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Financial development and dynamic investment behavior: Evidence from panel VAR

Inessa Love [a], Lea Zicchino [b,*]

[a] *World Bank, Research Department—Finance Group, 1818 Hst, NW, MC3-300, Washington, DC 20433, United States*
[b] *Bank of England, Monetary Instruments and Markets Division, HO-2, Threadneedle Street, London EC2R 8AH, UK*

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Abstract

We apply vector autoregression (VAR) to firm-level panel data from 36 countries to study the dynamic relationship between firms' financial conditions and investment. By using orthogonalized impulse-response functions we are able to separate the 'fundamental factors' (such as marginal profitability of investment) from the 'financial factors' (such as availability of internal finance) that influence the level of investment. We find that the impact of financial factors on investment, which indicates the severity of financing constraints, is significantly larger in countries with less developed financial systems. Our finding emphasizes the role of financial development in improving capital allocation and growth.

Keywords: Financial development; Vector autoregression; Dynamic investment behavior

1. Introduction

Unlike the neoclassical theory of investment, the literature based on asymmetric information emphasizes the role played by moral hazard and adverse selection problems in a firm's decision to invest in physical and human capital. The presence of asymmetric information means that the classical dichotomy between real and financial variables may no longer hold. Financial variables can have an impact on real variables, such as the level of investment and the real interest rate, as well as propagate and amplify the effects of exogenous shocks to the economy. For example, Bernanke

* Corresponding author. Tel.: +44 20 7601 5212; fax: +44 20 7601 3217.
E-mail address: lea.zicchino@bankofengland.co.uk (L. Zicchino).

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and Gertler (1989) show that a firm's net worth (a financial variable) can be used as collateral in order to reduce the agency cost associated with the presence of asymmetric information between lenders and borrowers. In this model, firms' investment decisions are not only dependent on the present value of future marginal productivity of capital, as the q-theory predicts, but also on the level of collateral available to the firms when they enter a loan contract.

Since economists started to look at real phenomena abstracting from the Arrow-Debreu framework with its frictionless capital markets, a vast literature has been developed on the relationship between investment decisions and firms' financing constraints (see Hubbard, 1998, for a review). Even though asymmetric information between borrowers and lenders may be not the only source of imperfection in the credit markets, firms seem to prefer internal to external finance to fund their investments. This observation leads to the prediction of a positive relationship between investment and internal finance. The first study on panel data by Fazzari, Hubbard, and Peterson (1988) finds that, after controlling for investment opportunities with Tobin's q, changes in net worth have a greater impact on investment by firms with higher costs of external financing.

The link between the cost of external financing and investment decisions not only sheds light on the dynamics of business cycles but also represents an important element in understanding economic development and growth. For instance, in the presence of moral hazard in the credit market, firms that need a bank loan may be induced to undertake risky investment projects with low expected marginal productivity. This corporate decision affects the growth path of the economy, which may even fall into a poverty trap (see Zicchino, 2001). Rajan and Zingales (1998), Demirguc-Kunt and Maksimovic (1998) and Wurgler (2000), among others, have investigated the link between finance and growth by asking whether underdeveloped legal and financial systems could prevent firms from investing in potentially profitable growth opportunities. Their empirical results show that an active stock market, developed financial intermediaries and the respect of legal norms are determinants of economic growth.

Estimation of the relationship between investment and financial variables is challenging because it is difficult for an econometrician to observe firms' net worth and investment opportunities. In theory, the measure of investment opportunities is the present value of expected future profits from additional capital investment, or what is commonly called marginal q. This is the shadow value of an additional unit of capital and, under certain conditions, it can be shown to be a sufficient statistic for investment (Hayashi, 1982). In other words, it is the 'fundamental' factor that determines investment policy of profit-maximizing firms in efficient markets. The difficulty in measuring marginal q, which is not observable, results in low explanatory power of the q-models and, typically, entails implausible estimates of the adjustment cost parameters.[1]

Another challenge is finding an appropriate measure for the 'financial' factors that enter the investment equation in models with capital markets imperfections. A widely used measure for the availability of internal funds is cash flow (current revenues less expenses and taxes, generally scaled by capital). However, cash flow is likely to be correlated with future investment profitability.[2] This makes it difficult to distinguish the response of investment to the 'fundamen-

[1] See Whited (1998) and Erickson and Whited (2000) for a discussion of the measurement errors in investment models. Also see Schiantarelli (1996) and Hubbard (1998) for a review on methodological issues related to investment models with financial constraints.

[2] For example, the current realization of cash flow would proxy for future investment opportunities if the productivity shocks were positively serially correlated.

tal' factors, such as marginal profitability of capital, and 'financial' factors, such as net worth (see Gilchrist and Himmelberg, 1995, 1998, for further discussion of this terminology).

In this paper we use the vector autoregression (VAR) approach to overcome this problem and isolate the response of investment to financial and fundamental factors. Specifically, we focus on the orthogonalized impulse-response functions, which show the response of one variable of interest (i.e. investment) to an orthogonal shock in another variable of interest (i.e. marginal productivity or a financial variable). By orthogonalizing the response we are able to identify the effect of one shock at a time, while holding other shocks constant.

We use firm-level panel data from 36 countries to study the dynamic relationship between firms' financial conditions and investment levels. Our main interest is to study whether the dynamics of investment are different across countries with different levels of development of financial markets. We argue that the level of financial development in a country can be used as an indication of the different degrees of financing constraints faced by firms. After controlling for the shocks to 'fundamental' factors, we interpret the response of investment to 'financial' factors as evidence of financing constraints and we expect this response to be larger in countries with lower levels of financial development. To test this hypothesis we divide our data in two groups according to the degree of financial development of the country in which they operate. We document significant differences in the response of investment to 'financial' factors for the two groups of countries. Furthermore, splitting the sample based on different indicators of economic development does not produce significant differences, supporting our claim that the level of *financial* development is the main determinant of financing constraints.

We believe our paper contributes to a number of strands in the recent financial economics literature. We contribute to the literature on financial constraints and investment in several ways. First, by using vector autoregressions on panel data we are able to consider the complex relationship between investment opportunities and the financial situation of the firms, while allowing for a firm-specific unobserved heterogeneity in the levels of the variables (i.e. fixed effects). Second, thanks to a reduced-form VAR approach, our results do not rely on strong assumptions that are necessary in models that use the q-theory of investment or Euler equations. Third, by analyzing orthogonalized impulse-response functions we are able to separate the response of investment to shocks coming from fundamental or financial factors.

We also contribute to the finance and growth literature by presenting new evidence that investment in firms operating in financially underdeveloped countries exhibits dynamic patterns consistent with the presence of financing constraints. Our paper also adds to the recent work that used dynamic panel-data techniques to argue that there is a casual link between financial development and growth (see, for example, Beck and Levine, 2004). While most of the previous studies relied on country-level data, our paper uses firm-level data to demonstrate how the link between finance and growth operates on the level of the firm and to provide additional evidence on the channels behind this link. Specifically, we find that financial development has an immediate effect on efficient allocation of capital via investment that follows the most productive uses of capital. Our finding is also consistent with the evidence presented by Beck, Demirguc-Kunt, Levine, and Maksimovic (2001) who found that it is easier for firms' to access external financing in countries with a higher level of overall financial sector development.

Our paper also adds to the recent debate on bank-based versus market-based financial systems (see, for example, Demirguc-Kunt and Levine, 2001a, b, and Beck and Levine (2002), among others). This literature demonstrated that despite conflicting theoretical predictions, there is no empirical evidence of the relationship between financial structures and economic growth. However, the literature has found that it is the overall financial development that helps in explaining

cross-countries differences in economic performance. Our findings are consistent with this literature and expand the range of real effect previously studied to include the micro-level evidence of the effect of financial development on investment behavior and capital allocation.

