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FINANCIAL CONSTRAINTS, DEBT OVERHANG AND CORPORATE INVESTMENT: A PANEL SMOOTH TRANSITION REGRESSION APPROACH

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ABSTRACT

This paper provides new evidence on the impacts of financial constraints, growth opportunities and debt overhang on firm-level investments in 12 Asian countries, Australia and New Zealand over the period 1990–2010. Using Panel Smooth Transition Regression (PSTR) models that overcome the shortcomings of linear investment models, we show that the PSTR models have greater explanatory power than linear models. The empirical results show that for firms with growth opportunities, (1) investment is sensitive to the availability of internal finance and (2) debt overhang reduces investment by firms with higher leverage through a 'liquidity' effect. Our findings imply that the managers of financially constrained firms in developed countries in the Asian region respond differently to productivity shocks and growth opportunities than financially constrained firms in emerging markets and developing countries. In addition, in emerging Asian economies, higher equity valuations increased firm-level investment after the stock markets opened to foreign investors. Accordingly, policy makers should review their liberalisation measures and seek to understand the mechanisms at work in order to bolster international investors' confidence and stimulate foreign investment.

Keywords: Asia, debt overhang, growth opportunities, investment, smooth transition model

INTRODUCTION

The impact of financial constraints on firms' investment decisions has been of longstanding interest to economists and policy makers. Starting with Fazzari, Hubbard and Petersen (1988), a common approach to investigating investment-cash flow (ICF) sensitivity has been to separate firms into multiple groups using a single and/or multiple financial variable(s)[1] that *a priori* mirror unobservable financial constraints. Thus, firms are *ex ante* partitioned into groups of *constrained* and *unconstrained* firms over the entire sample period.[2] Most studies find that *constrained* firms exhibit greater sensitivity of investment to cash flow irrespective of the proxy variable(s) used (see, e.g., Hubbard, 1998; Brown & Petersen, 2009).

The main motivation of this study is to extend ICF sensitivity analysis to Asian countries using a larger panel dataset. Because previous studies in this area have focused on US firms, less is known about the investment behaviour of firms in Asian countries.[3] Nonetheless, there are several reasons to study Asian countries, one of which is that reforms to financial markets were implemented differently in Asian countries than they were elsewhere (Bekaert, Harvey, & Lundblad, 2005; Schmukler & Vesperoni, 2002; Bekaert & Harvey, 2000). For instance, Laeven's (2003) study of 13 developing countries reports that the liberalisation of banking sectors in Asian countries focused on interest rate liberalisation, the entry of foreign banks and the reduction of state-directed credit. Although financial reforms were less comprehensive in some Asian countries than in others, the common underlying motivation was to decrease government control of financial markets. In addition, financial reforms were thought to have a 'quantitative' impact on economic growth.

Bekaert et al. (2005) argue that if markets are imperfect and financing constraints exist, then external finance will be more costly than internal finance and investment will be sensitive to cash flows. Financial liberalisation may affect economic growth by reducing imperfections in capital markets, which in turn may reduce the external finance premium. We argue that different strategies of financial liberalisation have different impacts on the wedge between the cost of internal funds and the cost of external funds. Laeven (2003) reports that financial liberalisation reduces market imperfections. In particular, the opening of stock markets to foreign investors reduces financing constraints by making more foreign capital available to domestic firms. Moreover, foreign investors may insist on better corporate governance, which may indirectly reduce the wedge between the costs of internal and external finance. Galindo, Schiantarelli and Weiss (2005) argue that the positive effect of financial liberalisation on growth may be due more to liberalisation's effect on the efficiency with which investment funds are allocated across firms and industry sectors and less to the quantity of resources mobilised.

In this paper, we used a panel smooth transition regression (PSTR) approach that allows individual firms to switch between *groups (regimes)* each year. The uniqueness of this approach lies in the fact that it does not require *a priori* segregation of the sample firms into groups of *financially constrained* firms and *financially unconstrained* firms, as was the case in previous studies. The PSTR approach uses a transition variable for sorting firms, which allows ICF sensitivities to be interpreted in a time-varying fashion and relates the magnitude of ICF sensitivities to capital market imperfections. González, Teräsvirta and Dijk (2005) developed this approach and estimated the model for US firms; our study is the only one to apply this model to Asian countries.

Our main results using the PSTR approach show that ICF sensitivity is explained by the non-linear influence of internal cash flows, growth opportunities and debt overhang problems. The results show that although all three of these factors influence firm-level investment in the Asian region during the period 1990–2010, the influence of growth opportunities is the most significant.

REVIEW OF RELATED LITERATURE

External finance is not a perfect substitute for internal finance due to its higher relative cost. Thus, firms that face information asymmetry problems may be crowded out of financial markets; these firms develop a relatively strong preference for internal finance over external finance. Moreover, information asymmetries in financial markets and the resulting preference of firms for internal finance are exacerbated in developing countries due to tighter governmental controls over the banking sectors. Accordingly, firms in developing countries face more severe financing constraints as a result of information asymmetries than firms in countries with developed financial markets. Indeed, Islam and Mozumdar (2007, p. 656) report that for every dollar reduction in internal cash flow, an average non-Organization for Economic Cooperation and Development (OECD) firm decreases investments by $ 0.23; the corresponding decrease for an average OECD firm is only $ 0.141. The greater degree of underinvestment in profitable investment opportunities that is associated with less developed financial markets represents a deadweight welfare loss.[4]

After the implementation of financial reforms and the development of capital market infrastructure in Asia, the reduction of ICF sensitivity in less developed countries depends on the extent to which their financial markets have developed. Our argument is centred on the assumption that investment patterns among Asian firms differ as a result of firm-specific characteristics and the country-specific effects of financial liberalisation (quantitative and qualitative). For example, decreased governmental control over the allocation of credit, reduced reserve requirements and the privatisation of banks may have positive quantitative effects on the availability of external finance. However, the elimination of subsidised credit programs (which is another common feature of financial reforms) may increase financing constraints for firms that previously benefited from access to bank loans at subsidised rates (Laeven, 2003). In addition, according to debt overhang theories (Myers, 1977; Hennessy, 2004), high leverage may reduce a firm's ability to finance investments through a liquidity effect. Debt overhang theories imply that an increase in leverage increases the probability that a firm will forego positive net present value (NPV) projects in the future.[5] Accordingly, the impact of debt overhang on the investments of highly leveraged firms is much more significant than its impact on the investments of low-leverage firms. Because all-equity firms can always issue safe debt, shortfalls in cash flow should have only a negligible effect on investment at these firms. In contrast, highly leveraged firms face an underinvestment problem and may not be able to raise outside funds at all. We argue that firms that benefitted from government-subsidised loans are likely to have much higher leverage than firms that did not receive subsidised loans. Firms that are highly leveraged due to government-subsidised loans can mitigate their debt overhang problems if incremental investment is financed partially with new secured debt (Myers, 1977) and partially with equity finance, i.e., if they rebalance their capital structures. The liberalisation of stock markets in Asia may help firms to achieve this. For instance, the introduction of a country fund and the opening of stock markets to foreign investors may drive up the stock prices of listed domestic firms and thereby reduce their respective costs of capital. When stock prices are high, firms are more likely to finance expansion by raising new external equity finance (which demonstrates a quantitative impact of financial liberalisation). Thus, access to equity finance is likely to reduce firms' financing constraints. The qualitative impact of liberalisation can be seen in better corporate governance and improved corporate disclosure policies, which also help to reduce the cost of equity capital.

