that those output produced by Taiwanese firms' foreign branches in China is included in the sales account. Thus, it is possible that FDI toward China had caused a hollowing-out of Taiwan domestic industries, although the degree of substitution will depend on the characteristics of each industry (see Hsu and Liu, 2004).

In addition, using firm's share of bank borrowing (*Sdebt*) and that of stock market value (*Smar*) as proxies for the credit degree of firm in the banking sector and stock market respectively, column 9 indicates that a firm's share of bank borrowing (*Sdebt*) and that of stock market value (*Smar*) have significant positive effects on the growth of that firm. It indicates that individual firm that could be financed more from either banks or equity market will enjoy high rate of growth compared to other firms in the same industry. Also, we examine whether those effects are different across industries. Hence, we include the interaction terms with industry dummies in the regression, as shown in columns 10 and 11. The estimated coefficients for the interaction term $IND1 \times Smar$ and $IND2 \times Smar$ become significantly negative, and the interaction terms $IND1 \times Sdebt$ are significantly positive, while the $IND2 \times Sdebt$ interaction terms are insignificantly positive. The net effects of *Sdebt* and *Smar* for firms in the traditional or basic industries are significantly positive. However, the estimated coefficients for *Smar* are lower than those for firms in the technology-intensive industry. Thus, this indicates that the effect of equity financing on firm growth are weaker for traditional and basic industries than for technology-intensive industry.

Regarding financing sources, in columns 12–16, all coefficients of internal financing (*Internal*) and bank-financing (*Bank*) are significantly positive. But when considering firm's financing sources from bond-financing (*Bond*) or equity-financing (*Stock*), firm growth is significantly negatively related to both *Bond* and *Stock*. This implies that firms with more retained earnings and lower equity financing are likely to have higher growth. In addition, firms capable of using bank financing also have higher growth. Similar results are found in many industrialized countries.[16]

Moreover, since the effects of financing source on firm growth may differ from industry to industry, the interaction terms of industry dummy with financing patterns are included in regressions. The results show that coefficients of these estimators for the interaction terms $Bank \times IND1$, $Bank \times IND2$, $Bond \times IND1$, $Bond \times IND2$, $Internal \times IND1$, and $Internal \times IND2$ are negative and statistically significant, while the coefficients for the interaction term $Stock \times IND1$, $Stock \times IND2$, and $Bond \times IND2$ are significantly positive. The net effects of various financing sources appear to be positive and significant for firms in traditional and basic industries except bond financing.

4. Conclusions

Using a firm-level panel data, the paper examines the determinants of firm growth for 280 listed and OTC manufacturing companies in Taiwan over the period of 1991–2002. Apart from firm characteristics, we also focus on the effects of financial structure, corporate financing pattern and outward FDI in China on the growth of Taiwanese manufacturing firms. The present findings can be summarized as in the following.

First, it shows that firm characteristics including age, size, capital-intensity, lagged R&D, investment ratio, return on total assets and export ratio have significantly positive effects on firm growth. Second, the study shows that high debt-to-equity ratio is associated with lower corporation growth, while high profitability of total assets is associated with higher firm growth. This reflects that a firm with financial structure relative sound will facilitate its growth.

[16] Data in US, UK, and Germany indicate that in the long run the bank-financing share is higher for corporate finance than other external financing. (See Mishkin, 2004.)

Third, higher liquidity of the stock market relative to the banking sector leads to higher growth of firms. However, larger size of the stock market relative to the banking sector leads to lower firm's growth during 1991–2002. This implies that the substitution of direct finance for indirect finance is harmful to firm growth. Fourth, FDI toward China might cause a hollowing-out of Taiwan domestic industries. Fifth, those firms that could be financed more from either banks or equity market will enjoy higher rates of growth compared to other firms in the same industry. However, the effects on traditional and basic industries are weaker than those on technology-intensive industry.

Finally, high bank-financing ratio and internal financing are associated with higher firm growth, while firms using more bond or equity financing tend to experience lower growth. However, it should be noted that the net effects of equity financing on the growth of firms in traditional and basic industries are significantly positive and greater during the study period. The relatively low productivity and low ratio of bank financing in those two industries during 1990s explain such results. The fact that traditional and basic industries have confronted the contraction of banking loans is thus quite reasonable.

Acknowledgements

We are grateful to Prof. Cheng F. Lee, the Editor, and an anonymous referee of this Journal for useful comments on an earlier draft. We also thank those workshop participants at Tokyo University, National Taiwan University, and National Sun Yat-Sen University for helpful comments and suggestions.