Our paper is also related to Gilchrist and Himmelberg (1995, 1998), who were the first to analyze the relationship between investment, future capital productivity and firms' cash flow with a panel-data VAR approach. They use a two-stage estimation procedure to obtain measures of what they call 'fundamental' q and 'financial' q. These factors are then substituted in a structural model of investment, which is a transformation of the Euler-equation model. Unlike Gilchrist and Himmelberg, we do not estimate a structural model of investment, but instead study the unrestricted reduced-form dynamics afforded by the VAR (which is in effect the first-stage in their estimation). Gallegati and Stanca (1999) also investigate the relationship between firms' balance sheets and investment by estimating reduced-form VARs on company panel data for UK firms. Despite some differences in the specification of the empirical model and the estimation methodology, the approach and the results of their paper are similar to ours. However, they do not present an analysis of the impulse-response functions, which we consider to be the main tool in separating the role of financial variables in companies' investment decisions. In addition, the distinguishing feature of our paper is the focus on the differences in the dynamic behavior of firms in countries with different levels of financial development.

Finally, our paper is related to Love (2003) who uses the Euler-equation approach and shows that financing constraints are more severe in countries with lower levels of financial development, the same as we find in this paper. However, the interpretation of the results in the previous paper is heavily dependent on the assumptions and parameterization of the model, while the approach we use here imposes the bare minimum of restrictions on parameters and temporal correlations among variables.

The rest of the paper is as follows: Section 2 presents the empirical specification and the data description; Section 3 provides the results of our work; and Section 4 presents our conclusions.

2. Empirical methodology

We use a panel-data vector autoregression methodology. This technique combines the traditional VAR approach, which treats all the variables in the system as endogenous, with the panel-data approach, which allows for unobserved individual heterogeneity. We specify a first-order VAR model as follows:

$$z_{it} = \Gamma_0 + \Gamma_1 z_{it-1} + f_i + d_{c,t} + e_t \tag{1}$$

where z_t is either a three-variable vector {SKB, CFKB, IKB} or a four-variable vector {SKB, CFKB, IKB, TOBINQ}; SKB, sales to capital ratio, is our proxy for the marginal productivity of capital,[3] IKB is the investment to capital ratio, which is our main variable of interest, CFKB is cash flow scaled by capital, and TOBINQ is 'Tobin's q', measured as market value of assets over book value of assets.

In this model sales to capital ratio and Tobin's q represent 'fundamental' factors, i.e. factors that capture the marginal productivity of capital. In the absence of market frictions, positive shocks to

[3] See Gilchrist and Himmelberg (1998) for a derivation of the ratio of sales to capital as a measure of marginal productivity of capital.

these fundamental factors should lead to an increase in investment as firms will take advantage of better investment opportunities.

Cash flow is commonly used in investment models as an indicator for internally available funds (see Hubbard, 1998, for a review). In our model, we consider cash flow also as a proxy for 'financial factors'.[4] Our analysis is implicitly based on an investment model in which, after controlling for the marginal profitability, the effect of the financial variables on investment is interpreted as evidence of financing constraints.[5] We do this by relying on the orthogonalization of impulse responses. Because the shocks are orthogonalized, i.e. 'fundamentals' are kept constant, the impulse response of investment to cash flow isolates the effect of the 'financial' factors. We use this orthogonalized response of investment to 'financial factors' as a measure of market frictions and financing constraints.

The impulse-response functions describe the reaction of one variable to the innovations in another variable in the system, while holding all other shocks equal to zero. However, since the actual variance–covariance matrix of the errors is unlikely to be diagonal, to isolate shocks to one of the variables in the system it is necessary to decompose the residuals in a such a way that they become orthogonal. The usual convention is to adopt a particular ordering and allocate any correlation between the residuals of any two elements to the variable that comes first in the ordering.[6] The identifying assumption is that the variables that come earlier in the ordering affect the following variables contemporaneously, as well as with a lag, while the variables that come later affect the previous variables only with a lag. In other words, the variables that appear earlier in the systems are more exogenous and the ones that appear later are more endogenous.[7]

In our specification we assume that current shocks to the marginal productivity of capital (proxied by sales to capital) have an effect on the contemporaneous value of investment, while investment has an effect on the marginal productivity of capital only with a lag. We believe this assumption is plausible for two reasons. First, the sales to capital ratio is likely to be the most exogenous firm-level variable since it depends on the demand for firms' output, which often is outside of the firms' control (of course, sales depend on firms' actions as well, but most likely with a lag). Second, investment is likely to become effective with some delay since it requires time to become fully operational (the so-called "time-to-build" effect). We also argue that the effect of sales on cash flow is likely to be contemporaneous and if there is any feedback effect it is likely to happen with a lag. Finally, we assume that investment responds to cash flow contemporaneously, while cash flow responds to investment only with a lag.[8] In the model with four variables, we

[4] Although cash flow is the most commonly used proxy for net worth, it is closely related to operating profits, and therefore to the marginal productivity of capital. If the investment expenditure does not result in higher sales but in lower costs (i.e. more efficiency), the sales to capital ratio (our main measure of marginal productivity of capital) would not pick up this effect, while the cash flow would. Thus, cash flow may partly capture fundamental factors rather than the financial factors affecting investment. To reduce this effect, we included *Tobinq* as another fundamental variable to control for marginal productivity and investment opportunities.

[5] See Gilchrist and Himmelberg (1998) for a more formal structural model that is behind their first-stage reduced VAR approach, which is similar to our approach.

[6] The procedure is know as Choleski decomposition of variance–covariance matrix of residuals and is equivalent to transforming the system in a "recursive" VAR for identification purposes. See Hamilton (1994) for the derivations and discussion of impulse-response functions.

[7] More formally, if a variable x appears earlier in the system than a variable y, then x is weakly exogenous with respect to y in the short run.

[8] Our results are robust to changing the order of cash flow and investment.

assume that Tobin's q affects all other variables with a lag and is simultaneously affected by all other variables. As a result, TOBINQ is the most endogenous variable in the system, thus capturing all available information (i.e. all the contemporaneous shocks to other variables).

Our main objective is to compare the response of investment to financial factors in countries on a different level of financial development. To achieve this, we split our firms into two samples according to the level of financial development of the country in which they operate and we analyze the difference in impulse responses for the two samples. We refer to these two groups as 'high' (financial development) and 'low' (financial development). This distinction is relative and is based on the median level of financial development among countries in our sample.[9]

In applying the VAR procedure to panel data, we need to impose the restriction that the underlying structure is the same for each cross-sectional unit. Since this constraint is likely to be violated in practice, one way to overcome the restriction on parameters is to allow for "individual heterogeneity" in the levels of the variables by introducing fixed effects, denoted by f_i in the model. Since the fixed effects are correlated with the regressors due to lags of the dependent variables, the mean-differencing procedure commonly used to eliminate fixed effects would create biased coefficients. To avoid this problem we use forward mean-differencing, also referred to as the 'Helmert procedure' (see Arellano and Bover, 1995). This procedure removes only the forward mean, i.e. the mean of all the future observations available for each firm-year. This transformation preserves the orthogonality between transformed variables and lagged regressors, so we can use lagged regressors as instruments and estimate the coefficients by system GMM.[10]

Our model also allows for country-specific time dummies, $d_{c,t}$, which are added to model (1) to capture aggregate, country-specific macro shocks that may affect all firms in the same way. We eliminate these dummies by subtracting the means of each variable calculated for each country-year.