A standard approach to measuring ICF sensitivity has been to estimate the linear regression of physical investment on cash flow and Tobin's q ratio and/or using the Euler dynamic optimisation equation. These regression estimations have been previously been performed using ordinary least squares (OLS) and/or the dynamic generalised methods of moments (GMM) techniques of Bond and Meghir (1994). However, these methods have been criticised on various grounds, including the discrepancy between the average q ratio and the marginal q ratio; the omission of important variables, such as equity financing and debt financing (Brown & Petersen, 2009); and the questionable validity of the instruments used in GMM. Recent studies report that ICF sensitivity has decreased in developing countries (see Islam & Mozumdar, 2007; Cleary, 2006; Laeven, 2003; Love, 2003; Wurgler, 2000). Using data from 31 countries, Islam and Mozumdar (2007) find evidence of a negative relationship between financial market development and the importance of internal capital. Cleary (2006) sorts the firms of developing countries using three different measures of financial development and concludes that ICF sensitivity is lower for smaller firms and for firms with greater financing constraints. In the study most closely related to ours, Laeven (2003) reports that financial liberalisation appears to affect small and large firms differently. Specifically, although financial liberalisation reduces the financing constraints of small firms (by approximately 80% on average), it increases the financing constraints of large firms. This is likely because large firms have better access to preferential directed credit before liberalisation.

Although some studies of developing countries find that ICF sensitivity decreases after the development of financial markets, other studies find no evidence of a change in financing constraints after financial reforms (see Agung, 2000; Jaramillo, Schiantarelli, & Weiss, 1996; Harris, Schiantarelli, & Siregar, 1994). We argue that the different findings may be explained by the inability of the selected proxy variables to capture the magnitude of financial constraints. Previous studies have tried to measure the severity of financial constraints using sales, dividend pay-out ratios, and relationships with large banks (see, e.g., Laeven, 2003; Love; 2003; Kaplan & Zingales, 1997; Hoshi, Kashyap, & Scharfstein, 1991). However, the relative importance of these proxy variables may differ depending on a country's level of financial development (Cleary, 2006).

Moreover, the level of a country's financial development may have different effects on firm-level investment (see Agca & Mozumdar, 2008; Laeven, 2003; Love, 2003) and investment efficiency (see Galindo et al., 2005) depending upon the impact of financial reforms on capital market imperfections. In addition, Laeven (2003) argues that financial reforms change the composition and allocation of savings but do not necessarily relax financial constraints for all firms. These factors limit the reliability of prior studies and give more credibility to the Panel Smooth Transition Regression (PSTR) approach.

The PSTR approach has several advantages. Essentially, PSTR is a regime-switching model that allows for a small number of extreme regimes associated with the extreme value of a transition function and where the transition from one regime to another is smooth (Fouquau, Hurlin, & Rabaud, 2008). The PSTR method helps us to determine whether a firm operates at any point in time in one of two investment regimes, each of which exhibits either a high or a low level of investment sensitivity to a threshold variable, such as cash flow. Movement from one regime to another can represent an adjustment in response to, e.g., a reduction in capital market imperfections. We argue that asymmetric firms' investment behaviour is better understood with a smooth transition model than with a linear investment model that is based on *a priori* classification of *constrained* and *unconstrained* firms.

DATA AND EMPIRICAL MODEL

Data

We collected firm-level financial data from *Thompson Financial & Worldscope* for listed manufacturing firms (2-digit Global Industry Classification Standard [GICS] 20) in 12 Asian countries (China, Hong Kong, India, Indonesia, Japan, Malaysia, Pakistan, South Korea, Philippines, Singapore, Taiwan and Thailand), Australia and New Zealand. We include developed countries (such as Japan) in the sample to gauge whether firms in emerging markets and developing countries in Asia have been able to finance investments in a manner *similar* to firms in developed countries. In other words, we evaluate whether financial reforms increase the size and structure of financial markets in emerging markets and developing countries and thereby reduce the cost of external finance in these areas to a level similar to that in developed countries. Using the same indicators as Beck and Levine (2002)[6] to measure the structure, activity and size of various financial markets, we classify the sample countries into three categories: Developed (Australia, Japan, New Zealand and Singapore), Emerging (China, India, Hong Kong, Taiwan and South Korea) and Developing (Indonesia, Malaysia, Pakistan, Philippines and Thailand). Some of the countries in our sample underwent multiple financial market reforms between 1991 and 2000. Laeven (2003) provides detailed descriptions of the financial market reforms in India, Indonesia, Malaysia, Pakistan, Philippines, South Korea, Taiwan and Thailand. As in Islam and Mozumdar (2007), we limit the sample to firms with at least three consecutive years of the financial data required for a PSTR estimation. We focus exclusively on manufacturing firms, which have been studied extensively in the investment literature (Brown & Petersen, 2009). Our main results are based on a final sample of 813 manufacturing firms over the period 1990–2010. Table 1 presents the descriptive statistics of the sample.

Table 1 shows that firms have a mean (median) investment ratio of 0.04 (0.03), a mean (median) cash flow-to-assets ratio of 0.045 (0.048) and low debt ratios. However, once we account for the sector affiliation of the sample firms, differences among them are revealed. For instance, firms in the airline manufacturing and aerospace and defence industries have the highest debt ratios and q ratios, whereas industrial conglomerates have the highest investment ratios and sales ratios.

Table 1
Descriptive statistics

This table reports the descriptive statistics. The means, medians, standard deviations, minimums and maximums of the explanatory variables are presented in Panel A. The mean values for each industry in the GIC 20 sector (Industrials) are presented in Panel B. *I* is the total investment in property, plant and equipment in year *t* divided by total assets at the beginning of year *t*; *CF* is the cash flow-to-assets ratio, which is calculated as after tax income before extraordinary items plus depreciation in year *t* divided by total assets at the beginning of year *t*. *D* is total debt divided by total assets at the beginning of year *t*; and *S* is total sales in year *t* divided by total assets at the beginning of year *t*. *Q* is Tobin's q ratio, which is calculated as the sum of the total market value of shares and the book value of debt divided by total assets the beginning of year *t.* N is the total number of firms.