Appendix: Arellano-Bond GMM Estimation Method

Our dynamic model specified in Eq. (1) is characterized by the presence of a lagged dependent variable among the regressors. This is presented as follows:

$$y_{it} = \alpha + \lambda y_{it-1} + \beta' x_{it} + \eta_i + v_{it}; \quad |\lambda| < 1; \ i = 1, \ldots, N; \ t = 2, \ldots, T_i \tag{A1}$$

where x_{it} is $1 \times k$ vector of explanatory variables, including our measures for financial structure and corporate finance, β are the vectors of coefficients, α and λ are scalars. T_i is the number of ways the firm i belongs. η_i is an unobserved individual specific effect and v_{it} is the error term.

In (A1) that the lagged dependent variable, which enters as an independent explanatory variable, is correlated with the individual specific component of the error term. The estimation of Eq. (A1) by OLS generates biased and inconsistent estimator. To resolve this problem, we use the generalized method of moments (GMM) estimators developed by Arellano and Bond (1991).[17]

To eliminate the individual specific effects η_i, we take first-differences of Eq. (A1):

$$\Delta y_{it} = \lambda \Delta y_{it-1} + \beta' \Delta x_{it} + \Delta v_{it}. \tag{A2}$$

The use of instruments is required to deal with the likely endogeneity of the explanatory variables, and the problem that by construction Δv_{it} is correlated with the lagged dependent variable, Δy_{it-1}. Arellano and Bond (1991) suggests a GMM procedure to estimate Eq. (A2) using the following moment conditions:

$$\mathrm{E}[y_{it-s}\Delta v_{it}] = 0, \quad \text{for } s = 2, \ldots, t-1;\ \ t = 3, \ldots, T_i, \tag{A3}$$

$$E[x_{it-s}\Delta v_{it}] = 0, \quad \text{for } s = 2, \ldots, t-1;\ \ t = 3, \ldots, T_i. \tag{A4}$$

Let W_i' is the matrix of instruments for individual i, then the moment conditions can be expressed more compactly as

$$E(W_i' \Delta v_i) = 0$$

where

$$W_i' = \begin{bmatrix} [y_{i1}, x_{i1}', x_{i2}'] & 0 & \cdots & 0 \\ 0 & [y_{i1}, y_{i2}, x_{i1}', x_{i2}', x_{i3}'] & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & [y_{i1}, \ldots, y_{iT-2}, x_{i1}', \ldots, x_{iT-1}'] \end{bmatrix},$$

and $\Delta v_i = (\Delta v_{i3}, \Delta v_{i4}, \ldots, \Delta v_{iT})'$.

The optimal matrix of instruments depends on whether the x_i are endogeneous, predetermined or strictly exogenous variables. If x is enogeneous, in the sense, the vector $(y_{i1}, y_{i2}, \ldots, y_{iT-2}, x_{i1}', x_{i2}', \ldots, x_{iT-1}')$ is replaced by the vector $(y_{i1}, y_{i2}, \ldots, y_{iT-2}, x_{i1}', x_{i2}', \ldots, x_{iT-2}')$ in forming each row of the instrument matrix W_i'. If the x_i series is strictly exogenous, then the vector $(y_{i1}, y_{i2}, \ldots, y_{iT-2}, x_{i1}', x_{i2}', \ldots, x_{iT-1}')$ is replaced by the vector $(y_{i1}, y_{i2}, \ldots, y_{iT-2}, x_{i1}', x_{i2}', \ldots, x_{iT}')$ to instrument matrix.

---

[17]See Arellano and Bond (1991), Bond (2002) and Baltagi (2001, pp. 131–135) for more details discussion.

Premultiplying the differenced Eq. (A2) in vector form by W', we have

$$W'\Delta y = W'(\Delta y_{-1})\lambda + W'(\Delta x)\beta + W'\Delta v. \tag{A5}$$