To analyze the impulse-response functions we need an estimate of their confidence intervals. Since the matrix of impulse-response functions is constructed from the estimated VAR coefficients, their standard errors need to be taken into account. We calculate standard errors of the impulse-response functions and generate confidence intervals with Monte Carlo simulations.[11] To compare the impulse responses across our two samples (i.e. 'high' and 'low' financial development) we simply take their difference. Because our two samples are independent, the impulse responses of the differences are equal to the difference in impulse responses (the same applies to the simulated confidence intervals).

Finally, we also present variance decompositions, which show the percent of the variation in one variable that is explained by the shock to another variable, accumulated over time. The variance decompositions show the magnitude of the total effect. We report the total effect accumulated over the 10 years, but longer time horizons produced equivalent results.

[9] A recent paper by Powell, Ratha, and Mohapatra (2002) uses similar approach to ours (i.e. splitting the countries into two groups and estimating VARs separately for each group) to study the interrelationships between inflows and outflows of capital and other macro variables.

[10] In our case the model is "just identified", i.e. the number of regressors equals the number of instruments, therefore system GMM is numerically equivalent to equation-by-equation 2SLS.

[11] In practice, we randomly generate a draw of coefficients Γ of model (1) using the estimated coefficients and their variance–covariance matrix and re-calculate the impulse-responses. We repeat this procedure 1000 times (we experimented with a larger number of repetitions and obtained similar results). We generate 5th and 95th percentiles of this distribution which we use as a confidence interval for the impulse-responses.

Table 1
Sample coverage across countries

Country	Country code	Number of observations	Percent of total observations	Number of firms	Financial development
Panel A: Low financial development sample					
Argentina	AR	250	0.005	39	−1.38
Belgium	BE	586	0.01	91	−0.82
Brazil	BR	894	0.02	143	−1.04
Chile	CL	507	0.01	74	−0.75
Colombia	CO	146	0.00	21	−1.6
Denmark	DK	1051	0.02	138	−0.49
Finland	FI	818	0.02	113	−0.41
Indonesia	ID	708	0.01	114	−1.17
India	IN	1856	0.03	294	−0.7
Italy	IT	1100	0.02	151	−0.64
Mexico	MX	522	0.01	76	−0.85
New Zealand	NZ	304	0.006	44	−0.53
Philippines	PH	406	0.008	68	−1.15
Pakistan	PK	546	0.01	88	−1.28
Portugal	PT	291	0.005	53	−0.67
Sweden	SE	1178	0.02	178	−0.31
Turkey	TR	248	0.005	54	−1.2
Venezuela	VE	92	0.002	13	−1.26
Group average		639	0.012	97	−1
Group total		11503		1752	
Panel B: High financial development sample					
Austria	AT	530	0.01	83	−0.27
Australia	AU	1383	0.03	184	0.42
Canada	CA	3136	0.06	443	0.03
Switzerland	CH	1087	0.02	151	2.2
Germany	DE	4092	0.08	582	1.68
Spain	ES	987	0.02	134	−0.14
France	FR	3338	0.06	524	0.1
United Kingdom	GB	8657	0.16	1165	1.68
Israel	IL	164	0.00	37	0.01
Japan	JP	6654	0.12	1271	3.3
South Korea	KR	1643	0.03	259	0.84
Malaysia	MY	1837	0.03	291	1.19
Netherlands	NL	1282	0.02	154	0.66
Norway	NO	878	0.02	148	−0.15
Singapore	SG	906	0.02	145	1.6
Thailand	TH	1233	0.02	185	0.36
USA	US	3399	0.06	356	1.35
South Africa	ZA	1189	0.02	244	0.25
Group average		2355	0.044	353	1
Group total		42395		6356	
Total sample		53898		8108	

Countries are split into two groups based on the median level of financial development.

Table 2
Variable definitions

Abbreviation	Description
Firm-level variables (from Worldscope)	
CAPEX	Capital expenditure
NETPEQ	Property plant and equipment
SALES	Net sales or revenues
IKB	Investment to capital ratio = CAPEX/(NETPEQ − CAPEX)
SKB	Sales to capital ratio = SALES/(NETPEQ − CAPEX)
CF	Cash flow (derived from Worldscope cash flow to sales ratio)
CFKB	Cash flow divided by (NETPEQ − CAPEX)
RANK	Ranking based on size of PPENT (first ranked by year, then averaged over the years), largest firm in each country has rank equal to one
TOBINQ	Tobin's q, generated as market value of equity plus book value of total liabilities divided by book value of total assets
Country-level variables	
STKMKT	Stock market development is Index 1 from Demirguc-Kunt and Levine (1996), equals to the sum of (standardized indices of) market capitalization to GDP, total value traded to GDP, and turnover (total value traded to market capitalization)
FININT	Financial intermediary development is Findex1 from Demirguc-Kunt and Levine (1996), equals to the sum of (standardized indices of) ratio of liquid liabilities to GDP, and ratio of domestic credit to private sector to GDP
FD	Financial development = STKMKT + FININT
GDPPC	GDP per capita from World development indicators
HIGHINC	World bank classification category based on 2002 gross national income per capita

2.1. Data

Our firm-level data come from the Worldscope database, which contains standardized accounting information on large publicly traded firms and includes 36 countries with over 8000 firms for the years 1988–1998. Table 1 gives the list of countries in the sample with the number of firms and observations per country, while details on the sample selection are given in Appendix 1. The number of firms included in the sample varies widely across the countries and the less developed countries are underrepresented. The US and UK have more than 1000 firms per country, while the rest of the countries have only 136 firms on average (Japan is the third largest with over 600 firms). Such a prevalence of US and UK companies might overweight these countries in the cross-country regressions and prevent smaller countries from influencing the coefficients.[12]

We constructed the index of financial development, FD by combining standardized measures of five indicators from Demirguc-Kunt and Levine (1996): market capitalization over GDP, total value traded over GDP, total value traded over market capitalization, ratio of liquid liabilities (M3) to GDP and credit going to the private sector over GDP. We split the countries into two groups based on the median of this indicator. We refer to these two groups as 'high' (financial development) and 'low' (financial development), but we remind the reader that this distinction

[12] To reduce the influence of countries with a large number of firms we also run our regressions with a subgroup of firms in each country, i.e. only including a fixed number of the largest firms. The inclusion criteria are based on firm ranking, where rank one is given to the largest firm in each country. The results obtained were very similar to the ones reported in the paper and are available on request.

Table 3
Summary statistics for main variables

	Low financial development sample					High financial development sample				
	Mean	Standard deviation	25th percentile	50th percentile	75th percentile	Mean	Standard deviation	25th percentile	50th percentile	75th percentile
SKB	3.39	3.54	1.06	2.31	4.38	4.12	4.05	1.41	2.92	5.33
IKB	0.21	0.15	0.10	0.17	0.28	0.21	0.14	0.11	0.18	0.27
CFKB	0.29	0.32	0.11	0.22	0.38	0.28	0.28	0.13	0.23	0.38
TOBINQ	1.35	0.78	0.89	1.11	1.51	1.46	0.76	1.00	1.22	1.63

Summary statistics by country for main variables. Variable definitions are given in Table 2. Countries are split into two groups based on the median level of financial development.

is relative and is based on the median level of financial development among countries in our sample.

Table 2 summarizes all the variables used in the paper (note that we normalize all the firm-level variables by the beginning-of-period capital stock), and Table 3 reports the summary statistics for the firm-level variables.