Panel A

	Mean	Median	Std	Min	Max	N
I	0.0414	0.0290	0.0435	0.0473	0.5632	813
CF	0.0457	0.0481	0.1815	–10.2133	1.3924	813
S	0.9437	0.8937	0.4227	0.0014	4.6614	813
Q	0.9512	0.7141	1.2318	0.0748	59.6337	813
D	0.2286	0.2033	0.3003	0.0000	19.0667	813

Panel B: Average values

GIC 20 category: Industrials	I	S	CF	D	Q
Industry-sector					
Aerospace and defence	0.08774	1.20620	0.26025	0.5829	4.01742
Building products	0.04941	1.20242	0.06670	0.2267	1.03240
Construction/engineering	0.02942	1.28898	0.02288	0.2062	0.82982
Electrical equipment	0.07262	1.30068	0.07696	0.2193	1.44499
Industrial conglomerates	0.20853	3.11383	0.17487	0.2706	2.82397
Machinery	0.05565	1.06054	0.06871	0.2119	1.19418
Trading companies/distributors	0.08817	2.84229	0.04546	0.2531	1.39809
Commercial services and supplies	0.10180	1.93912	0.18178	0.1449	3.18959
Diversified commercial	0.03099	1.37158	0.05969	0.1835	2.09224
Air freight logistics	0.05848	1.67964	0.08710	0.2039	0.92590
Airlines	0.49208	2.43751	0.32605	0.5002	2.49417
Marine	0.16394	1.27774	0.14119	0.4109	1.19834
Road and rail	0.18939	1.98476	0.23374	0.4508	4.16468
Transport infrastructure	0.04245	0.57038	0.00005	0.3575	3.75660

Empirical Model

The smooth transition model is a *relatively* new technique in the investment literature. Its approach is similar to the threshold regression technique of Hansen (2000), which specifies that firm-level observations can be divided into classes based on the values of an observed variable. The smooth transition model has found immense usefulness in macroeconomic studies. For instance, Fouquau et al. (2008) use the PSTR model developed by Gonzalez et al. (2005) to solve the Feldstein-Horioka puzzle of the relationship between domestic savings and investment rates. The basic PSTR model of Gonzalez et al. (2005) is defined as

$$y_{it} = \mu_i + \beta_0' x_{it} + \beta_1' x_{it} g(s_{it}; \gamma, c) + u_{it} \qquad (1)$$

for $i = 1, \ldots, N$ and $t = 1, \ldots, T$, the dependent variable y_{it} is a scalar, x_{it} is a k-dimensional vector of time-varying exogenous variables, μ_i represents the fixed individual effect and u_{it} is the error variable. β_0' and β_1' are parameters, and N and T denote the cross-section and time dimensions of the panel, respectively. The transition function $g(s_{it};\ \gamma,\ c)$ is a continuous function of the observable variable s_{it} and is normalised to be bounded between 0 and 1. The transition variable s_{it} determines the value of $g(s_{it};\ \gamma,\ c)$, i.e., the effective regression coefficients for an individual firm i in period t. The transition function $g(s_{i,j,t};\gamma,c)$ is a continuous and bounded function of the threshold variable (or appropriately named transition variable), as follows:

$$g(s_{it-1};\gamma,c) = (1+\exp\{-\gamma \prod_{j=1}^{m}(s_{it}-c)\})^{-1} \text{ with } \gamma > 0; c_1 \le c_2 \le \ldots \le c_m \qquad (2)$$

where s_{it} denotes the transition variable and $c = (c_1, \ldots c_m)$ denotes a vector with m dimensions of location parameters. γ is the slope parameter that determines the smoothness of the transition variable. The value of the estimated slope parameter is crucial; a large value implies that the transition function is sharp and corresponds to indicator function, whereas a small value implies that the panel cannot be divided into a small number of classes because the estimated parameters are distributed over a "continuum". A small value also provides strong evidence against artificially dividing firms into sub-samples and estimating a linear model for each sub-sample, which is the norm in current empirical studies. Let us consider the following PSTR investment model:

$$\begin{aligned} I_{i,j,t} &= \alpha_{i,j} + d_{t,j} + \beta_{0,1}CF_{i,j,t-1} + \beta_{0,2}Q_{i,j,t-1} + \beta_{0,3}D_{i,j,t-1} + \beta_{0,4}S_{i,j,t} \\ &+ \{\beta_{1,1}CF_{i,j,t-1} + \beta_{1,2}Q_{i,j,t-1} + \beta_{1,3}D_{i,j,t-1} + \beta_{1,4}S_{i,j,t-1}\}F_L(s_{i,j,t-1};\gamma,c) + \upsilon_{i,j,t} \end{aligned} \qquad (3)$$

where for a firm *i* in a country *j*, *I* is the total investment in property, plant and equipment in year *t* divided by total assets at the beginning of year *t*. The main explanatory variables are as follows. Cash flow-to-assets ratio, denoted by *CF*, is calculated as after tax income before extraordinary items plus depreciation in year *t* divided by total assets at the beginning of year *t*. Leverage, denoted by *D*, is total debt divided by total assets at the beginning of year *t*. Future growth opportunity is proxied by Tobin's q ratio (*Q*), which is the sum of the market value of outstanding shares and the book value of debt in year *t* divided by total assets at the beginning of year *t*. According to Bond, Klemm, Newton-Smith, Syed and Vlieghe (2004), the effectiveness of the q ratio as a proxy for future growth opportunity depends on whether there are measurement errors due to stock market overvaluation (see Erickson & Whited, 2000). Including the cash flow-to-assets ratio in the model is useful in this regard because it provides information about expected future profitability that is not correlated with Tobin's q ratio. *S* is total sales divided by total assets at the beginning of year *t*. The lagged *S* is a proxy for future demand for a firm's output; therefore, it is included as an additional control for a firm's future profit opportunities. Under imperfect competition, lagged *S* should have a positive effect on firm-level investment. $\alpha_{i,j}$ denotes firm-specific fixed effects to control for unobservable firm effects, and d_t denotes time-dummies to capture unobserved macroeconomic shocks. All variables are in nominal terms.

$$F_L(s_{i,j,t-1};\gamma,c) = (1+\exp\{-\gamma\prod_{j=1}^{m}(s_{i,j,t}-c)\})^{-1} \text{ with } \gamma>0; c_1 \le c_2 \le \ldots \le c_m \quad (4)$$

We choose the logistic function over the exponential function in equation (4) for the following reasons. A logistic function takes values in $-0.5 \le F(.) \le 0.5$ and generates data when the dynamics of the regime differ depending on signs of innovation. In contrast, in an exponential function, the dynamics of the regime depend on the magnitude of innovations. Thus, when innovation is a continuous process, the logistic function does a better job tracking smooth transitions between states.[6]

Prior to the estimation of the PSTR investment model, we must select an appropriate transition variable and test the non-linearity of the PSTR investment models (with fixed-effects) against the linear investment model (with fixed-effects), i.e., Lagrange Multiplier (LM)1_F (H_0: $\gamma = 0$; H_1: $\gamma \neq 0$) in equation (2).[7] To select an appropriate transition variable, we start with variables that have been used in the previous investment literature. A number of studies have found a non-linear relationship between cash flow and investment (see, e.g., Minton & Schrand, 1999), which suggests that cash flow is an ideal variable for testing non-linearity. Under perfect capital market conditions, firms with investment opportunities are free to borrow. However, when capital markets are imperfect and information asymmetries about the quality of investment projects exist between borrowers and lenders, lenders demand a higher interest rate on debt. This situation creates heavy reliance on cash flows (internal financing). Thus, in the first PSTR specification (hereafter Model A), we assume that the transition is determined by *CF*, and firms are automatically assigned to upper (lower) regimes of *CF*.

