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Growth, profits and R&D investment

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ABSTRACT

This study uses firm-level panel data from Korea over the period 1990–2012 to examine the relationship between growth, profitability and R&D investment. The empirical results show that (i) the effect of profits on growth is negative, which, however, is significant only after the financial crisis; (ii) the effect of growth on profits is insignificant, but a positive relationship is found before the crisis and for old firms; and (iii) there is an inverse U-shaped relationship between R&D investment and cash flow, and the effect of cash flow on R&D investment is positive before the crisis and for non-group firms. The empirical results reflect the institutional setting and historical context of Korea. Theoretical and practical implications are discussed.

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1. Introduction

This paper examines the relationship between growth, profitability and R&D investment by using panel data of pharmaceutical and biotechnology firms from South Korea (hereafter Korea) over the period 1990–2012. First, we consider the relationship between firm growth and profit. Theoretical discussions did not unambiguously predict how firm growth is related to profits. Some theories argue that growth and profits are mutually supportive and thus are positively correlated, while others hold that profits and growth are incompatible and thus a negative relationship between them is expected (for a summary of theories, see Lee, 2014 p. 2). We empirically assess these two conflicting hypotheses of the relationship between growth and profit.

In addition to the relationship between growth and profit, this study empirically examines the role of investment as an important intermediary between growth and profit. Growth takes place through investment (Penrose, 1959). Investment can play the important role, linking profit to growth, if investment is financed by retained profits (Hubbard, 1998). Thus, we examine the hypothesis that investment responds positively to cash-flow movements. The sensitivity of investment to cash flow has long been a matter of considerable debate (for a review, see Hall, 2002). Firms prefer to use internal funds to finance investment since internal finance is cheaper than external finance in the presence of imperfect capital markets. Two reasons why external funds are expensive have been receiving attention: asymmetric information and agency problems. This study focuses

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on R&D investment by examining R&D intensive industries such as pharmaceutical and biotechnology since the problems of asymmetric information and agency costs would be more critical for R&D investment than for ordinary investment (Lee, 2012, p. 120).

As far as we are aware, little work has yet been reported in examining growth, profits and R&D investment simultaneously. The novelty of this study is to extend previous work on the relationship between growth and profits by considering the role of investment in establishing the nexus between growth and profits. Furthermore, this study considers the characteristics of R&D and the institutional setting and historical background of Korea when conducting the empirical analysis and interpreting the empirical findings.

2. Previous studies

There were a few empirical studies that examined both the effect of profit on growth and the effect of growth on profit simultaneously by examining firm-level data. The existing studies are presented by Table 1.

According to Table 1, a series of empirical studies conducted by Alex Coad and his colleagues (Coad, 2007, Coad, 2010, Coad et al., 2011) reported a positive effect of growth on profits, Goddard et al. (2004) showed a positive effect of profits on growth, and Cowling (2004) found both positive effects to be significant. Most studies used firm-level panel data from advanced European countries and confirmed the positive relationship between growth and profits. However, a recent study by Lee (2014) investigated the data of Korean firms to show that profit affects growth negatively, but growth affects profit positively. The difference of the results between Korea and other countries might reflect institutional and historical variations such as the *chaebol* system and the financial crisis.

The sensitivity of investment to the availability of internal cash flow has been a topic of interest in corporate finance. The pioneering study by Fazzari et al. (1988) estimated:

$$\frac{I}{K} = a + bQ + c\frac{CF}{K} + \epsilon, \tag{1}$$

where I represents investment, K is the replacement value of the capital stock, Q is Tobin's Q and CF is the cash flow. This method added a proxy for the availability of cash flow to the

Table 1. Previous studies of growth and profits.

	Sample		Variable		Result	
	Country	Period	g	π	$\pi \to g$	$g \to \pi$
Coad (2007)	France	96-04	sales employees	V.A. O.S.	0	+
Coad (2010)	France	96-04	sales employees	G.O.S.	0	+
Coad et al. (2011)	Italy	89-97	sales employees	G.O.S.	0	+
Cowling (2004)	U.K.	91-93	sales	profit	+	+
Goddard et al. (2004)	E.U.	92-98	assets	R.O.E.	+	0
Lee (2014)	Korea	99-08	sales employees	R.O.S.	−	+

The table summarizes previous empirical studies of the relationship between growth and profit. g refers to growth and π refers to profit. ROE to return on equity; VA to value added; OS to operating surplus; and GOS to gross OS. $+$, $-$ and 0 refer to positive, negative, and insignificant (or very weak) effects, respectively.
Source: Author.

Table 2. Previous studies of R&D investment-cash flow sensitivity.

	Sample		Variable		
	Country	Period	R&D	CF	Result
Brown and Petersen (2009)	U.S.	70-06	R&D/A	CF/A	+
Cincera (2003)	Belgium	91-00	R&D/K	CF/K	+
Hao and Jaffe (1993)	U.S.	73-88	log(R&D)	log(CF)	+
Harhoff (1998)	Germany	87-94	R&D/K	CF/K	+
Himmelberg & Petersen (1994)	U.S.	83-87	R&D/K	CF/K	+
Martinsson (2010)	Europe	95-04	R&D/A	CF/A	+
Mulkay et al. (2001)	U.S./France	79-93	R&D/K	CF/K	+
Ughetto (2008)	Italy	98-03	R&D/K	CF/K	+

The table shows previous empirical studies of corporate R&D investment and cash flow. +, −, and 0 represent the positive, negative, and insignificant effects of cash flow on investment, respectively.
Source: Author.

standard investment model and checked whether it is significant. This model has become a standard approach to investigate the relationship between cash flow and investment. Many empirical studies using this approach reported that investment is affected positively by cash flow (Hubbard, 1998).

In addition to ordinary investment, R&D investment also seems to be sensitive to cash flow (for a survey, see Hall, 2005). Table 2 summarises the main empirical studies that examined the effect of cash flow on R&D investment. According to the table, all the studies used firm-level panel data from advanced countries and confirmed the positive relationship between R&D investment and cash flow.

3. Methods

For the empirical analysis, this paper employed a panel data set of 96 pharmaceutical and biotechnology firms in Korea over the period 1990–2012. The sample firms were listed on the Korea Stock Exchange (K.S.E.), and the data were obtained from the database of the Korea Listed Companies Association, which offered firm-level information based on annual reports, quarterly reports and audit reports of Korean companies. We applied static as well as dynamic regressions to the panel data and investigated the issues of nonlinearity, macroeconomic shock, business groups and firm maturity.

3.1. Static models

We examined the relationship between growth and profit, and the static regression model to be estimated was expressed as

$$\mathtt{g}_{i,t} = \alpha_i + \beta_1 \pi_{i,t-1} + \beta_2 \mathtt{control}_{i,t-1} + \epsilon_{i,t} \quad (2)$$

$$\pi_{i,t} = \alpha_i + \beta_1 \mathtt{g}_{i,t-1} + \beta_2 \mathtt{control}_{i,t-1} + \epsilon_{i,t} \quad (3)$$

where $\mathtt{g}$ refers to the growth variables, π to the profit variable, $\mathtt{control}$ to the control variables, i to the firm, t to time period, α and β to parameters and ϵ to the classical error term. Lagged terms of independent variables were used to address the possible endogeneity problem. We also examined the sensitivity of R&D investment to cash flow by estimating the following model:

Table 3. Summary statistics.