3. Results

We estimate the coefficients of the system given in (1) after the fixed effects and the country-time dummy variables have been removed. In Table 4 we report the results of the model with three variables {SKB, IKB, CFKB}, while in Table 5 we report the model with four variables {SKB, IKB, CFKB, TOBINQ}. We report the results that include all sample of firms in each

Table 4
Main results of a 3-variable VAR model

Response of	Response to		
	SKB(t-1)	CFKB(t-1)	IKB(t-1)
Panel A: Low financial development sample			
SKB(t)	0.571 (6.77)***	0.359 (1.54)	−1.528 (−7.03)***
CFKB(t)	0.025 (3.61)***	0.300 (9.68)***	−0.124 (−5.66)***
IKB(t)	−0.009 (−1.98)	0.129 (5.54)***	0.111 (5.83)***
N obs	7228		
N firms	1518		
Panel B: High financial development sample			
SKB(t)	0.462 (13.55)***	0.771 (5.56)***	−1.599 (−12.22)***
CFKB(t)	0.010 (3.75)***	0.361 (19.99)***	−0.104 (−7.89)***
IKB(t)	0.004 (−2.19)	0.084 (7.06)***	0.132 (9.99)***
N obs	26675		
N firms	5370		

Variable definitions are in Table 2. Three variable VAR model is estimated by GMM, country-time and fixed effects are removed prior to estimation (see Section 2 for details). Countries are split into two groups based on the median level of financial development. Reported numbers show the coefficients of regressing the row variables on laggs of the column variables. Heteroskedasticity adjusted t-statistics are in parentheses. *** indicates significance at 1% level.

Table 5
Main results of a 4-variable VAR with Tobin's q

Response of	Response to			
	SKB(t-1)	CFKB(t-1)	IKB(t-1)	TOBINQ(t-1)
Panel A: Low financial development sample				
SKB(t)	0.589 (6.04)***	0.363 −1.470	−1.610 (−6.82)***	0.208 (2.26)
CFKB(t)	0.023 (2.70)	0.275 (8.03)***	−0.111 (−4.47)***	0.024 (1.56)
IKB(t)	−0.012 (−2.12)	0.123 (4.98)***	0.118 (5 49)***	0.041 (2.77)
TOBINQ(t)	−0.0005 (−0.08)	0.039 (1.27)	−0.020 (−0.96)	0.449 (12.97)***
N obs	5813			
N firms	1381			
Panel B: High financial development sample				
SKB(t)	0.447 (11.93)***	0.578 (3.89)***	−1.442 (−10.25)***	0.330 (6.10)***
CFKB(t)	0.009 (2.9)**	0.329 (18.31)***	−0.097 (−6.89)***	0.070 (8.37)***
IKB(t)	0.005 (2.04)	0.065 (5.21)***	0.122 (9.33)***	0.055 (7.63)***
TOBINQ(t)	−0.004 (−1.75)	0.071 (4.36)***	−0.029 (−2.00)	0.464 (24.61)***
N obs	24253			
N firms	5032			

Variable definitions are in Table 2. Four variable VAR model is estimated by GMM, country-time and fixed effects are removed prior to estimation (see Section 2 for details). Countries are split into two groups based on the median level of financial development. Reported numbers show the coefficients of regressing the row variables on laggs of the column variables. Heteroskedasticity adjusted t-statistics are in parentheses. *** and ** indicates significance at 1% and 5% level, respectively.

country.[13] We present graphs of the impulse-response functions and the 5% error bands generated by Monte Carlo simulation. Fig. 1 reports graphs of impulse responses for the model with three variables estimated for a sample of countries with 'low' financial development, while Fig. 2 reports this model for countries with 'high' financial development. In Fig. 3 we show the differences in impulse responses of two samples (the difference is 'low' minus 'high'). Figs. 4–6 present similar graphs for the model with TOBINQ.

We discuss general results first before proceeding to the ones of our particular interest. We observe that the response of the sales to capital ratio to investment is negative in the estimated coefficients and impulse responses. This is expected as sales to capital is our proxy for marginal product of capital. A shock to investment increases the capital stock, which moves the firm along the production frontier. With diminishing returns to capital, the marginal product will decrease. A similar pattern is observed in the response of TOBINQ to investment shock (however, it is only significant in the 'high' development sample, suggesting that in less developed countries TOBINQ is less responsive to firms investment). Since TOBINQ is a measure of investment opportunities, an investment shock implies that the available opportunities have been acted upon and therefore the market to book value drops.

The investment shows an expected positive response to a shock in the sales to capital ratio (i.e. marginal profitability), both in the estimated coefficients and in the impulse responses. A similar

[13] As mentioned above, we repeated our analysis with a sample including only up to 150 largest firms in each country using a rank-based approach described in the data section. We also considered models with different proxies for cash flow and different normalizations (for example, scaling by total assets instead of capital stock). Finally, we used different cutoff points—such as 50 or 100 firms. The results were similar to the ones reported and are available on request.

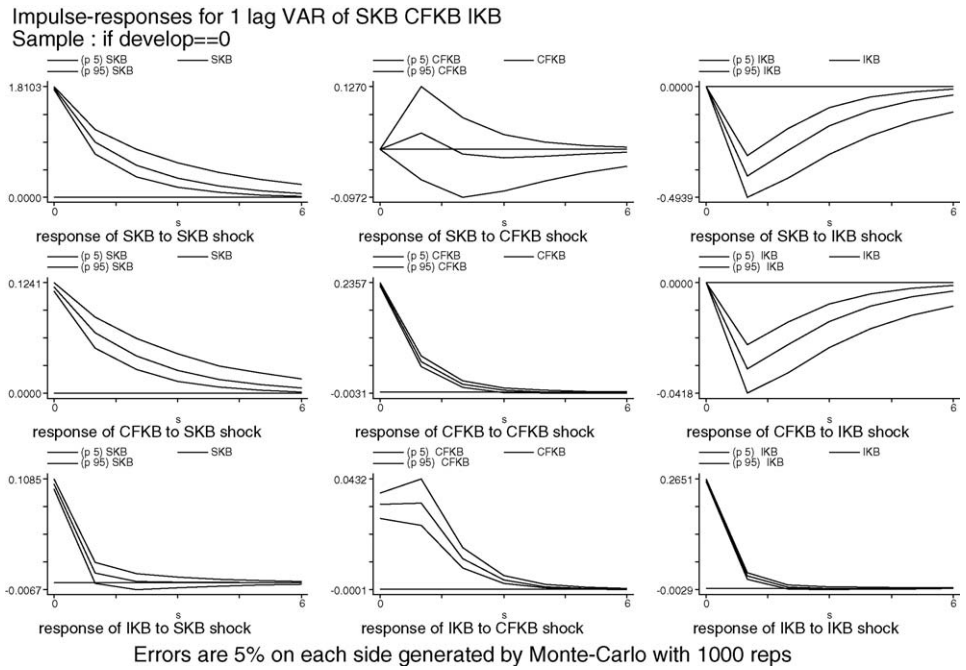

Fig. 1. Impulse responses for low financial development sample (model with three variables: SKB, CFKB, IKB).