From an economic perspective, in perfect capital and output markets, Tobin's q ratio is an important determinant of a firm's investment. Abel and Ebery (1994) find evidence of non-linearity in the investment function using the q ratio under assumptions of convex costs and irreversibility of investment. In that framework, there are regions in which investment in a homogeneous capital good is insensitive to the q ratio as well as regions where investment is sensitive to the q ratio. Barnett and Sakellaris (1998) estimate the relationship between investment and the q ratio at the firm level by allowing the relationship to vary across regimes based on the level of the q ratio. Furthermore, Morgado and Pindado (2003) argue that the relationship between investment and cash flow is positive for firms that have low-quality growth opportunities. Similarly, for firms with high quality growth opportunities, a positive relationship exists between investment and cash flow. Therefore, in line with the previous literature, we use the q ratio as the transition variable in the second specification (hereafter Model B).

According to the debt overhang hypothesis (Hennessy, 2004; Whited, 1992), leverage may reduce firms' ability to finance investments through a liquidity effect. Debt overhang has a much greater effect on highly leveraged firms than on low-leverage firms. In particular, because firms with higher debt ratios are burdened with debt repayment, their investment decisions are much more sensitive to internal cash flows. Therefore, in the third specification (hereafter Model C), the threshold (or transition) variable is *D.* Hu and Schiantarelli (1998) use the debt ratio in their switching regression for US firms. We argue that the selection of variables is not *ad hoc*; rather, because each variable makes sense from an economic standpoint, each should influence firms' transitions between the *upper* and *lower* regimes.

In addition to the linearity test, we must decide on the number of transition functions, i.e., the number of regimes required to capture all remaining non-linearity. To do this, we use the testing procedure outlined in Gonzalez et al. (2005).[8] Table 2 reports the values of statistics $LM1_F$ and $LM2_F$. The results show clearly that the non-linear PSTR investment models[9] (with fixed-effects) are *superior* to the linear investment model (with fixed-effects). The linearity test clearly rejects the null hypothesis of linearity using *CF*, *Q* and *D*, but the value of the $LM1_F$ statistic is higher for *CF*.[10] However, $LM2_F$ is strongly rejected only for *CF* and *D*, which suggests a PSTR investment model with two transition functions, as follows:

$$\begin{aligned} I_{i,j,t} = {} & \alpha_{i,j} + d_{t,j} + \beta_{0,1}CF_{i,j,t-1} + \beta_{0,2}Q_{i,j,t-1} + \beta_{0,3}D_{i,j,t-1} + \beta_{0,4}S_{i,j,t} \\ & + \{\beta_{1,1}CF_{i,j,t-1} + \beta_{1,2}Q_{i,j,t-1} + \beta_{1,3}D_{i,j,t-1} + \beta_{1,4}S_{i,j,t-1}\}F_{L1}(CF_{i,j,t-1};\gamma_1,c_1) + \\ & + \{\beta_{2,1}CF_{i,j,t-1} + \beta_{2,2}Q_{i,j,t-1} + \beta_{2,3}D_{i,j,t-1} + \beta_{2,4}S_{i,j,t-1}\}F_{L2}(D_{i,j,t-1};\gamma_2,c_2) + \upsilon_{i,j,t} \end{aligned} \quad (5)$$

Where F_{L1} is the first transition function, F_{L2} is the second transition function, $CF_{i,j,t-1}$ is the second transition variable.

We argue that a PSTR model with two transition functions is a better representation of firms' investment behaviour in the sample countries because information asymmetries and investment opportunities change over time, and a model with two transition functions allows firms to switch between regimes accordingly. In addition, cross-country heterogeneity and time variations in ICF sensitivity can be tested more precisely with two transition functions.

Table 2
Linearity and number of regimes test

Panel A of this table reports the LM test statistics and associated *p*-values for tests of the hypothesis H_0: $\gamma = 0$; H_1: $\gamma \neq 0$. The results of the linear investment model are presented alongside the results of non-linear PSTR investment models. Panel B reports the results for PSTR investment models with one transition function and PSTR investment models with two transition functions.

Panel A: Linearity test		Model A	Model B	Model C
		CF	*Q*	*D*
$LM1_F$	(H_0: $\gamma = 0$; H_1: $\gamma \neq 0$)	113.64	122.14	54.47
p value		(0.0000)	(0.0000)	(0.0000)

Panel B: No. of transition functions		Model A	Model B	Model C
		CF	*Q*	*D*
(H_0:$r = 0$; H_1: $r = 1$)	$LM2_F$	97.94	30.43	58.56
	p value	(0.0000)	(0.0000)	(0.0000)
		Single vs. Two transition functions		
(H_0:$r = 1$; H_1: $r = 2$)		(*CF*,*Q*)	(*CF*,*D*)	(*Q*,*D*)
	$LM2_F$	65.93	171.42	26.37
	p value	(0.0001)	(0.0000)	(0.0000)

We estimate the PSTR models using the maximum likelihood method. We hypothesise that firms with estimated coefficients of $\beta_{0,1} > 0, \beta_{1,1} < 0$ in Model A, which imply *lower* cash flows, will have higher ICF sensitivities than firms with *higher* cash flows. For Model B, we hypothesise that firms with estimated coefficients of $\beta_{0,2} < 0, \beta_{1,2} > 0$, i.e., firms with low growth opportunities, will decrease investments relative to firms with high growth opportunities. For Model C, we hypothesise that firms with estimated coefficients of $\delta_{0,3} > 0$, $\delta_{1,3} < 0$, which imply lower leverage, will increase investments. Our reasoning for this hypothesis is as follows: after liberalisation, firms with lower leverage can borrow in foreign capital markets to fund future investments, whereas highly leveraged firms will reduce investments due to increased financial risk.

EMPIRICAL RESULTS

Table 3 reports the estimation results. The estimation results using the linear investment model (with fixed effects) with and without industry dummies show that only the q ratio has a significant impact on investment. The value of *Adj.* R^2 implies that the linear investment model (with fixed effects) explains 50% of the variation in firm-level investments in the sample countries. However, the estimation results from the PSTR investment models tell a different story. First, the respective values of *Adj.* R^2 show that the PSTR investment models (with fixed effects) have higher explanatory power than the linear investment model (with fixed effects). Second, the estimated values of the slope parameter γ indicate that Model B is superior to both Model A and Model C, which implies that the transition between the extreme regimes is smoother when the q ratio is used as a threshold variable.[11] Figure 1 shows the transition functions estimated from Models B and C.[12] These results provide further evidence of heterogeneity in investment opportunities for Asian firms over the period 1991–2010.