	Median	Mean	s.d.
gsales	11.35	35.58	348.72
gemployee	2.85	7.48	61.23
roa	4.08	3.03	11.87
ros	4.87	−21.38	318.15
lev	0.77	1.37	10.00
age	17.00	21.13	21.28
rd/sales	0.01	0.11	1.15
rd/asset	0.00	0.02	0.06
Q	0.57	0.95	1.31
cf	0.05	0.07	0.08

The table shows the summary statistics of the variables used in the study.
Source: Author.

$$\mathtt{R\&D}_{i,t} = \alpha_i + \beta_1 \pi_{i,t-1} + \beta_2 \mathtt{cf}_{i,t-1} + \beta_3 \mathtt{control}_{i,t-1} + \epsilon_{i,t}, \tag{4}$$

where R&D refers to R&D investment and cf to cash flow.

This study used the ratio of net income to assets (roa) and the ratio of net income to sales (ros) as proxies for firm profits. Sales growth (gsales) and employee growth (gemployee) served as proxies for growth. R&D investment was measured by R&D spending divided by total sales (rd/sales) and R&D spending divided by total assets (rd/asset). The ratio of cash flow to total assets (cf) was used as a proxy for cash flow.

In addition to the main variables, firm financial status and firm maturity were included in the analysis as control variables. A leverage ratio, the debt-to-equity ratio, was used as a control for the financial status of firms. Leverage can affect a firm's profitability and growth. For example, high leverage can reduce a firm's ability to finance growth (Lang et al., 1996). For maturity, firm age (age), measured in years since the founding of the firm, was used as the control variable. Firm age can affect firm behavior and decisions. For example, firm growth decreases with firm age (Evans, 1987). Table 3 reported the summary statistics for the sample.

Tobin's Q was widely used to control for profitability in empirical studies since the profitability of the firm was thought to be reflected by the firm's market value. However, it has been criticised due to its lack of reliability. In a model using Tobin's Q, marginal Q was supposed to be a proxy for investment profitability, but average Q was used instead since marginal Q was not observable. However, average Q was hardly a precise measure of marginal Q (Schiantarelli, 1996). Furthermore, it was questionable whether Q was applicable to R&D investment since Q was the ratio between the stock market value and the replacement value of the physical assets. Considering the argument against using the Q variable, we included sales growth as well as the Q variable, based on the idea that a firm's investment depends on its recent performance.

There are three main regression models for panel data: pooled, fixed effects and random effects models. In order to statistically determine which one is more suitable for the data used in the study, we conducted the F test, LM test and Hausman test (Hausman, 1978). The test results indicated that the fixed effects model was appropriate for some regression equations and the random effects model was appropriate for the other equations. Model selection was based on the test results, which are not reported here for simplicity and the regression results were robust across the models.

Standard panel regression models assumed that regression disturbances were homoskedastic with the same variance across individuals. This assumption was restrictive for firm-level panel data since firms were of varying size. We performed the Breusch–Pagan test (Breusch & Pagan, 1979) against heteroskedasticity and the results confirmed the presence of heteroskedasticity in the data. In order to alleviate the heteroskedasticity problem, the White estimator (Arellano, 1987) was employed in the regressions.

3.2. Dynamic models

The dynamic regression model for the relationship between profit and growth used in the study was as follows:

$$\mathtt{g}_{i,t} = \alpha_i + \gamma_i \mathtt{g}_{i,t-1} + \beta_1 \pi_{i,t-1} + \beta_2 \mathtt{control}_{i,t-1} + \epsilon_{i,t} \tag{5}$$

$$\pi_{i,t} = \alpha_i + \gamma_i \pi_{i,t-1} + \beta_1 \mathtt{g}_{i,t-1} + \beta_2 \mathtt{control}_{i,t-1} + \epsilon_{i,t}. \tag{6}$$

For the sensitivity of R&D investment to cash flow, the following dynamic model was used:

$$\mathtt{R\&D}_{i,t} = \alpha_i + \gamma_i \mathtt{R\&D}_{i,t-1} + \beta_1 \pi_{i,t-1} + \beta_2 \mathtt{cf}_{i,t-1} + \beta_3 \mathtt{control}_{i,t-1} + \epsilon_{i,t}. \tag{7}$$

If lagged dependent variables were used as explanatory variables, they were likely to be endogenous and thus the O.L.S. estimates were inconsistent. In this study, the dynamic equations were estimated by the generalised method of moments (G.M.M.) method (Blundell & Bond, 1998) to obtain consistent and efficient estimates. The $t-2$ and $t-3$ lagged values of the dependent variable were used as a G.M.M. instrument, because very remote lags were not informative in practice (Bond & Meghir, 1994). The Sargan test (`Sargan`) and the test for second-order autocorrelation of the residuals (`AR(2)`) were conducted to evaluate the specification of the model and the validity of the instruments.

Controlling the previous profit ($\pi_{i,t-1}$) in Equation (6) was closely related to the 'persistence of profit' research. According to Mueller (1967), profits above or below a normal level would disappear because of market competition and thus firm profitability would converge with the normal level in efficient markets. There were two possibilities: i) profitable firms with firm-specific advantages were likely to be successful in the future, and ii) the current success of a firm might have adverse effects on future profitability of the firm owing to imitation or attempts to supersede potential competitors (Goddard & Wilson, 1999 pp. 663–664). In both cases, serial relationships among profit values needed to be examined.

The lagged R&D intensity variable was included as an independent variable because it could be an important determinant of current R&D investment. R&D intensive industry was such that the fixed cost was high while the variable cost was low. R&D had high adjustment costs and thus R&D budgets tended to be 'set by standard rules of thumb based upon historical precedence' (Hansen & Hill, 1991, p. 4). In this sense, previous R&D spending could have a significant influence on current R&D investment.

3.3. Nonlinearity and macroeconomic shock

The theoretical discussion of the relationship between growth and profits suggested that both positive and negative relationships were possible. In an empirical analysis, the trade-

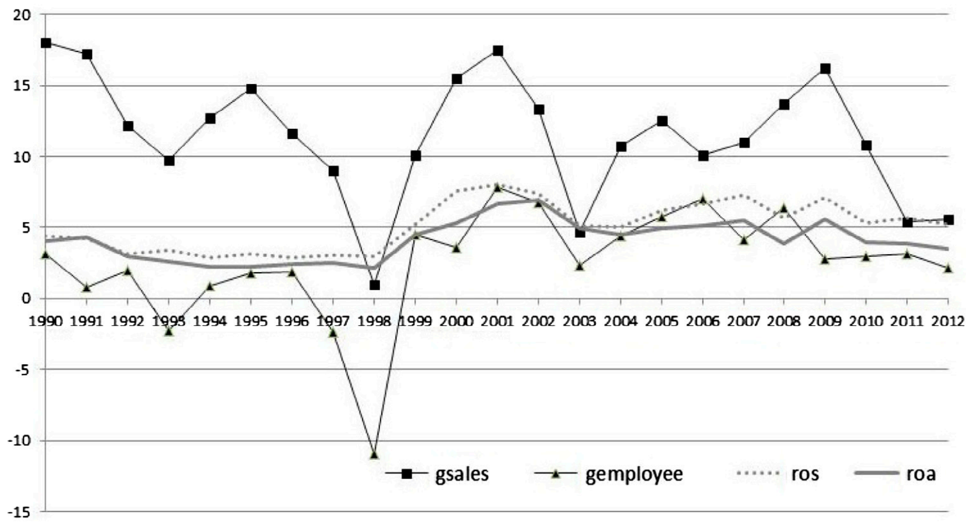

Figure 1. Firm growth (gsales, gemployee) and profits (ros, roa), 1990–2012. Source: Author.

off between positive and negative factors could be captured by nonlinear models. It might be argued that profitability improves as growth rate increases, but eventually declines as growth becomes too high. When growth occurs at too fast a rate, profits may decrease because managers fail to effectively handle the rapidly-increasing number of operations (Penrose, 1959).