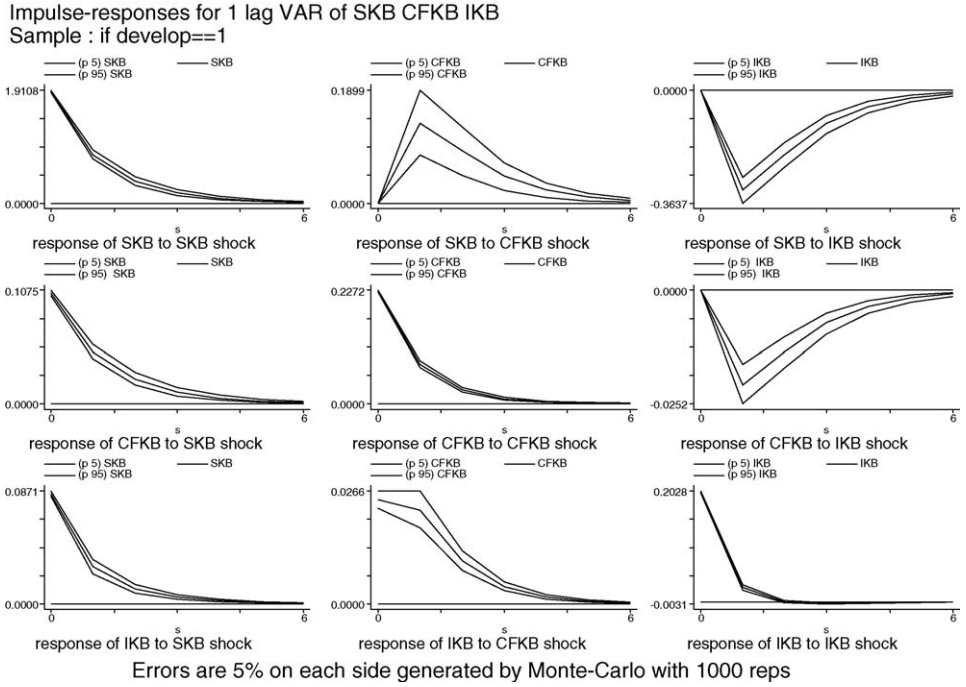

Fig. 2. Impulse responses for high financial development sample (model with three variables: SKB, CFKB, IKB). Errors are 5% on each side generated by Monte-Carlo with 1000 reps.

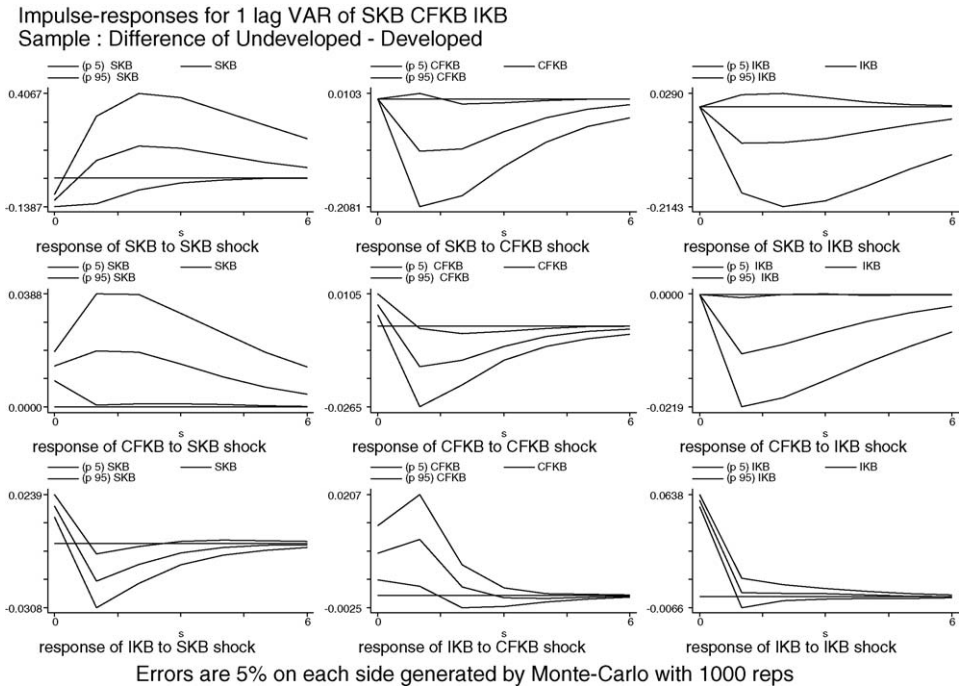

Fig. 3. Difference in impulse responses (low–high) for the model with three variables: SKB, CFKB, IKB.

pattern is observed in the response to TOBINQ in the model with four variables, confirming the prediction that TOBINQ captures a part of the "fundamental" shock.

Cash flow increases in response to a sales shock (higher revenues imply more cash), while it decreases in response to investment. Cash flow has no significant effect on sales to capital (and there is no reason to expect such an effect). These patterns are very similar across our two groups of countries.

The result of our particular interest is the response of investment to our financial variable—the cash flow. We observe that the impact of the lagged cash flow on the level of investment is much larger in countries with 'low' financial development than it is in countries with 'high' financial development. This difference is most pronounced in the model with TOBINQ in which the cash flow coefficient is twice as large in the 'low development' sample than in the 'high development' one (i.e. 0.123 compared with 0.065—see second column in Table 5), and this difference is statistically significant. In the model with three variables, the coefficient is one and a half times larger in the 'low' sample than in the 'high' one.

The panels representing the impulse response of investment to a one standard deviation shock in cash flow clearly show a positive impact. We also notice that this response has a larger impact on the value of the investment for firms in the 'low' sample. This can be seen most clearly in Fig. 3 that reports the difference in two samples responses (i.e. 'low' minus 'high'). The difference between two impulse responses is significant at better than 5% (i.e. the 5% lower band is quite above the zero line). The same is true when we use a model which includes TOBINQ (see Fig. 6). These results suggest that financial factors have larger effect on investment in countries with lower levels of financial development.