The estimation results of Model A show that the coefficients $\beta_{1,1}$ and $\beta_{0,1}$ are positive and negative, respectively. Firms with higher cash flows rely to a greater extent on internal finance for investments than firms with lower cash flows, and the investments of firms with higher cash flows respond more positively to changes in growth opportunities (i.e., $\beta_{1,2}$ is more significantly positive than $\beta_{0,2}$). From an economic perspective, for every dollar reduction in internal cash flow, a firm must reduce investment by \$ 0.12. This result demonstrates that although ICF sensitivity has decreased in Asian countries, it has not been eliminated. In addition, as hypothesised, firms with high levels of internal finance do not use external finance, i.e., the coefficient $\beta_{1,3}$ is more significantly negative than $\beta_{0,3}$.

For Model B, in which transition is determined by the q ratio, the coefficient $\beta_{0,1}$ is not significant but the coefficient $\beta_{1,1}$ is both positive and significant, which implies that firms with valuable growth opportunities face financial constraints. $\beta_{0,2}$ is significantly positive, and $\beta_{1,2}$ is significantly negative. According to Jensen (1988), the control function of debt is more important in organisations that have low growth prospects. The coefficient $\beta_{0,3}$ is significantly negative and $\beta_{1,3}$ is significantly positive, which suggests that firms with high-quality future growth opportunities are able to use debt finance. This finding is supported by Campello, Graham and Harvey (2009), who find that when financially constrained firms have growth opportunities, they draw heavily on bank lines of credit.

For Model C, $\beta_{0,1}$ is significantly positive and $\beta_{1,1}$ is significantly negative. This result implies that firms with lower debt ratios are financially constrained whereas firms with higher debt ratios are not. Although the coefficient $\beta_{0,2}$ is not significant, $\beta_{1,2}$ is both positive and significant, which implies that firms with more future growth opportunities increase their levels of investment. $\beta_{0,3}$ is significantly negative, which provides strong support for the pecking order hypothesis, i.e., firms with low leverage rely more on cash flows than external debt (which provides a mechanical justification for a positive sign on $\beta_{0,1}$). The coefficient $\beta_{0,4}$ is significantly positive compared to $\beta_{1,4}$, suggesting that although changes in sales affect investment levels at firms with lower debt ratios, they do not affect investment levels at firms with higher debt ratios. This finding suggests that the *accelerator* effect fits the investment behaviour of less leveraged firms in Asian economies. The increased economic growth experienced by Asian economies after the implementation of financial reforms in the 1990s may have contributed to increases in output, which may have led in turn to further increases in investment in these economies via a *multiplier* effect caused by increased aggregate domestic consumption.

Table 3
Panel smooth transition regression estimation – single transition function

This table reports the estimation results of the PSTR investment model that has one transition function (refer to Eq. [3]).

	Expected sign	Linear model (without industry sector dummies)	Linear model (with industry sector dummies)	Model A	Model B	Model C
Transition variable, $s_{i,j,t}$		–		*CF*	*Q*	*D*
$\beta_{0,1}$	(–)	0.0006 (0.0022)	0.0013 (0.0046)	– 0.1051*** (0.0254)	– 0.0150 (0.0139)	0.0303*** (0.0069)
$\beta_{0,2}$	(+)	0.0014*** (0.0004)	0.0015** (0.0004)	– 0.0051*** (0.0012)	0.0345*** (0.0053)	0.0006 (0.0005)
$\beta_{0,3}$	(+)	– 0.0164*** (0.0040)	– 0.0160*** (0.0047)	0.0103 (0.0148)	– 0.1069*** (0.0122)	– 0.0545** (0.0256)
$\beta_{0,4}$	(+)	0.0046* (0.0023)	0.0044* (0.0023)	– 0.0466*** (0.0137)	– 0.0030 (0.0048)	0.0071*** (0.0027)
$\beta_{1,1}$	(–)	–	–	0.1247*** (0.0258)	0.0401*** (0.0199)	– 0.0365*** (0.0089)
$\beta_{1,2}$	(+)	–	–	0.0115*** (0.0018)	– 0.0339*** (0.0052)	0.0085*** (0.0013)
$\beta_{1,3}$	(+)	–	–	– 0.0509*** (0.0157)	0.1233*** (0.0178)	0.0187 (0.0249)
$\beta_{1,4}$	(+)	–	–	0.0486*** (0.0135)	0.0096 (0.0087)	– 0.0067*** (0.0024)
γ_1		–	–	29.68340*** (0.5275)	0.0917** (0.0147)	14.5073*** (6.5159)
c_1		–	–	– 2.1117 (0.0145)	8.8858*** (3.2596)	0.6143*** (0.0549)
γ_2		–	–	–	–	–
c_2		–	–	–	–	–

(*continued on next page*)

Table 3 *(continued)*

	Expected sign	Linear model (without industry sector dummies)	Linear model (with industry sector dummies)	Model A	Model B	Model C
Transition variable, $s_{i,j,t}$		–		*CF*	*Q*	*D*
Adj. R^2		0.5139	0.5147	0.5279	0.5301	0.5222
Durbin-Watson (DW) test		1.5219	1.7731	1.5428	1.5598	1.5358
Residual sum squared (RSS)		4.0373		3.8487	3.8997	3.9654
No. of firms		813	813	813	813	813
N		5222	5222	5209	5222	5222

Note: *, ** and *** indicate statistical significance at the 10%, 5% and 1% levels, respectively.

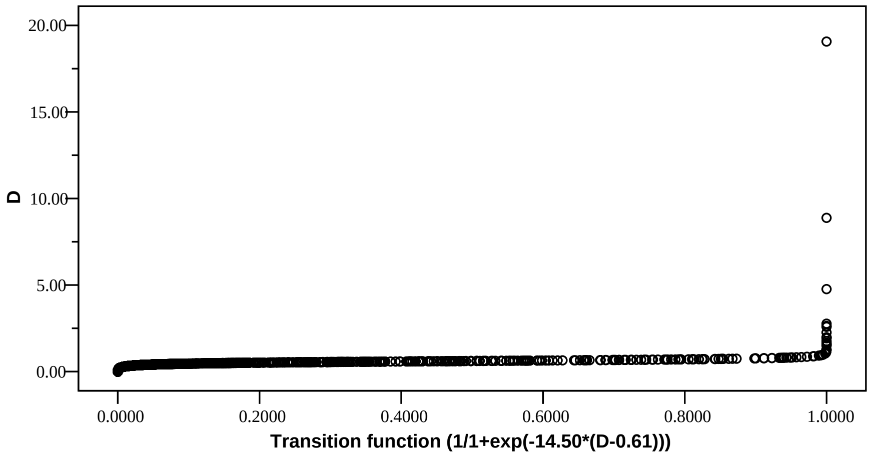

Figure 1. Transition functions of the q ratio and the debt ratio

The estimation results for Models D, E and F, which use two transition functions,[13,14] are reported in Table 4. Apparently, there is an increase in the explanatory power of the models; however, there is also an increase in the value of the slope parameter γ_1. The increase in γ_1 is higher for Model E than for Models D and F for the first transition but lower for Model E than for Models D and F for the second transition. Accordingly, because a higher value of the slope parameter indicates much faster transitions, the PSTR investment models with two transition functions are not 'optimal' models despite their higher explanatory powers. Therefore, these results should be interpreted with caution.