In order to examine the nonlinear relationship, this study used quadratic regression. The quadratic regression equations used in the study were as follows:

$$g_{i,t} = \alpha_i + \beta_1 \pi_{i,t-1} + \beta_2 \pi_{i,t-1}^2 + \beta_3 \mathtt{control}_{i,t-1} + \epsilon_{i,t} \quad (8)$$

$$\pi_{i,t} = \alpha_i + \beta_1 g_{i,t-1} + \beta_2 g_{i,t-1}^2 + \beta_3 \mathtt{control}_{i,t-1} + \epsilon_{i,t} \quad (9)$$

$$\mathrm{R\&D}_{i,t} = \alpha_i + \gamma_1 \pi_{i,t-1} + \beta_1 \mathtt{cf}_{i,t-1} + \beta_2 \mathtt{cf}_{i,t-1}^2 + \beta_3 \mathtt{control}_{i,t-1} + \epsilon_{i,t} \quad (10)$$

where β_1 indicates the overall linear trend and β_2 indicates the direction of curvature. If β_2 is positive, the relationship is concave upward. If β_2 is negative, the relationship is concave downward.

On the other hand, this study considered the effect of a macroeconomic shock on corporate behavior and decisions. We examined the trends in median sales growth, employee growth, return on assets and return on sales, which were shown in Figure 1. A sharp fall in the growth variables was observed during the financial crisis of 1997–1998. In contrast, the figure showed stable trends for the profit variables.

The Korean development process before the crisis was defined as a state-led model. The government controlled most major banks and directed policy loans to strategically targeted sectors such as heavy and chemical industries (H.C.I.s) that can realise economies of scale and scope, but involve substantial risks. In 1997, the East Asian financial crisis hit Korea and changed Korea's economic landscape quite substantially. In December 1997, Korea received an emergency rescue loan from the I.M.F., which required Korea to undertake structural reforms. As the reforms were market oriented, the state capacity was undermined. Firms made more and more decisions based on profit orientation at the expense of firm growth (Kalinowski, 2008). Korea overcame the financial crisis rapidly: 'Economic growth averaged approximately 5.65 per annum between 1999 and 2007'(Lee-Gong, 2011, p. 128). While some argued that Korea's recovery from the crisis was made possible by the market-oriented reforms, others claimed that the recovery was achieved mainly by the pre-crisis state-controlled development strategy (Kalinowski, 2008). Although the debate about the recovery has been ongoing, most would agree that the crisis and the following market-oriented policies have had a great impact on the Korean economy.

In order to examine whether the macroeconomic shock changes the way growth and profit interact as well as the way investment responds to cash flow, we divided the study period (1990–2012) into two periods: 1990 to 1997 (pre-crisis) and 1999 to 2013 (post-crisis). The regression analysis was applied to the two periods separately and then the results were compared.

3.4. A split-sample method

This study used a split-sample method, dividing the sample firms into two groups by firm characteristics, business group affiliation and maturity, and estimated the three regression equations, Equation (2), Equation (3) and Equation (4), in each of the groups.

First, we partitioned the sample firms into two groups, *chaebol* firms and non-*chaebol* firms, based on whether the firm belongs to *chaebol*, a Korean business group. In order to determine whether or not a firm is a *chaebol*-affiliated member, we examined the Korea Fair Trade Commission annual reports. The relationship between cash flow and investment was expected to be more important for non-group-affiliated firms than for group-affiliated firms, since a business group facilitated mutual insurance and risk sharing among affiliated firms. Thus, the amount of available funds was not a critical matter for group-affiliated firms. In Korea, founders and their families in *chaebol* groups usually gained control over their affiliated firms through interlocking ownership among the firms, called a pyramidal shareholding structure, and made capital budgeting decisions relatively independently of the availability of funds for the investment. *Chaebol* affiliated firms used internal capital markets to invest in strategically targeted projects by shifting necessary funds within the group. That is, *chaebols* redistributed funds within the group and thus reduced the affiliated firms' risk of financial distress. The group affiliation was more important in R&D investment decisions since risk-taking is an important component of R&D decision-making.

This idea has been confirmed by empirical studies. A main bank in *keiretsu*, a large business group in Japan, often assisted distressed firms within the group with the help of the group members (Khanna & Yafeh, 2005, p. 302). Hoshi et al. (1991) found that the effect of internal funds on investment was more important in non-*keiretsu* firms than in *keiretsu* firms. In another empirical study by Chirinko & Schaller (1995), a similar result was obtained by using a sample of Canadian firms. Shin & Park (1999) also reported the insignificant investment-cash flow sensitivity for *chaebol* firms and the significant sensitivity for non-*chaebol* firms. An interesting finding relevant to this issue was reported by Hsee & Weber (1999). They investigated cross-national differences in risk preferences between Americans and Chinese by using questionnaire data, and found that the Chinese respondents were more risk-seeking than the American respondents. They proposed a 'cushion hypothesis' that people in collectivist cultures were likely to receive financial help if they were in need, and thus they were less risk-averse than those in individualistic cultures. Business groups was an example of the cushion hypothesis at an organisational level. Business groups' internal capital market could provide a financial cushion to absorb fluctuations in available funds.

The second classification of firms was based on firm maturity measured by firm age (age). We differentiated firms into two groups, old firms and young firms. The firms in the sample were sorted out according to firm age and divided into two equal size groups, that is, old firms with ages above the median age and young firms with ages below the median. It was expected that the effect of cash flow on investment was more significant in young firms than in old firms. Generally, old firms were bureaucratic and imposed controls on managerial access to financial resources, and thus the sensitivity of investment to internal funds was not sufficiently high. In addition, old firms usually had easy access to external funds, and thus they were less sensitive to financial resources when making investment decisions. Brown et al. (2009) investigated whether the 1990s R&D boom and subsequent decline in the U.S. could be explained by supply shifts in finance, and found that the relationship was statistically and economically significant for young firms, but not for old firms.

On the other hand, the expected positive effect of growth on profits might not be observed for young firms since competitive advantages obtained from growth for young firms were hard to achieve. If young firms could not take advantage of scale economies, experience curve effects and other related factors, their growth could not contribute to profits. Indeed, experience curve effects might not play a significant role in the management of young firms, because the effects could create entry barriers for young firms by bringing substantial cost advantages to established entrants (Spence, 1981). Furthermore, high growth caused problems for young firms. As high growth leads to increased structural complexity, younger and growing firms may encounter more challenges than do their older counterparts that have more specialised management teams (Hambrick & Crozier, 1985).