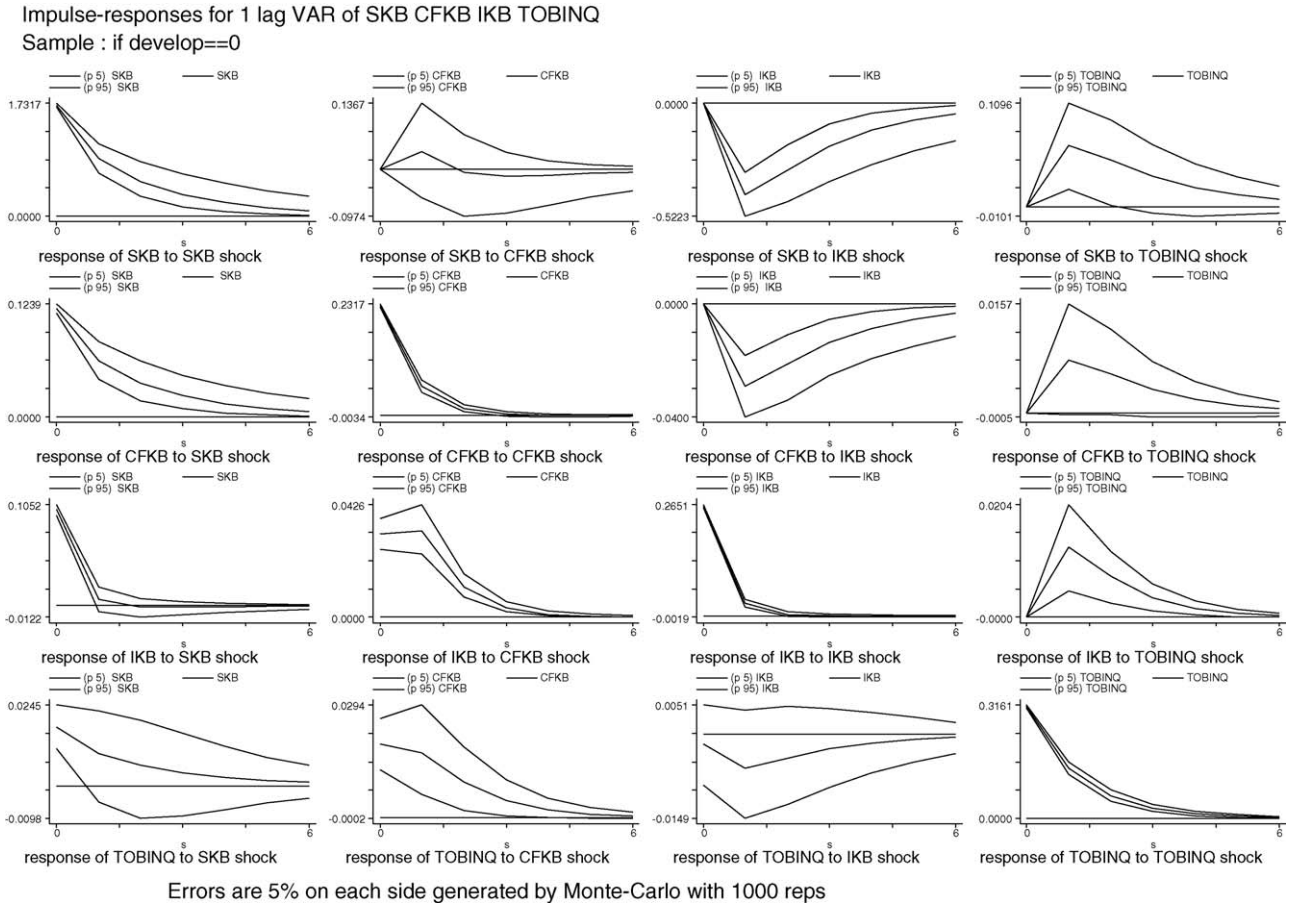

Fig. 4. Impulse responses for low financial development sample (model with four variables: SKB, CFKB, IKB, TOBINQ). Errors are 5% on each side generated by Monte-Carlo with 1000 reps.

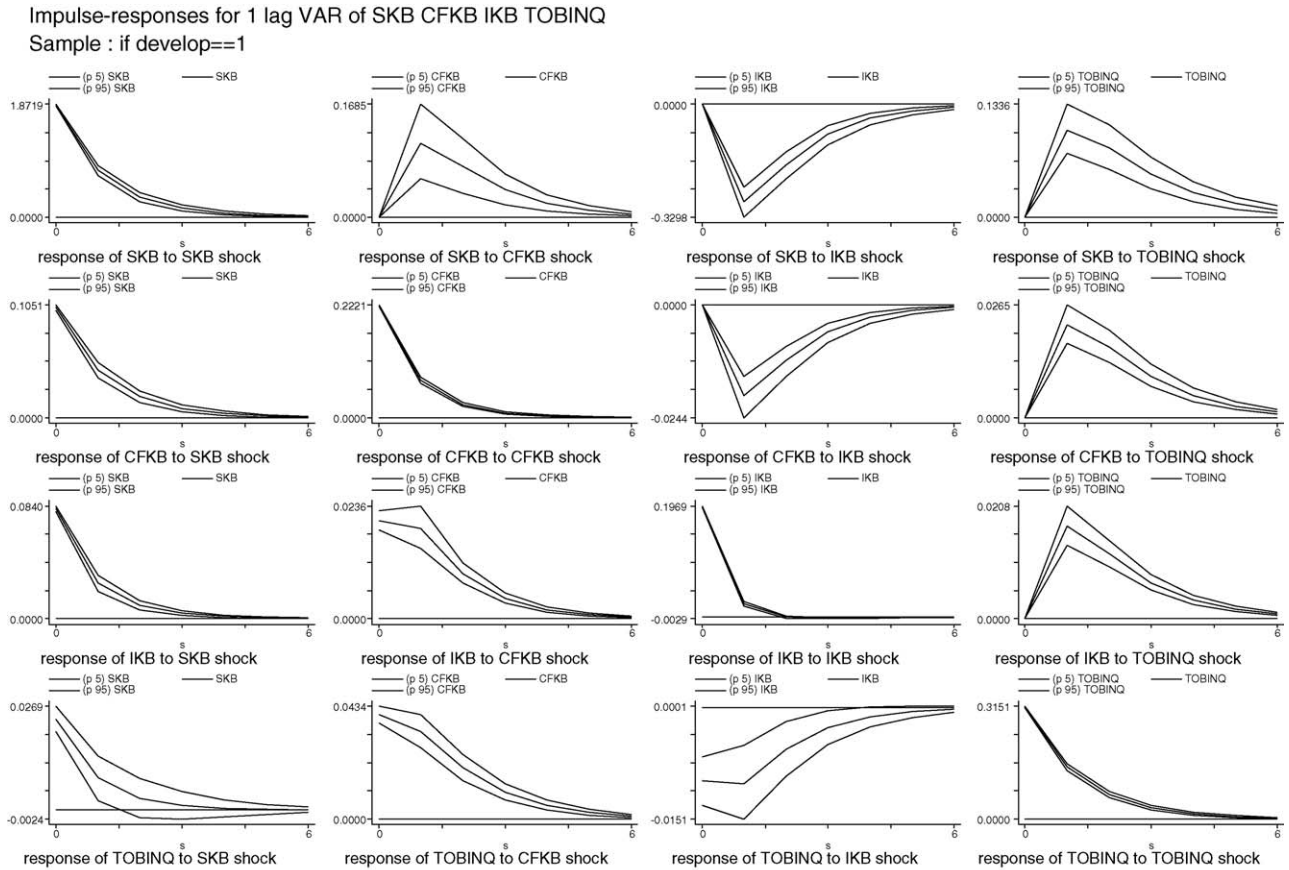

Fig. 5. Impulse responses for high financial development sample (model with four variables: SKB, CFKB, IKB, TOBINQ).