Performing Generalized Least Squares (GLS) on (A5), a one-step GMM estimator is given by

$$\begin{bmatrix} \tilde{\lambda} \\ \tilde{\beta} \end{bmatrix} = [(\Delta y_{-1}\Delta x)'W(W'(I_N \otimes G)W)^{-1}W'(\Delta y_{-1}\Delta x)]^{-1} \times [(\Delta y_{-1}\Delta x)'W(W'(I_N \otimes G)W)^{-1}W'(\Delta y)]$$

where G is $(T-2)\times(T-2)$ matrix with 2's in the main diagonal, -1's in the first off-diagonals, and zeros otherwise. $E(\Delta v_i \Delta v_i') = \sigma_v^2(I_N \otimes G)$. Given $\tilde{\lambda}$ and $\tilde{\beta}$, the efficient two-step GMM estimator for λ and β are obtained:

$$\begin{bmatrix} \widehat{\lambda} \\ \widehat{\beta} \end{bmatrix} = [(\Delta y_{-1}\Delta x)'WV_N^{-1}W'(\Delta y_{-1}\Delta x)]^{-1} \times [(\Delta y_{-1}\Delta x)'WV_N^{-1}W'(\Delta y)] \tag{A6}$$

where $V_N = \sum_{i=1}^{N} W_i'(\Delta \widehat{v}_i)(\Delta \widehat{v}_i')'W_i$, $\Delta \widehat{v}_i$ are residuals from an initial consistent estimator.

Consistency of the two-step GMM estimator depends on the validity of the instruments. Following Arellano and Bond (1991), we use two specifications tests: the Sargan test of over-identifying restrictions, which tests the validity of the instruments, and a test that the error term is not second-order serially correlated.

The first is a Sargan's (1958) test of overidentifying restrictions given by

$$s = \Delta\hat{v}'W\left[\sum_{i=1}^{N} W_i'(\Delta\hat{v}_i)(\Delta\hat{v}_i')W_i\right]^{-1} W'(\Delta\hat{v}) \sim \chi^2_{p-k-1}$$

where p refers to the number of columns of W and $\Delta\hat{v}$ denote the residuals from a two-step estimation given in (A6).

The second test examine the null hypothesis that the error term Δv_{it} is not second-order serially correlated, i.e., $E(\Delta v_{it}\Delta v_{it-2}) = 0$. The test statistic is

$$m_2 = \frac{\hat{v}_{-2}\hat{v}_*^{asy}}{\hat{v}^{1/2}} \sim N(0,1).$$

Note that m_2 is only defined for $T \geq 5$, since it involves differenced residuals two periods apart.

References

Anderson, T and C Hsiao (1982). Formulation and estimation of dynamic models using panel data. *Journal of Econometrics*, 18, 47–82.

Arellano, M and S Bond (1991). Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations. *Review of Economic Studies*, 58, 277–297.

Audretsch, DB (1995). Innovation, growth and survival. *International Journal of Industrial Organization*, 13, 441–457.

Audretsch, DB and T Mahmood (1995). New firm survival: New results using a hazard function. *Review of Economics and Statistics*, 77, 97–103.

Baltagi, BH (2001). *Econometric Analysis of Panel Data*, 2nd edition. New York: John Wiley & Sons.

Beck, T, R Levine and N Loayza (2000). Finance and the sources of growth. *Journal of Financial Economics*, 58, 261–300.

Beck, T, A Demirgüc-Kunt, R Levine and V Maksimovic (2001). Financial structure and economic development: Firm, industry, and country evidence. In A Demirgüc-Kunt and R Levine (eds.), *Financial Structure and Economic Growth: A Cross-Country Comparison of Banks, Markets, and Development*, pp. 189–241. Cambridge, MA and London, England: The MIT Press.

Beck, T, A Demirgüc-Kunt, R Levine and V Maksimovic (2002). Financial and legal constraints to firm growth: Does size matter? *World Bank Working Papers 2784*.

Bond, S (2002). Dynamic panel data models: A guide to micro data methods and practice. *CEMMAP Working Paper 09/02*. The Institute for Fiscal Studies, London.

Christopoulos, DK and EG Tsionas (2004). Financial development and economic growth: Evidence from panel unit root and cointegration tests. *Journal of Development Economics*, 73, 55–74.

Chan, VL (2002). Financial liberalization and investment: The case of Taiwan. *Taiwan Economic Forecast and Policy*, 32, 29–59.

Chen, TJ and YH Ku (2000). The effect of foreign direct investment on firm growth: The case of Taiwan's manufacturers. *Japan and the World Economy*, 12, 153–172.

Demirgüc-Kunt, A and V Maksimovic (1998). Law, finance, and firm growth. *Journal of Finance*, 53, 2107–2137.

Demirgüc-Kunt, A and R Levine (2001). Based and market-based financial systems: Cross-country comparisons. In A Demirgüc-Kunt and R Levine (eds.), *Financial Structure and Economic Growth: A Cross-Country Comparison of Banks, Markets, and Development*, pp 81–140. Cambridge, MA and London, England: The MIT Press.