The split-sample method had another advantage in that it could be used to correct for possible endogeneity. A potential endogeneity problem in this kind of analysis was that cash flow became an endogenous variable in an investment model. The expected cause–effect sequence, leading profit to growth, assumed that retained profit was a source of funds for investment. However, internal funding, or cash flow, also indicated future profitability of investment since high liquidity showed that the firm had performed well and was likely to continue doing well. Accordingly, 'more liquid firms have better investment opportunities; it is not surprising that they tend to invest more' (Hoshi et al., 1991, p. 35). Cash flow could affect investment decisions not only because it provided funds for investments but also because it signalled future profitability. If we observed a positive relationship between cash flow and investment, the evidence might be obtained due to the future profitability effect of cash flow. One solution to this problem of endogeneity was to control for the profitability of investment when conducting regression analysis. In addition to the control variables for profitability such as Tobin's Q and sales growth, the split-sample method played a role in suppressing the effects of expected profitability on investment. If there was no reason that the expected profitability of cash flow differed between the groups, the difference, if any, should indicate the pure effect of cash flow on investment when controlling for the profitability of investment (Fazzari et al., 1988). A relevant benefit of the split-sample approach was that even though individual estimates were biased, the estimated difference in the coefficients between groups would be an unbiased estimate of the true difference since the bias was to be the same for the two groups (Hoshi et al., 1991, p. 36).

4. Empirical results

This section presents and discusses the empirical results of the regressions. For all the G.M.M. regression results, all specifications passed the Sargan test and the second order serial correlation test, which indicated that the models used in the study were correctly specified.

4.1. Regression results

Table 4 shows the empirical results of the effect of profits on growth using the model of Equation (2) and Equation (5). Overall, unlike most previous findings, the profit variables had significantly negative coefficient estimates, which implied the negative effect of profit on growth. The negative effect was observed in most models and thus was robust against variation of models. This result implied that managers were geared towards profit at the expense of growth. Among control variables, age showed a negative effect, implying that,

Table 4. Regression results: $g_t = f(\pi_{t-1})$.

Static	$gsales_t$		$gemployee_t$	
roa_{t-1}	−2.5202*** (−3.7182)		−0.3421* (−2.3053)	
ros_{t-1}		−0.1035* (−2.4121)		−0.0077 (−0.9466)
lev_{t-1}	1.1758 (0.6653)	1.2426 (0.6925)	−0.0763 (−0.5080)	−0.0683 (−1.0590)
age_{t-1}	−1.5741** (−2.8081)	−1.5475** (−2.6584)	−0.3275** (−3.1018)	−0.3280*** (−3.3191)
R^2	0.0144	0.0170	0.0127	0.0104
Dynamic	$gsales_t$		$gemployee_t$	
roa_{t-1}	−1.6800*** (−47.3236)		−0.4161*** (−9.4405)	
ros_{t-1}		−0.2587*** (−36.5846)		−0.0076** (−3.0398)
lev_{t-1}	1.0173** (2.7116)	1.3434*** (4.7610)	−0.0081 (−1.0102)	0.0087 (1.3692)
age_{t-1}	−0.9879*** (−12.4926)	−0.8016*** (−8.4375)	−0.2840*** (−5.6998)	−0.2854*** (−6.1082)
$gsales_{t-1}$	0.0017*** (11.8669)	0.0000 (0.1762)		
$gemployee_{t-1}$			−0.0005 (−0.2980)	−0.0021 (−1.4020)
Sargan	0.0613	0.0614	0.2155	0.3918
AR(2)	0.2065	0.3575	0.1052	0.1418

Notes: The table shows the results of the panel data regressions. Figures are regression coefficient estimates, and t values are shown in parentheses below coefficient estimates. The symbols, ***, **, and *, respectively, indicate significance levels at 0.1%, 1%, and 5% levels. R^2, Sargan, and AR(2) refer to R^2 value, p values for the Sargan test, and the autocorrelation test for AR(2) process, respectively.
Source: Author.

Table 5. Regression results: $\pi_t = f(g_{t-1})$.

Static	roa$_t$		ros$_t$	
gsales$_{t-1}$	0.0001		−0.0091	
	(0.3474)		(−0.5588)	
gemployee$_{t-1}$		0.0075		0.1047
		(1.7336)		(0.9647)
lev$_{t-1}$	−0.0036	−0.0039	−0.0289	0.0897
	(−0.2952)	(−0.3069)	(−0.3311)	(0.7723)
age$_{t-1}$	0.0541	0.0484	0.6978*	1.7563
	(1.6214)	(0.8568)	(1.9790)	(1.8647)
R^2	0.0006	0.0036	0.0050	0.0060
Dynamic	roa$_t$		ros$_t$	
gsales$_{t-1}$	−0.0003		−0.0154	
	(−0.5637)		(−0.5511)	
gemployee$_{t-1}$		−0.0007		0.0318
		(−1.1418)		(0.8213)
lev$_{t-1}$	0.0077	0.0039	−0.2442	−0.0437
	(0.6677)	(1.8065)	(−0.2618)	(−0.4250)
age$_{t-1}$	0.0125	0.0251*	0.4124	0.5938
	(0.7849)	(2.3718)	(0.3610)	(1.7956)
roa$_{t-1}$	0.4019***	0.3355***		
	(7.0411)	(21.6830)		
ros$_{t-1}$			0.4005***	0.1307***
			(7.4156)	(8.5161)
Sargan	0.9998	0.2910	1.0000	1.0000
AR(2)	0.2012	0.1937	0.3988	0.2710

Notes: The table shows the results of the panel data regressions. Figures are regression coefficient estimates, and t values are shown in parentheses below coefficient estimates. The symbols, ***, **, and *, respectively, indicate significance levels at 0.1%, 1%, and 5% levels. R^2, Sargan, and AR(2) refer to R^2 value, p values for the Sargan test, and the autocorrelation test for AR(2) process, respectively.
Source: Author.

as firms get older, the growth rates decline, which is consistent with the finding of Evans (1987).

Table 5 presents the empirical results of the effect of growth on profits using the basic model of Equation (3) and Equation (6). The results showed that the growth variables had insignificant coefficient estimates irrespective of whether the explanatory variable was sales growth or employment growth. That is, in contrast with most existing empirical studies mentioned above, firm-level growth did not have any statistically significant effect on profits.

Table 6 summarises the empirical results of the R&D investment-cash flow sensitivity using the basic model of Equation (4) and Equation (7). The table shows that the cash flow variable did not yield significant estimates. It held whether profitability was controlled by Q or sales growth. This result indicated that, contrary to previous results, R&D investment did not respond to variations in cash flow. It implied a lack of a condition for the positive link between profits and growth.

In summary, the regressions showed i) the negative effect of profits on growth, ii) the insignificant effect of growth on profits and iii) the insignificant effect of cash flow on R&D investment. These results were not in line with other evidence. In order to explain the inconsistent results, this study considered the institutional and historical contexts as well as robust estimation.

Table 6. Regression results: $\texttt{R\&D}_t = f(\texttt{cash}_{t-1})$.