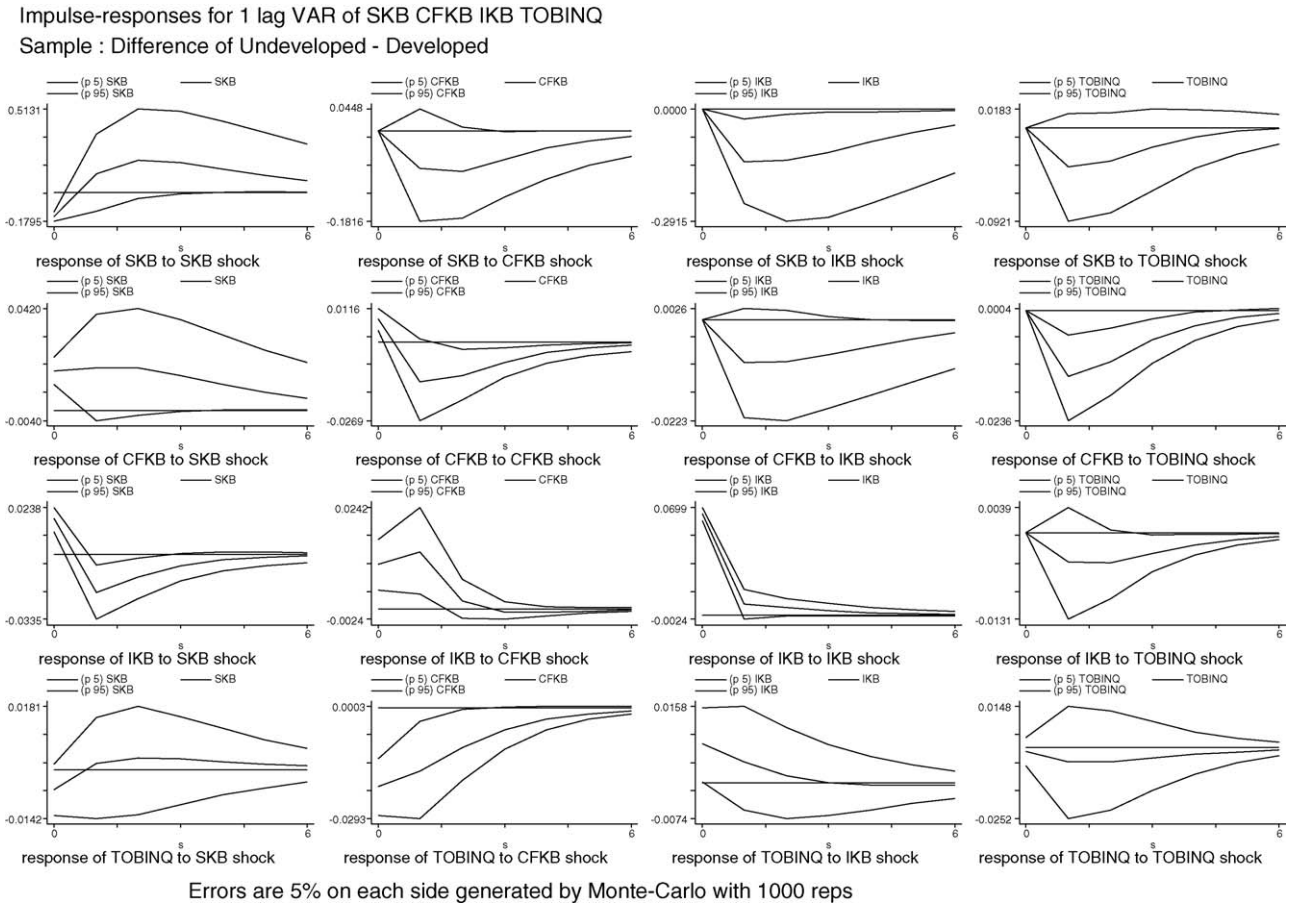

Fig. 6. Difference in impulse responses (low–high) for the model with four variables: SKB, CFKB, IKB, TOBINQ. Errors are 5% on each side generated by Monte-Carlo with 1000 reps.

Table 6
Variance decompositions

	SKB	CFKB	IKB	
Panel A: Low financial development sample				
SKB	0.940	0.000	0.061	
CFKB	0.263	0.713	0.024	
IKB	0.131	0.029	0.840	
Panel B: High financial development sample				
SKB	0.959	0.006	0.035	
CFKB	0.194	0.796	0.010	
IKB	0.162	0.024	0.814	
	SKB	CFKB	IKB	TOBINQ
Panel C: Low financial development sample				
SKB	0.923	0.0	0.075	0.002
CFKB	0.260	0.718	0.021	0.001
IKB	0.123	0.027	0.847	0.003
TOBINQ	0.004	0.006	0.001	0.989
Panel D: High financial development sample				
SKB	0.963	0.005	0.028	0.005
CFKB	0.188	0.791	0.008	0.013
IKB	0.158	0.019	0.813	0.010
TOBINQ	0.005	0.025	0.002	0.968

Percent of variation in the row variable (10 periods ahead) explained by column variable.
Panels A and B refer to the model with three variables (SKB, CFKB, IKB); panels C and D to the model with four variables (SKB, CFKB, IKB, TOBINQ).

The variance decompositions for the different models, presented in Table 6, are in line with these results. Cash flow explains more of the investment variation 10 periods ahead in the sub-sample of countries characterised by low financial development. However, the magnitude of the effect is rather small, cash flow only explains about 2.7% of total variation in investment in low development sample and about 1.9% in high development sample (using the model with four variables).

The orthogonalization of the VAR residuals (discussed in Section 2) allows us to isolate the response of investment to 'financial' factors (cash flow) from the response to 'fundamental' factors (marginal productivity of capital). We interpret our results as evidence that the response of investment to 'financial' factors (and, therefore, the intensity of financing constraints) is significantly larger in countries with less developed financial markets.

A mirror image result is that 'fundamental' factors have less effect on investment in countries with low financial development sample. The impulse response of investment to sales to capital is significantly lower in the 'low' sample (but only after the contemporaneous response, which, surprisingly, is higher). However, over time the response of investment to sales to capital is significantly lower in the low development sample, as shown by the variance decomposition: sales to capital explains about 12% of variation in the 'low' sample and about 16% in the 'high' sample (using the model with four variables).[14]

[14] While impulse-responses show that investment responds less to *Tobinq* in the 'low' sample, this difference is not significant at 5% level. The percent of variation in investment explained by *Tobinq* is very small (1% in the 'high' sample and 0.3% in the 'low' sample). Thus, *Tobinq* has a negligible additional explanatory power in the model, which uses sales to capital as a proxy for the marginal product of capital.

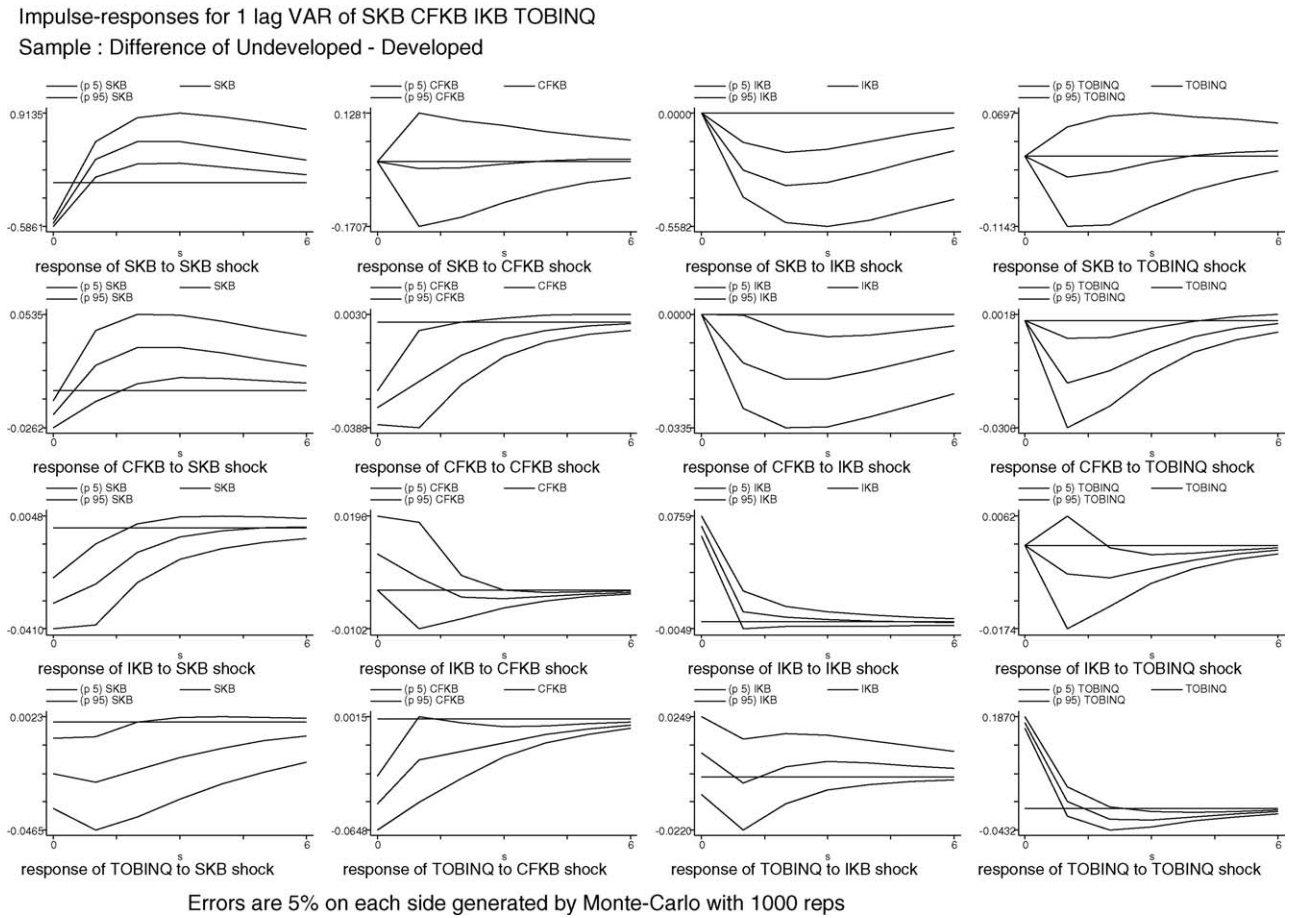

Fig. 7. Difference in impulse responses (low–high) for a model with four variables and development defined over the median of GDP PC.