Our results show that for Model D, the respective signs of coefficients *CF*, *Q* and *D* associated with the first transition function (where the transition variable is *CF*) are similar to those reported for Model E. However, the respective signs of coefficients *CF*, *Q* and *D* associated with the second transition function vary across all models. Our empirical results imply that due to internal cash flow constraints and debt overhang problems, firms with valuable growth opportunities face financial constraints; as a result, they decrease their investments relative to firms without such growth opportunities. This provides empirical support for the underinvestment problem identified by Islam and Mozumdar (2007).

Table 4
Panel smooth transition regression estimation – two transition functions

This table reports the estimation results of the PSTR investment model that has two transition functions (refer to Eq. [5]).

	Expected sign	Model D	Model E	Model F
$\beta_{0,1}$	(–)	– 0.1369***(0.0215)	– 0.3215***(0.1030)	– 4.7842***(1.7085)
$\beta_{0,2}$	(+)	– 0.0106***(0.0022)	– 0.3394***(0.0552)	– 7.4835***(1.1662)
$\beta_{0,3}$	(+)	– 0.0194(0.0250)	– 0.1575***(0.0781)	– 6.6079***(1.6938)
$\beta_{0,4}$	(+)	– 0.0189***(0.0120)	– 0.1268***(0.0192)	– 0.06523*(0.3365)
1st transition variable, $s1_{i,j,t}$		*CF*	*CF*	*Q*
$\beta_{1,1}$	(–)	0.1683***(0.0216)	0.1629***(0.0236)	4.8206***(1.7126)
$\beta_{1,2}$	(+)	0.0143***(0.0026)	0.0125***(0.0026)	7.4828***(1.1660)
$\beta_{1,3}$	(+)	– 0.0485***(0.0132)	– 0.0579***(0.0121)	6.6004***(1.6991)
$\beta_{1,4}$	(+)	0.0887***(0.0126)	0.0959***(0.0128)	0.6546***(0.3383)

(*continued on next page*)

Table 4 *(continued)*

	Expected sign	Model D	Model E	Model F
2nd transition variable, $s2_{i,j,t}$		*D*	*Q*	*D*
$\beta_{2,1}$	(–)	– 0.0297**(0.0145)	0.1860*(0.1063)	– 0.0739***(0.1040)
$\beta_{2,2}$	(+)	0.0137***(0.0017)	0.3270***(0.0549)	– 0.0027(0.0018)
$\beta_{2,3}$	(+)	0.0129(0.0217)	0.1806**(0.0779)	– 0.0290***(0.0097)
$\beta_{2,4}$	(+)	– 0.0067***(0.0025)	0.0349**(0.0162)	0.0102***(0.0054)
γ_1		5.8368***(0.0192)	69.8886***(8.4304)	1.8672***(0.1029)
c_1		– 2.3604***(0.0036)	– 0.4232***(0.0207)	– 2.2229****(0.2582)
γ_2		64.3229***(27.5194)	2.2086(0.2736)	67.1630***(4.8868)
C_2		0.1156***(0.0080)	– 0.3709(0.4579)	0.4930***(0.0086)
Adj. R^2		0.5367	0.5407	0.6087
DW Test		1.5366	1.5519	1.5659
RSS		3.8152	3.8051	3.8589
No. of firms		813	813	813
N		5219	5219	5222

Note: *, ** and *** indicate statistical significance at 10%, 5% and 1% levels, respectively.

Table 5 presents the PSTR estimation results for the sample countries separated into the three categories described above (Developed, Emerging and Developing). *CF* is used as a transition variable, and we control for the impact of economic growth using GDP, shareholder rights and creditor rights. The data on shareholder rights and creditor rights were obtained from La Porta et al. (1998). There are three points worth mentioning when comparing the pooled results (see Table 4) with the country-classification results. First, the magnitude and sign of $\beta_{0,1}$ for financially constrained firms in developed countries imply that ICF sensitivity is much lower for these firms than for financially constrained firms in emerging markets and developing countries. Second, both $\beta_{0,2}$ and $\beta_{1,2}$ are significantly positive for financially constrained firms in developing countries and emerging markets, suggesting that these firms experience underinvestment problems when presented with growth opportunities. Third, financially constrained firms in developing countries experience underinvestment problems due to debt overhang; therefore, these firms respond differently to productivity shocks and growth opportunities than financially constrained firms in emerging markets and developed countries. The results also show that financially unconstrained firms in all three categories use both internal and external finance to fund future investments.

Table 5
Panel smooth transition regression estimation using alternative sample splits

This table reports the estimation results of the following PSTR investment model (refer to Eq. [3]).

	1	2	3
Coefficients	Developed	Emerging	Developing
$\beta_{0,1}$	0.0192	0.0359**	0.0387*
	(0.0422)	(0.0170)	(0.0235)
$\beta_{0,2}$	0.0154***	0.0408***	0.0501***
	(0.0042)	(0.0105)	(0.0128)
$\beta_{0,3}$	0.0353***	– 0.0695*	– 0.0611
	(0.0149)	(0.0377)	(0.0396)
$\beta_{0,4}$	– 0.0202***	0.0314	0.0317
	(0.0109)	(0.0321)	(0.0318)
$\beta_{1,1}$	– 0.0732	– 0.0644***	– 0.0665***
	(0.1060)	(0.0272)	(0.0313)
$\beta_{1,2}$	– 0.0139***	– 0.0497**	– 0.0571***
	(0.1802)	(0.0252)	(0.0216)
$\beta_{1,3}$	– 0.0485	0.0146***	0.0135*
	(0.0354)	(0.0018)	(0.0786)
$\beta_{1,4}$	0.0248*	0.0003	– 0.0059
	(0.0471)	(0.0069)	(0.0555)
γ_1	10.0319***	3.347***	2.2222***
	(0.9965)	(1.5596)	(0.8869)
c_1	9.4163***	0.4298***	1.0006***
	(0.9530)	(0.0714)	(0.5215)
Control variables			
Real_gross domestic product (GDP)	0.0197***	0.0017*	0.0009**
	(0.0075)	(0.0009)	(0.0003)
Creditor_rights	0.0003	– 0.0003	– 0.0113
	(0.0001)	(0.0018)	(0.0188)
Shareholder_rights	0.0005	– 0.0001	– 0.0013
	(0.0121)	(0.0001)	(0.0008)
Adj. R^2	0.253	0.069	0.0700
DW test	1.5098	1.8062	1.8022
Firms	412	278	123
N	3221	1628	480

Note: *, ** and *** indicate statistical significance at 10%, 5% and 1% levels, respectively.