Dunne, T, MJ Roberts and L Samuelson (1989). The growth and failure of US manufacturing plants. *Quarterly Journal of Economics*, 104, 671–698.

Dunne, P and A Hughes (1994). Age, size, growth and survival: UK companies in the 1980's. *Journal of Industrial Economics*, 42, 115–140.

Evans, DS (1987a). Tests of alternative theories of firm growth. *Journal of Political Economy*, 95, 657–674.

Evans, DS (1987b). The relationship between firm growth, size, and age: Estimates for 100 manufacturing industries. *Journal of Industrial Economics*, 35, 567–581.

Gallego, F and N Loayza (2001). Financial structure in Chile: Macroeconomic developments and microeconomic effects. In A Demirgüc-Kunt and R Levine (eds.), *Financial Structure and Economic Growth: A Cross-Country Comparison of Banks, Markets, and Development*, pp. 299–346 Cambridge, MA and London, England: The MIT Press.

Greenwood, J and B Jovanovic (1990). Financial development, growth, and the distribution of income. *Journal of Political Economy*, 98, 1076–1107.

Griliches, Z and J Mairesse (1983). Comparing productivity growth: An exploration of French and US industrial and firm data. *European Economic Review*, 21, 89–119.

Hall, BH (1987). The relationship between firm size and firm growth in the US manufacturing sector. *Journal of Industrial Economics*, 35, 583–606.

Hall, BH and J Mairesse (1995). Exploring the relationship between R&D and productivity in manufacturing firms. *Journal of Econometrics*, 65, 263–293.

Holtz-Eakin, D (1988). Testing for individual effects in autoregressive models. *Journal of Econometrics*, 39, 297–307.

Hsiao, C (1986). *Analysis of Panel Data*. New York: Cambridge University Press.

Hsu, CM, WC Liu and SF Lee (2003). The role of financial development in economic growth: The experiences of Taiwan, Korea, and Japan. Paper presented at the Asian Crisis V Conference on *New Challenges and Opportunities for the Post-Crisis Asia*, Kangwon National University, Chuncheon, Korea, December 9–10.

Hsu, CM and WC Liu (2004). The role of Taiwanese foreign direct investment in China: Economic integration or hollowing-out? *Journal of the Korean Economy*, 5, 207–231.

Jovanovic, B (1982). Selection and evolution of industry. *Econometrica*, 50, 649–670.

King, RG and R Levine (1993). Finance and growth: Schumpeter might be right. *Quarterly Journal of Economics*, 108, 717–737.

Lee, J and E Shim (1995). Moderating effects of R&D on corporate growth in US and Japanese hi-tech industries: An empirical study. *Journal of High Technology Management Research*, 6, 179–191.

Levine, R (2000). Bank-based or Market-based financial systems: Which is better? Mimeo, Department of Finance, University of Minnesota.

Levine, R and S Zervos (1998). Stock markets, banks, and economic growth. *American Economic Review*, 88, 537–558.

Levine, R, N Loayza and T Beck (2000). Financial intermediation and growth causality and causes. *Journal of Monetary Economics*, 46, 31–77.

Mishkin, FS (2004). *The Economics of Money, Banking and Financial Markets*, 7th Edition. Addison-Wesley.

Myers, SC and NS Majluf (1984). Corporate financing and investment decisions when firms have information that investors do not. *Journal of Financial Economics*, 13, 187–221.

Paul AG, SJ Machin and CF Walters (1997). Corporate growth and profitability. *Journal of Industrial Economics*, 45, 171–189.

Rajan, R and L Zingales (1998). Financial dependence and growth. *American Economic Review*, 88, 559–586.

Raut, LK (1995). R&D spillover and productivity growth: Evidence from Indian private firms. *Journal of Development Economics*, 48, 1–23.

Schmukler, S and E Vesperoni (2001). Firms' financing choices in bank-based and market-based economies. In A Demirgüc-Kunt and R Levine (eds.), *Financial Structure and Economic Growth: A Cross-Country Comparison of Banks, Markets, and Development*, pp. 347–241, Cambridge, MA and London, England: The MIT Press.

Singh, A and G Whittington (1975). The size and growth of firms. *Review of Economic Studies* 42, 15–26.

Variyam, JN and DS Kraybill (1992). Empirical evidence on determinants of firm growth. *Economics Letters*, 38, 31–36.

Yang, CH and JR Chen (2002). R&D, patents and productivity: Evidence from Taiwanese manufacturing. *Taiwan Economic Review*, 30, 27–48.