Static	$\texttt{rd/sales}_t$		$\texttt{rd/asset}_t$	
$\texttt{Q}_{t-1}$	0.0019		0.0007	
	(1.6658)		(1.3996)	
$\texttt{gsales}_{t-1}$		0.0000		0.0000
		(0.1390)		(1.5126)
$\texttt{cf}_{t-1}$	0.0225	0.2158	0.0146	0.0502
	(0.7983)	(1.6718)	(1.7251)	(1.1249)
$\texttt{lev}_{t-1}$	0.0003	−0.0001	0.0001	−0.0000
	(1.3866)	(−1.6281)	(0.8885)	(−1.2685)
$\texttt{age}_{t-1}$	0.0007**	−0.0020	0.0006***	0.0002
	(2.7957)	(−1.8670)	(3.5242)	(0.6668)
R^2	0.0064	0.0253	0.0765	0.0229
Dynamic	$\texttt{rd/sales}_t$		$\texttt{rd/asset}_t$	
$\texttt{Q}_{t-1}$	0.0183		0.0017	
	(0.7499)		(0.2291)	
$\texttt{gsales}_{t-1}$		0.0000		0.0001
		(0.2252)		(0.8995)
$\texttt{cf}_{t-1}$	−0.1191	0.0107	0.0808	0.0467
	(−0.6995)	(0.0769)	(0.4956)	(0.9847)
$\texttt{lev}_{t-1}$	−0.0138	0.0131	0.0043	0.0094
	(−0.7432)	(0.9600)	(0.3195)	(1.0795)
$\texttt{age}_{t-1}$	−0.0007	−0.0001	0.0000	0.0000
	(−0.9296)	(−0.4300)	(0.1119)	(0.4249)
$\texttt{rd/sales}_{t-1}$	0.4298	0.6005*		
	(1.3975)	(2.2150)		
$\texttt{rd/asset}_{t-1}$			0.9245**	0.2040
			(2.8909)	(0.7095)
Sargan	1.0000	1.0000	1.0000	1.0000
AR(2)	0.3625	0.3567	0.3789	0.2893

Notes: The table shows the results of the panel data regressions. Figures are regression coefficient estimates, and t values are shown in parentheses below coefficient estimates. The symbols, ***, **, and *, respectively, indicate significance levels at 0.1%, 1%, and 5% levels. R^2, Sargan, and AR(2) refer to R^2 value, p values for the Sargan test, and the autocorrelation test for AR(2) process, respectively.
Source: Author.

4.2. Nonlinearity and financial crisis

The second and the third results—insignificant effects—might be due to a nonlinear relationship between the variables or overall changes caused by macroeconomic shocks. First, we examined the possibility of nonlinear relationships by using a quadratic regression method. Table 7 shows the quadratic regression results. The first panel shows the results of the regression of growth on profits using Equation (9), and the second panel reports the results of the regression of cash flow on R&D investment using Equation (10).

According to the first panel, the quadratic regression did not yield significant results for the effect of growth on profits. In contrast, for the regression of cash flow on R&D, a positive linear term and a negative quadratic term were reported as statistically significant when controlling for Tobin's Q. This result did not necessarily guarantee an inverse U-shaped relationship between R&D investment and cash flow. "To do so would require the demonstration of an inflection point beyond which the curve becomes downward sloping, as opposed to just asymptotic, and a demonstration that this point is not just a statistical abstraction, but that it is within the range of acceptable or realistic values of the independent variable' (Herold et al., 2006, p. 384). In order to check whether the evidence meets the

Table 7. Quadratic regression results.

$\pi_t = f(g_{t-1})$	roa_t		ros_t	
$gsales_{t-1}$	−0.0000		−0.0867	
	(−0.0093)		(−0.7450)	
$gsales^2_{t-1}$	0.0000		0.0000	
	(0.0481)		(0.7478)	
$gemployee_{t-1}$		0.0252		0.4780
		(1.2730)		(0.8601)
$gemployee^2_{t-1}$		−0.0000		−.0003
		(−1.0769)		(−0.8205)
lev_{t-1}	−0.0037	−0.0047	−0.0222	0.0731
	(−0.3053)	(−0.3645)	(−0.2705)	(0.6951)
age_{t-1}	0.0540	0.0494	0.6512	1.8127
	(1.6681)	(0.8760)	(1.7079)	(1.8232)
R^2	0.0006	0.0066	0.0101	0.0071
$R\&D_t = f(cash_{t-1})$	$rd/sales_t$		$rd/asset_t$	
Q_{t-1}	0.0022		0.0008	
	(1.8635)		(1.4652)	
$gsales_{t-1}$		0.0000		0.0000
		(0.1008)		(1.5031)
cf_{t-1}	0.1627***	0.3731*	0.0486**	0.0825**
	(3.4799)	(2.3228)	(2.9100)	(2.6248)
cf^2_{t-1}	−0.3735**	−0.4546	−0.0905**	−0.0841
	(−3.0043)	(−1.6204)	(−3.0272)	(−1.1254)
lev_{t-1}	0.0002	−0.0001	0.0001	−0.0000
	(0.7976)	(−1.6840)	(0.7162)	(−1.3219)
age_{t-1}	0.0007**	−0.0018	0.0006***	0.0002
	(3.1267)	(−1.7454)	(3.6032)	(0.7194)
R^2	0.0135	0.0227	0.0856	0.0236

Notes: The table shows the results of the panel data regressions. Figures are regression coefficient estimates, and t values are shown in parentheses below coefficient estimates. The symbols, ***, **, and *, respectively, indicate significance levels at 0.1%, 1%, and 5% levels. R^2 refers to R^2 value.
Source: Author.

requirement, we examined the inflection point by plotting the relationship between R&D investment and cash flow.

The inverse U-shaped relationship between R&D investment and cash flow is illustrated by Figure 2. The horizontal axis represents the level of cash flow and the vertical axis represents the level of innovation. We use the interval of 0.0 to 1.0 as the acceptable range of the cash flow ratio. The two curves in the figure confirm the inverse U-shaped relationship, which indicate the following equations:

$$\mathtt{R\&D\ investment} = -0.3735\mathtt{cash\ flow}^2 + 0.1627\mathtt{cash\ flow} \tag{11}$$

$$\mathtt{R\&D\ investment} = -0.0905\mathtt{cash\ flow}^2 + 0.0486\mathtt{cash\ flow} \tag{12}$$

This evidence of the quadratic relationship confirmed that, as cash flow increases, R&D investment first increases and then decreases.

In addition to the issue of the quadratic relationship, this study examined the macroeconomic effect of the financial crisis on the relationships among growth, profits, investment and cash flow. Table 8 presents the static regression results of the effect of profit on growth before and after the East Asian financial crisis of 1997–1998. The results showed that while the profit terms had significant negative estimates after the crisis, the estimates were insignificant before the crisis. The negative effect of profit on growth observed