Heterogeneity and Time Variation of the PSTR Estimated Coefficients

We also examine the heterogeneity and time variation of the estimated coefficients from a non-linear PSTR model. To this end, we only consider Model B, i.e., the model that uses the q ratio as a transition variable. We again split the sample firms into three categories (Developed, Emerging and Developing) to highlight the economic and financial development that occurred over the period 1991–2010. Figure 2 shows that the q ratio coefficients from the PSTR model are heterogeneous from one country to another. For instance, when the q ratio is between 0.5 and 1, the q ratio coefficients are lower for developed countries than for emerging economies. When the q ratio is between 1.50 and 2, a completely different trend appears; specifically, the coefficient is higher only for developed countries. In summary, the heterogeneity of q ratio coefficients proves that the PSTR model efficiently detects changes in firm-level investment in response to changes in investment opportunities over the period 1991–2010.

Figure 3 shows the estimated coefficients of the q ratio for each individual country over the period 1991–2010. These estimates are derived using the values of the estimated parameters of Model B and the average values of the q ratio for each country from 1991 to 2010. The estimated coefficients are remarkably heterogeneous across the three categories of countries. Although the estimated coefficients for the four developed countries during 1993–1996 are similar to each other, the curves for Australia and New Zealand take a more upward direction after 1997 than the curves for Japan and Singapore. For both emerging markets and developing countries, the estimated coefficient values were higher during the period of financial reforms (1990–1995) than during other periods, suggesting that firm-level investments in these economies respond to new future investment opportunities. This finding is in line with the classical economics prediction that new investments are valuable only to the extent that their marginal returns exceed the cost of capital. The results also imply that higher equity valuations in emerging economies caused a greater increase in firm-level investment in these areas compared to developing countries. Thus, stock market liberalisation in emerging economies allows local firms to raise new capital to invest in new ventures. The more significant decreases in the values of the estimated coefficients in East Asian countries as a result of the Asian financial crisis in 1997 shows that the crisis had a greater impact on investment opportunities in these areas. In addition, the declining values of the coefficients for developed countries starting in 2007 suggest that the global financial crisis had a significant effect on firms in these areas; moreover, the recovery in emerging countries in the Asian region has been faster than the recovery in developed countries.