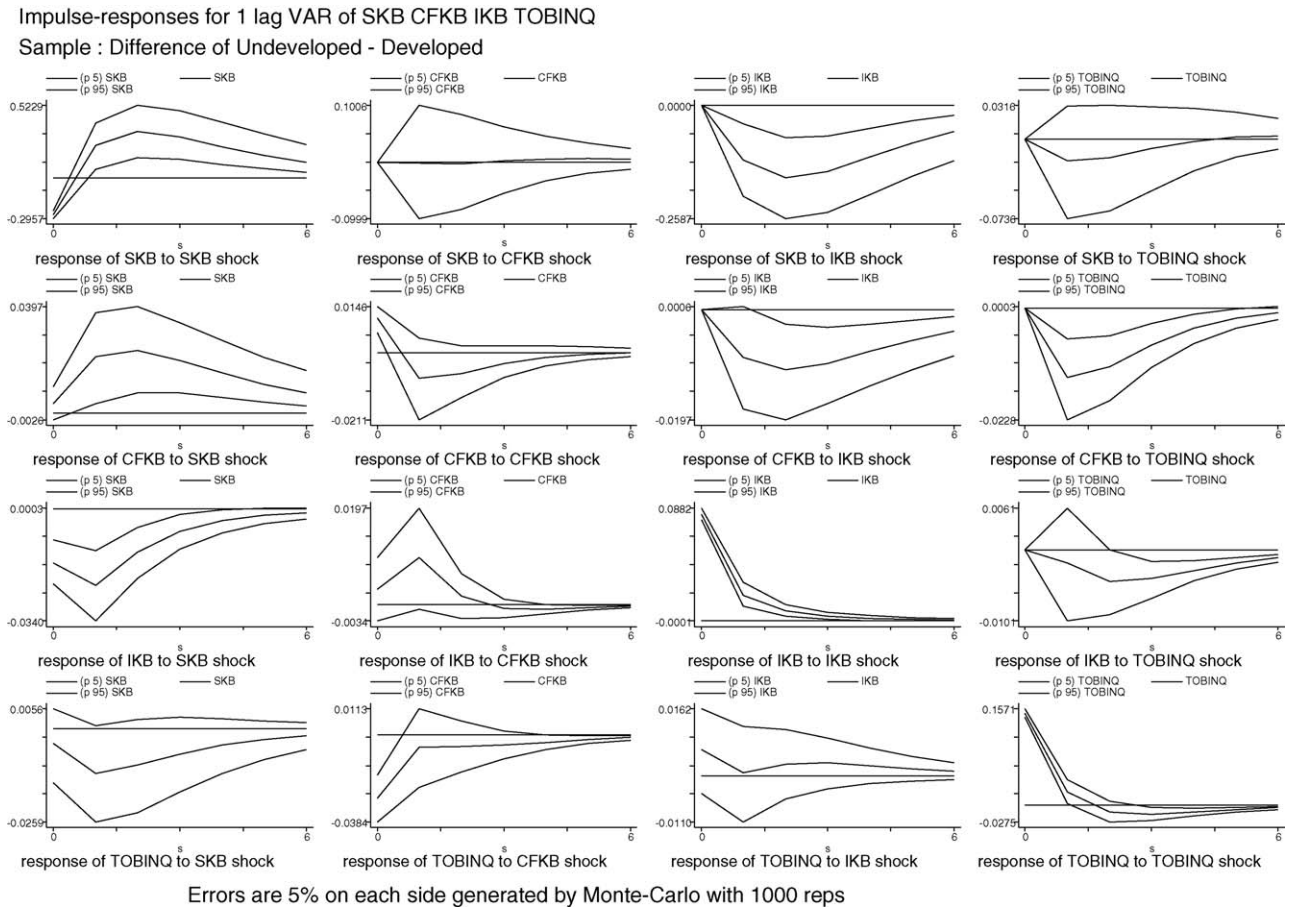

Fig. 8. Difference in impulse responses (low–high) for a model with four variables and development defined as high income (using World Bank classification). Errors are 5% on each side generated by Monte-Carlo with 1000 reps.

To confirm that our main result of a significantly different impact of cash flow shocks on investment is capturing the level of financial development rather than economic development we ran two further tests. First, we split the countries according to their GDP per capita (using the sample median). Second, we use the World Bank classification of countries into different income categories based on GNI per capita, separating high-income countries from the rest. The graphs of the differences between the impulse responses for the model with four variables are shown in Figs. 7 and 8.[15] There was no significant difference in the response of investment to a cash flow shock in either case, corroborating our finding that firms in less financially (rather than less economically) developed countries are more likely to need to rely on internal sources of finance in order to invest.

To conclude, the coefficient estimates, the impulse-response functions, and the variance decompositions resulting from the vector autoregressions support our claim that in the presence of financing constraints, which are more stringent in countries that do not have a well-developed financial system, the availability of liquid assets affects firms' investment decisions. Financing constraints manifest not only in higher response of investment to 'financial' factors but also in lower response of investment to 'fundamental' factors. Both of these effects imply that financial under-development adversely affects the dynamic investment behavior, thus leading to inefficient allocation of capital.

4. Conclusions

This paper uses a VAR approach to analyze the relationship between firms' investment decisions and the level of financial development in their hosting countries. It shows that the availability of internal funds is more important in explaining investment in countries with less developed financial systems. More specifically, the impact of a positive shock to cash flow on investment is significantly higher in countries with a 'low' level of financial development than in countries with a 'high' level of financial development. Symmetrically, we find that positive shock to marginal productivity has less impact on investment of firms in countries with low level of financial development.

Our paper complements earlier work in finance and growth literature by Demirguc-Kunt and Levine (2001a, b), Beck and Levine (2002, 2004) and others. While this literature did not find links between financial structure (i.e. market-based versus bank-based systems) and growth, it found strong casual links between overall financial development and growth. Our results contribute to this literature by showing that in countries with underdeveloped financial markets firms have inefficient allocation of capital and that they exhibit slower growth rates.

We believe our paper contributes to the literature on financial constraints and investment decisions by adopting a simple approach to separate the fundamental from the financial factors that influence the level of investment. The analysis of the impulse-response functions obtained from a reduced-form VAR model allowed us to obtain clear evidence of the importance of financial development for capital investment without having to impose the strong structural assumptions necessary in the q-theory or the Euler-equation approaches. In conclusion, while supporting earlier results, our paper also presents a simple methodology that could be used to further explore the differences in dynamic firm behaviour across different countries.

[15] We used the model with three variable as well and obtained similar results.

Acknowledgment

The paper was completed while Lea Zicchino was at Columbia University, New York. The views presented here are the author's own and not necessarily those of the World Bank, its member countries or the Bank of England

Appendix A. Sample selection

All countries in the Worldscope database (May 1999 Global Researcher CD) with at least 30 firms and at least 100 firm-year observations are included in the sample (in addition we include Venezuela (VE), though it has only 80 observations); former socialist economies are excluded. This results in a sample of 40 countries. The sample does not include firms for which the primary industry is either financial (one digit SIC code of 6) or service (one digit SIC codes of 7 and above).

In addition we delete the following (see Table 2 for variable definitions):

- All firms with 3 or less years of coverage;
- All firm-years with missing CAPEX, Sales, Netpeq, Compnumb or Cash;
- Outliers for the distributions of SKB, IKB, CFK, and TOBINQ.

The resulting data set has about 54,000 observations. The number of observations by country is given in Table 1.

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