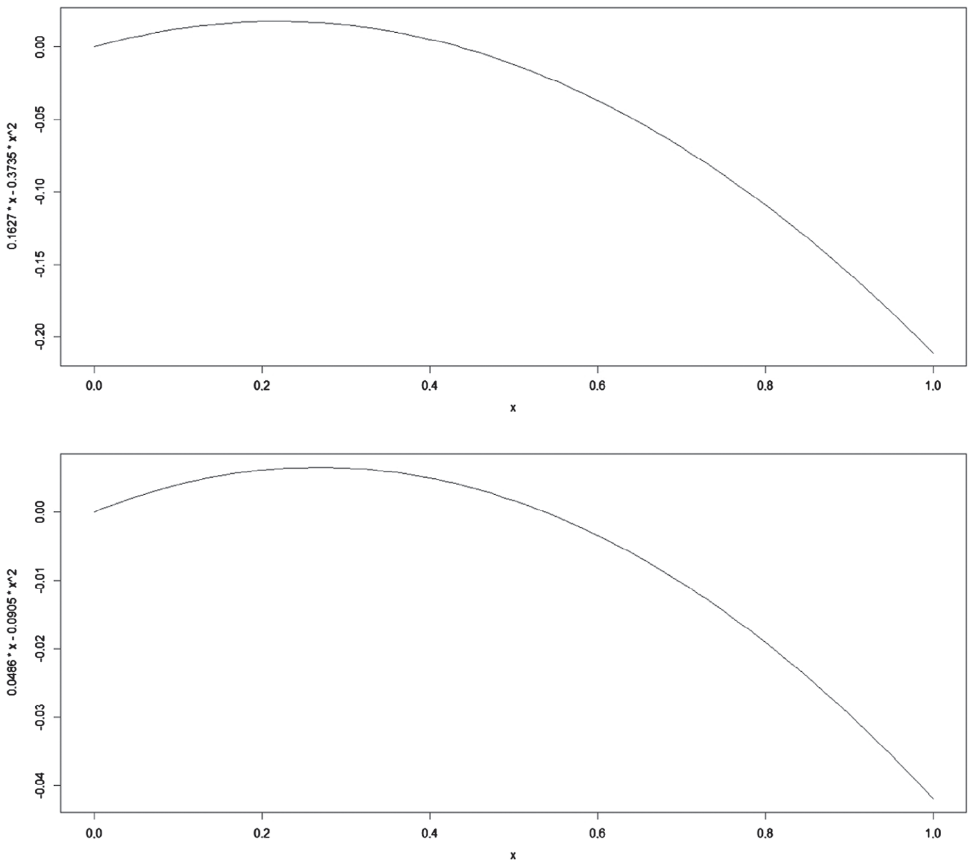

Figure 2. Quadratic relationship: $\mathrm{R\&D}_t = f(\mathrm{cash}_{t-1})$. Source: Author.

in the regression for the whole period held only for the post-crisis period. That is, the negative effect after the crisis was dominant over the insignificant effect before the crisis, which resulted in the negative effect over the whole period. This reflected the pressure on firms to achieve profit-oriented outcomes after the crisis, which dominated the business environment in the pre-crisis period.

Table 9 presents the regression results for the effect of growth on profit before and after the financial crisis. Before the crisis, the sales growth terms showed significantly positive estimates although the employee growth terms were not significant. The positive effect of growth on profits was explained by the theories of scale economies, first mover advantages, network externalities, and experience curve effects. For the post-crisis period, significant results were not observed. The lack of a significant effect of growth on profit for the whole period was the result of the combination of the positive effect before the crisis and the insignificant effect after the crisis. It implied that increasing profits through growth was pervasive during the pre-crisis period, but not after the crisis due to the profit-oriented environment.

Table 10 shows the results of the regression of cash flow on R&D investment before and after the financial crisis. For the relationship between growth and profit, after considering

Table 8. Macroeconomic shock: $g_t = f(\pi_{t-1})$.

90-97	gsales$_t$		gemployee$_t$	
roa$_{t-1}$	−1.3812		0.0922	
	(−1.0106)		(1.3750)	
ros$_{t-1}$		−1.3952		0.0129
		(−1.0205)		(0.3717)
lev$_{t-1}$	−1.8600	−1.0537	−0.4027	−0.3907
	(−1.1425)	(−1.0848)	(−1.4969)	(−1.3917)
age$_{t-1}$	−0.9163	−0.8378	−0.1770*	−0.1801*
	(−1.2968)	(−1.3549)	(−2.2623)	(−2.2998)
R^2	0.0267	0.0595	0.0403	0.0373
99-13	gsales$_t$		gemployee$_t$	
roa$_{t-1}$	−2.4601***		−0.4094*	
	(−3.3984)		(−2.1830)	
ros$_{t-1}$		−0.1046*		−0.0069
		(−2.4705)		(−0.8952)
lev$_{t-1}$	26.4425	27.3265	0.3078	0.4548
	(0.8544)	(0.8834)	(0.3895)	(0.3261)
age$_{t-1}$	−1.6206*	−1.5925*	−0.3603**	−0.3717**
	(−2.4909)	(−2.4662)	(−3.0128)	(−3.2890)
R^2	0.0451	0.0492	0.0156	0.0118

Notes: The table shows the results of the panel data regressions. Figures are regression coefficient estimates, and *t* values are shown in parentheses below coefficient estimates. The symbols, ***, **, and *, respectively, indicate significance levels at 0.1%, 1%, and 5% levels. R^2 refers to R^2 value.
Source: Author.

Table 9. Macroeconomic shock: $\pi_t = f(g_{t-1})$.

90-97	roa$_t$		ros$_t$	
gsales$_{t-1}$	0.0032***		0.0031***	
	(5.7292)		(3.8806)	
gemployee$_{t-1}$		0.0163		0.0063
		(1.1240)		(0.2362)
lev$_{t-1}$	−0.3957**	−0.2860**	−0.6138*	−0.5222*
	(−3.0658)	(−2.6112)	(−2.2093)	(−2.1254)
age$_{t-1}$	−0.0305	−0.3266*	−0.0208	−0.0199
	(−1.6850)	(−2.5604)	(−0.9767)	(−0.8794)
R^2	0.0362	0.0380	0.0247	0.0179
99-13	roa$_t$		ros$_t$	
gsales$_{t-1}$	−0.0001		−0.0113	
	(−0.3832)		(−0.6411)	
gemployee$_{t-1}$		0.0059		0.1156
		(1.6395)		(0.9705)
lev$_{t-1}$	−0.1131	−0.1274	−1.7157	−0.8341
	(−0.6318)	(−0.6976)	(−1.0349)	(−0.4368)
age$_{t-1}$	0.0076	−0.1894	1.1344*	2.0723
	(0.1834)	(−1.5620)	(2.0660)	(1.9307)
R^2	0.0002	0.0105	0.0075	0.0078

Notes: The table shows the results of the panel data regressions. Figures are regression coefficient estimates, and *t* values are shown in parentheses below coefficient estimates. The symbols, ***, **, and *, respectively, indicate significance levels at 0.1%, 1%, and 5% levels. R^2 refers to R^2 value.
Source: Author.

the financial crisis, we found a positive relationship before the crisis and a negative relationship after the crisis. Similar to the results of the regression of growth on profit, the sensitivity of R&D investment to cash flow was significantly positive only for the sample before the crisis.

Table 10. Macroeconomic shock: $\mathtt{R\&D}_t = f(\mathtt{cash}_{t-1})$.