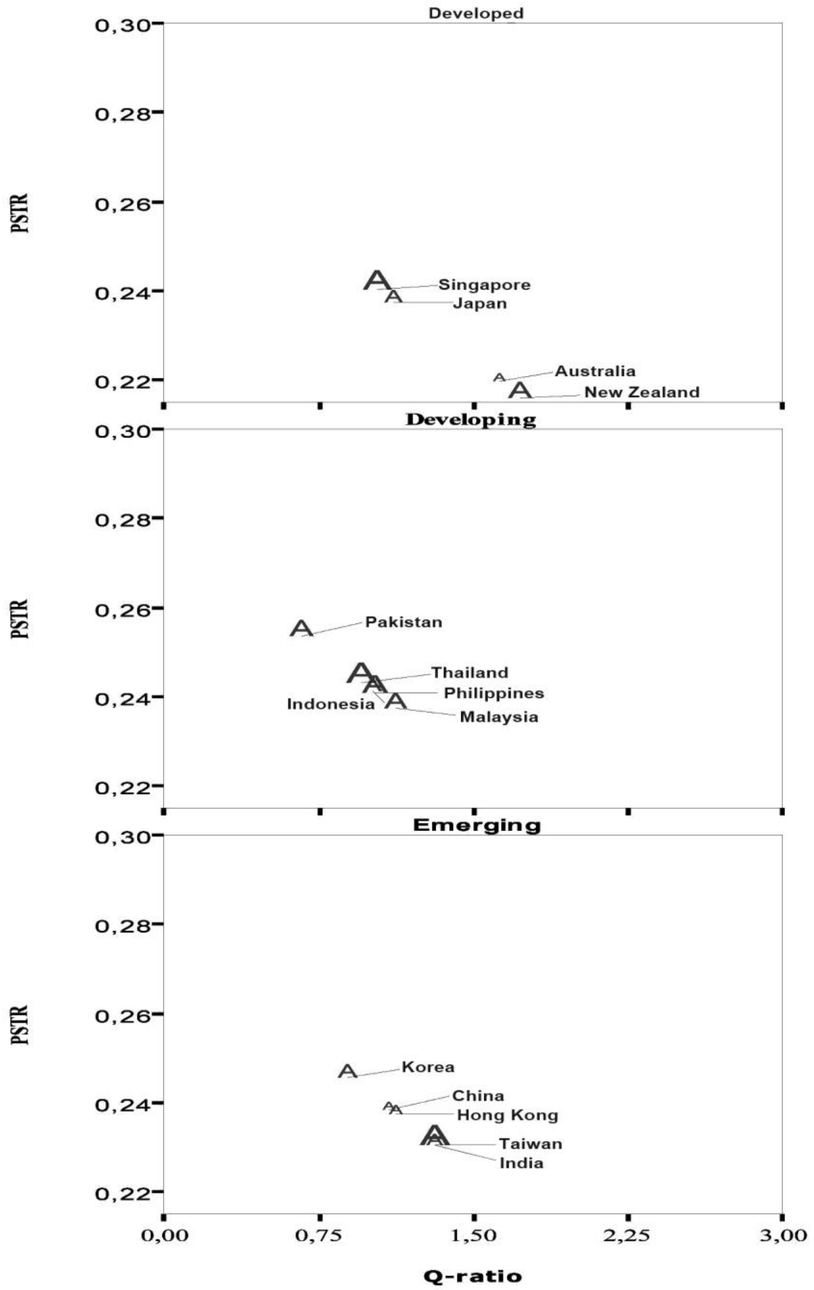

Figure 2. PSTR coefficients of q ratios

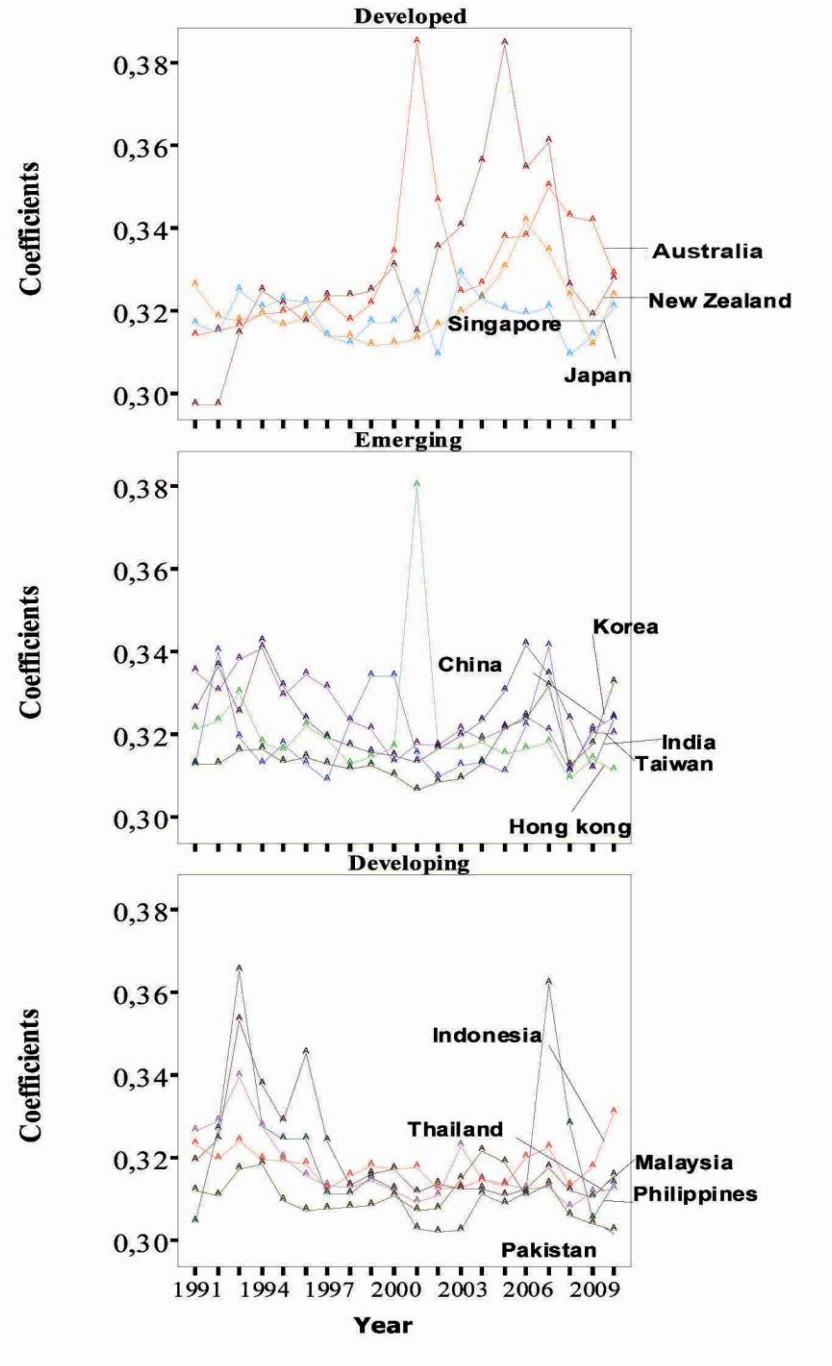

Figure 3. Estimated time-varying coefficients of the q ratio, 1991–2010

CONCLUSION

This paper investigates the impact of financial constraints on firm-level investment in 12 Asian countries, Australia and New Zealand. We find evidence of financial constraints faced by Asian firms and support for the underinvestment hypothesis reported in previous studies (see, e.g., Aivazian, Ge, & Qiu, 2005). Our study is the first to use PSTR models to provide strong evidence that firm-level investment is not sensitive only to *cash flow*, as advocated by previous studies. Furthermore, our results suggest that recent studies that use the *age* or *size* of firms as proxies for financial constraints do not properly gauge the levels of ICF sensitivity in developing countries. Our results show strong heterogeneity and significant variation in the investment responses to q ratios over time and across countries. A strong link between investment opportunities and actual investments in the sample countries suggests that stock market valuations in these economies are good indicators of future economic growth. We are mindful of the fact that our results might be sensitive to measurement errors in the q ratio; these potential measurement errors are not completely eliminated even after controlling for future profitability and output growth. However, we do not examine the measurement errors, if there are any, because this issue is beyond the scope of our paper.

There are certain related empirical questions that are not answered in this paper that could provide avenues for future research. For example, we do not segregate firms' fixed-asset investments according to core business operations and geographical focus. It is probable that export-oriented firms have growth opportunities that differ from the growth opportunities of import-oriented firms, and export- and import-oriented firms may have different responses to profit shortfalls and growth opportunity shocks. In this regard, it would be useful to examine the influence of foreign trade exposure at the firm-level. In addition, the monopoly power of firms in some Asian countries allows them to secure favourable access to external finance. It would be useful to identify the link between market power and firm-level investment. Furthermore, it has been shown in the asset pricing literature that financial constraints affect risk and expected returns (Livdan, Sapriza, & Zhang, 2009). A follow-up study using an Asian sample could have implications for foreign fund managers.

NOTES

1. In some cross-country regressions, indicators of financial development at the macro level have been used to divide samples of firms into developed and less developed markets to test ICF sensitivities across countries (see Islam & Mozumdar, 2007; Love, 2003; Wurgler, 2000).

2. Variables that have been used to separate firms into groups of constrained and unconstrained firms include gross cash flow (Brown & Petersen, 2009; Almeida & Campello, 2007) and net sales (Laeven, 2003). Schiantarelli (1996) provides a useful review of the methodological issues associated with time-invariant classifications and the use of proxy variables.

3. Several studies that have included Asian countries are Islam and Mozumdar (2007, Love (2003) and Laeven (2003).

4. Minton and Schrand (1999) argue that higher cash flow volatility implies that a firm is more likely to have periods of cash flow shortages, and a firm may forgo investment if additional finance is only available at a higher cost. Consequently, firms that rely more on external capital than on internal capital will decrease future investment.

5. Using a sample of Compustat firms and measuring growth with several proxy variables (e.g., increase in capital expenditure), Lang et al. (1996) find that leverage reduces US firms' growth only for firms with low q ratios. Likewise, Hu and Schiantarelli (1998) report that U.S. firms with high debt ratios are more sensitive to the availability of internal funds. Cai and Zhang (2011, p. 392) report that an increase in the leverage ratio is associated with lower real investment in the future. Specifically, they find that a 10% increase in the leverage ratio in the current quarter on average is associated with a 6.23% reduction in the investment rate in the next four quarters.

6. The first variable (Structure-Activity) equals the log of the ratio of Value Traded to Bank Credit. Value Traded equals the value of stock transactions as a share of national output. Bank Credit equals the claims of the banking sector on the private sector as a share of GDP. The second variable (Structure-Size) equals the log of the ratio of Market Capitalization to Bank Credit. Market Capitalization is defined as the value of listed shares divided by GDP (Beck & Levine, 2002, p. 147).

7. The logistic smooth transition autoregressive model (LSTAR) has been used by Terasvirta and Anderson (1992) to characterise the dynamics of industrial production indexes in a number of OECD countries during expansions and recessions.

8. According to Gonzalez et al. (2005), a variable that strongly rejects the linearity test (as determined using the p-value of the linearity test statistic, LM_F) is an ideal transition variable.

9. See the technical appendix in Gonzalez et al. (2005) for this procedure.

10. The PSTR investment model is a non-linear model because the transition function is multiplied by right-hand side variables.

11. The q ratio and the debt ratio are used in transition functions by Gonzalez et al. (2005) and Hu and Schiantarelli (1998).

12. In other models, such as Models A and C, the values of the slope parameter γ are higher, which implies that the transition function is sharp and might correspond to an indicator function, as suggested by Fouquau et al. (2008).

13. Transition function estimated from the Model A corresponds to an indicator function.

14. Although Model D explains more than 50% of the variation in firms' investments, it has higher values for the slope parameters γ_1 and γ_2; thus, the results of Model D are weaker than the results of Model B**.**

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