90-97	rd/sales$_t$		rd/asset$_t$	
Q_{t-1}	0.0013		0.0009	
	(0.4320)		(0.4202)	
gsales$_{t-1}$		−0.0000***		−0.0000***
		(−20.8253)		(−15.3373)
cf$_{t-1}$	0.0553**	0.0556*	0.0356*	0.0989**
	(2.6520)	(2.1388)	(2.4699)	(2.6068)
lev$_{t-1}$	−0.0003	−0.0000	−0.0002	−0.0000
	(−0.3929)	(−0.2629)	(−0.4873)	(−0.0479)
age$_{t-1}$	0.0016***	0.0012**	0.0010***	−0.0001
	(6.0495)	(3.2041)	(5.7374)	(−1.0291)
R^2	0.2263	0.1730	0.2080	0.1645
99-13	rd/sales$_t$		rd/asset$_t$	
Q_{t-1}	0.0027*		0.0002	
	(1.9690)		(0.5119)	
gsales$_{t-1}$		0.0000		0.0000
		(0.0251)		(1.5452)
cf$_{t-1}$	0.0248	0.1136	0.0093	0.0031
	(0.6679)	(0.7547)	(0.9427)	(1.6374)
lev$_{t-1}$	−0.0000	−0.0008	0.0000	−0.0003
	(−0.0820)	(−1.7042)	(0.1794)	(−1.2264)
age$_{t-1}$	0.0001	−0.0013	0.0013***	−0.0000
	(0.2779)	(−0.3800)	(4.0020)	(−0.0208)
R^2	0.0076	0.0018	0.1445	0.0299

Notes: The table shows the results of the panel data regressions. Figures are regression coefficient estimates, and *t* values are shown in parentheses below coefficient estimates. The symbols, ***, **, and *, respectively, indicate significance levels at 0.1%, 1%, and 5% levels. R^2 refers to R^2 value.
Source: Author.

When considering the financial crisis, the evidence shed light on the institutional changes in Korea and their effect on corporate behavior. The empirical results implied that, before the crisis, the two factors of growth and profit were mutually supportive and the role of investment in linking the two factors worked well. After the crisis, however, due to the short-term profit orientation, the relationship between growth and profit turned into a negative one.

4.3. Business group and firm maturity

This study employed a split-sample regression method to examine a moderating role of business group and firm maturity in the relationship between profit and growth and the relationship between R&D investment and cash flow. Among the split-sample regressions, two significant results were obtained.

Table 11 reports the results of the split-sample regression of the R&D investment-cash flow sensitivity based on business group. The results indicated that the investment-cash flow sensitivity was statistically significant and positive for the non-group sample only. In other words, R&D investment was not sensitive to cash flow for firms belonging to a business group, but responded to movements in cash flow in firms with no business group affiliation. This result agreed well with the prediction discussed above that, since business groups provided member firms with access to financial resources, group-affiliated firms were less sensitive than non-group-affiliated firms to internal cash flow.

Table 11. Split-sample results (business group): $\text{R\&D}_t = f(\text{cash}_{t-1})$.

Non-group	rd/sales$_t$		rd/asset$_t$	
Q_{t-1}	0.0002		0.0004	
	(0.2653)		(1.3794)	
gsales$_{t-1}$		−0.0000		0.0000
		(-0.0458)		(1.2056)
cf$_{t-1}$	0.1471*	0.5911*	0.0568**	0.1432***
	(2.0001)	(2.4740)	(2.6525)	(3.4110)
lev$_{t-1}$	0.0004***	−0.0000	0.0000	−0.0000*
	(4.5888)	(−0.7555)	(1.3663)	(−2.2106)
age$_{t-1}$	0.0014	0.0010	0.0002	−0.0011
	(1.8055)	(0.5385)	(1.4228)	(−1.5137)
R^2	0.0066	0.0240	0.0882	0.0611
Group	rd/sales$_t$		rd/asset$_t$	
Q_{t-1}	0.0065***		0.0013	
	(3.4188)		(1.3586)	
gsales$_{t-1}$		0.0000		0.0000
		(0.5999)		(1.1658)
cf$_{t-1}$	0.0130	−0.0781	0.0072	0.0818
	(0.4819)	(−1.1161)	(0.7771)	(1.9592)
lev$_{t-1}$	−0.0000	−0.0005	0.0002	0.0001
	(−0.2583)	(−1.4494)	(0.9793)	(0.6805)
age$_{t-1}$	−0.0000	−0.0007	0.0006**	−0.0000
	(−0.2894)	(−0.7556)	(3.1075)	(−1.4128)
R^2	0.0801	0.0020	0.0830	0.1394

Source: Author.

Table 12. Split-sample results (maturity): $\pi_t = f(g_{t-1})$.

Old	roa$_t$		ros$_t$	
gsales$_{t-1}$	0.0229*		−0.0114	
	(2.0267)		(−0.1963)	
gemployee$_{t-1}$		0.1048***		0.1501***
		(4.4429)		(3.5853)
lev$_{t-1}$	−0.1418	−0.0491	0.1279	0.3186
	(−0.7885)	(−0.0949)	(0.1490)	(0.3966)
age$_{t-1}$	0.0291	0.0229	0.0518	0.0540
	(0.8488)	(0.5401)	(0.6683)	(0.6923)
R^2	0.0086	0.0336	0.0011	0.0216
Young	roa$_t$		ros$_t$	
gsales$_{t-1}$	0.0001		−0.0088	
	(0.3111)		(−0.5415)	
gemployee$_{t-1}$		0.0062		0.1201
		(1.5550)		(1.0045)
lev$_{t-1}$	−0.0016	−0.0037	−0.0318	0.1671
	(−0.1364)	(−0.2942)	(−0.3209)	(0.9898)
age$_{t-1}$	0.0906	0.0401	0.8430	5.0020
	(1.3487)	(0.4180)	(1.1999)	(1.7163)
R^2	0.0009	0.0027	0.0051	0.0092

Source: Author.

Table 12 presents the results of the split-sample regression of growth on profits based on firm maturity. The results showed that growth had a positive effect on profits for old firms. This evidence was consistent with the argument discussed above that the competitive advantages from growth was hard for young firms to achieve. Thus, the moderating effect of firm maturity was confirmed.

5. Conclusion

This study uses firm-level panel data from Korea over the period 1990–2012 to examine the relationship between growth, profitability and R&D investment. First, the analysis reveals the negative effect of profit on growth. The observed negative effect shows that profit-oriented managers try to maintain high levels of profit by foregoing growth opportunities. This interpretation is also supported by the result that the negative effect was statistically significant after the financial crisis but insignificant before the crisis. It may imply that the economy-wide reforms that have been implemented in Korea since the crisis push managers to concentrate on profit goals at the expense of growth.

The empirical analysis reports insignificant effects of growth on profits and of cash flow on R&D investment for the whole sample period. However, positive effects are found for both relationships before the crisis. This is closely related to the negative effect of profit on growth after the crisis, since these results may come from the profit-focused management in Korea after the crisis. In particular, due to the long-term nature, R&D investment did not respond to cash flow in a short-term quick-profit oriented business environment after the crisis. This implies that the financial crisis and the following reforms transform the relationship between growth and profits from a complementary one into a competing one. The evidence in this paper sheds light on the understanding of the institutional change caused by the financial crisis and its effect on corporate behavior.

The quadratic regression reports the inverse U-shaped relationship between R&D investment and cash flow. It implies the positive effect of cash flow on investment holds for the low level of cash flow only. This is related to the result that the positive relationship holds for unaffiliated firms only. A business group affiliation enables firms to access the financial resources required for R&D investment. However, unaffiliated firms cannot obtain support and thus are sensitive to variations in cash flows. These results show that investment responds to cash flow for firms with financial constraints.

One more notable result is that the positive effect of growth on profit is significant for old firms only. We discussed that high growth leads to high profit via the effects of scale economies, network externalities and experience curve. Thus, the result is consistent with the argument that the competitive advantages obtained from growth are hard for young firms to achieve.

The empirical results for the whole sample—the negative effect of profit on growth, the insignificant effect of growth on profit and the insignificant effect of cash flow on R&D investment—are not consistent with the previous studies discussed above, most of which report positive relationships. We attribute the difference between the current study and the previous studies to the institutional and business environment of Korea and various other factors. This study uses robust econometric approaches to evaluate the interpretation of the empirical findings and the empirical results confirm the idea.

Disclosure statement

No potential conflict of interest was reported by the authors.

References

Arellano, M. (1987). Computing robust standard errors for within-groups estimators. *Oxford Bulletin of Economics and Statistics, 49*(4), 431–434.
Blundell, R., & Bond, S. (1998). Initial conditions and moment restrictions in dynamic panel data models. *Journal of Econometrics, 87*(1), 115—143.
Bond, S., & Meghir, C. (1994). Dynamic investment models and the firm's financial policy. *Review of Economic Studies, 61*(2), 197—222.
Breusch, T., & Pagan, A. (1979). A simple test for heteroscedasticity and random coefficient variation. *Econometrica, 47*(5), 1287—1294.
Brown, J. R., Fazzari, S. M., & Petersen, B. C. (2009). Financing innovation and growth: Cash flow, external equity, and the 1990s R&D boom. *Journal of Finance, 64*(1), 141–185.
Brown, J. R., & Petersen, B. C. (2009). Why has the investment-cash flow sensitivity declined so sharply? Rising R&D and equity market developments. *Journal of Banking & Finance, 33*(5), 971—984.
Chirinko, R. S. , & Schaller, H. (1995). Why does liquidity matter in investment equations? *Journal of Money, Credit and Banking, 27*(2), 527–548.
Cincera, M. (2003). Financing constraints, fixed capital and R&D investment decisions of belgian firms. Butzen, P., & Fuss, C. eds. *Firms' investment and finance decisions: Theory and empirical methodology*. Cheltenham: Edward Elgar Publishing.
Coad, A. (2007). Testing the principle of 'growth of the fitter': The relationship between profits and firm growth. *Structural Change and Economic Dynamics, 18*(3), 370–386.
Coad, A. (2010). Exploring the processes of firm growth: Evidence from a vector auto-regression. *Industrial and Corporate Change, 19*(6), 1677–1703.
Coad, A., Rao, R., & Tamagn, F. (2011). Growth processes of italian manufacturing firms. *Structural Change and Economic Dynamics, 22*(1), 54–70.
Cowling, M. (2004). The growth-profit nexus. *Small Business Economics, 22*(1), 1–9.
Evans, D. S. (1987). The relationship between firm growth, size, and age: Estimates for 100 manufacturing industries. *Journal of Industrial Economics, 35*(4), 567–581.
Fazzari, S. M., Hubbard, R. G., & Petersen, B. C. (1988). Financing constraints and corporate investment. *Brookings Papers on Economic Activity, 1988*(1), 141–206.
Goddard, J., Molyneux, P., & Wilson, J. O. S. (2004). Dynamics of growth and profitability in banking. *Journal of Money, Credit and Banking, 36*(6), 1069–1090.
Goddard, J., & Wilson, J. O. S. (1999). The persistence of profit: a new empirical interpretation. *International Journal of Industrial Organization, 17*(5), 663—687.
Hall, B. H. (2002). The financing of research and development. *Oxford Review of Economic Policy, 18*(1), 35–51.
Hall, B. H. (2005). The financing of innovation. In S. Shane (Ed.), *Blackwell Handbook of technology and innovation management*. Oxford: Blackwell Publishers.
Hambrick, D. C., & Crozier, L. M. (1985). Stumblers and stars in the management of rapid growth. *Journal of Business Venturing, 1*(1), 31—45.
Hansen, G. S., & Hill, C. W. L. (1991). Are institutional investors myopic? A time-series study of four technology-driven industries. *Strategic Management Journal, 12*(1), 1—16.
Hao, K. Y., & Jaffe, A. B. (1993). Effect of liquidity on firms' R&D spending. *Economics of Innovation and New Technology, 2*(4), 275—282.
Harhoff, D. (1998). Are there financing constraints for R&D and investment in German manufacturing firms? *Annales d'Économie et de Statistique, 49*(50), 421–456.
Hausman, J. A. (1978). Specification tests in econometrics. *Econometrica, 46*(6), 1251–1271.
Herold, D. M., Jayaraman, N., & Narayanaswamy, C. R. (2006). What is the relationship between organizational slack and innovation? *Journal of Managerial Issues, 18*(3), 372–392.
Himmelberg, C. P., & Petersen, B. C. (1994). R&D and internal finance: A panel study of small firms in high-tech industries. *Review of Economics and Statistics, 76*(1), 38–51.
Hoshi, T., Kashyap, A., & Scharfstein, D. (1991). Corporate structure, liquidity, and investment: Evidence from Japanese industrial groups. *Quarterly Journal of Economics, 106*(1), 33–60.

Hsee, C. K., & Weber, E. U. (1999). Cross-national differences in risk preference and lay predictions. *Journal of Behavioral Decision Making, 12*(2), 165—179.
Hubbard, R. G. (1998). Capital-market imperfections and investment. *Journal of Economic Literature, 36*(1), 193–225.
Kalinowski, T. (2008). Korea's recovery since the 1997/98 financial crisis: The last stage of the developmental state. *New Political Economy, 13*(4), 447–462.
Khanna, T., & Yafeh, Y. (2005). Business groups and risk sharing around the world. *Journal of Business, 78*(1), 301—340.
Lang, L., Ofek, E., & Stulz, R. M. (1996). Leverage, investment, and firm growth. *Journal of Financial Economics, 40*(1), 3–29.
Lee, S. (2012). Financial determinants of corporate R&D investment in Korea. *Asian Economic Journal, 26*(2), 119–135.
Lee, S. (2014). The relationship between growth and profit: Evidence from firm-level panel data. *Structural Change and Economic Dynamics, 28*, 1–11.
Lee-Gong, E. (2011). Social policy in challenging times: Economic crisis and welfare systems. Farnsworth, K., & Irving, Z. eds. *South Korea after the 1997 economic crisis: a 'paradigm shift'?* Bristol: Policy Press.
Martinsson, G. (2010). Equity financing and innovation: Is Europe different from the United States? *Journal of Banking & Finance, 34*(6), 1215–1224.
Mueller, D. C. (1967). The persistence of profits above the norm. *Economica, 44*(176), 369–380.
Mulkay, B., Hall, B.H., & Mairesse, J. (2001). Investing today for the world of tomorrow: Studies on the investment process in Europe. Bundesbank, D. ed. *Firm level investment and R&D in France and the United States: A comparison*. New York, NY: Springer-Verlag.
Penrose, E. (1959). *The theory of the growth of the firm*. Oxford: Oxford University Press.
Schiantarelli, F. (1996). Financial constraints and investment: Methodological issues and international evidence. *Oxford Review of Economic Policy, 12*(2), 70–89.
Shin, H.-H., & Park, Y. S. (1999). Financing constraints and internal capital markets: Evidence from Korean 'chaebols'. *Journal of Corporate Finance, 5*(2), 169—191.
Spence, A. M. (1981). The learning curve and competition. *Bell Journal of Economics, 12*(1), 49–70.
Ughetto, E. (2008). Does internal finance matter for R&D? New evidence from a panel of Italian firms. *Cambridge Journal of Economics, 32*(6), 907–925.