Financing behavior of R&D investments in the emerging markets: The role of alliance and financial system

Abstract: This paper examines the financing behaviour of R&D investments in emerging markets. Drawing on institutional theory and using panel data of generalized methods of moment (GMM) estimation for a sample of 302 firms from 20 countries during the period 2003-2015, we find that emerging market firms tend to use internal funds for financing R&D investments. Interesting results emerged when the sample was divided as alliance and non-alliance firms, and bank-based and market-based financial systems. The results show that R&D financing behaves differently for alliance and non-alliance firms. Alliance firms use both internal and external funds for R&D investments, while non-alliance firms do not use external funds. We also document that a country's financial system influences the choice of available sources of finance. Firms from countries that follow a bank-based financial system tend to rely on external funds while firms from countries that follow a market-based financial system depend more on internal funds for financing R&D investments. This study is important as it provides new evidence on financing R&D investments in emerging countries taking into account the institutional arguments of financing choices, and so should guide stakeholders about appropriate sources of R&D financing.

Keywords: Financing, R&D Investments, Emerging Markets

1. Introduction

Investment in Research and Development (R&D) activities has long been treated as an important driver for economic growth. The average private rate of return from R&D investment may go as high as 30% (Hall, 1996) and the social return may go even further (Griliches, 1992) due to the possibility of spillover effect (Griffith et al., 2000). This stunning rate of return has encouraged thousands of firms across the globe to increase the investments in R&D activities. Both Narula and Martínez-Noya (2015) and Bakker (2013) confirmed the phenomenal growth of R&D investments over the last few decades. Researchers have long

been trying to explore the determinants for this spectacular growth and concluded that firm profitability, firm size, degree of capital intensity, exposure to international markets, degree of firm diversification, age of the firm, ownership structure, and market share are among the important internal firm-level factors that affect R&D investments (Anwar and Sun, 2013). Moreover, some external factors, such as sectoral variation and industry concentration (Anwar and Sun, 2013), national system of innovation, research clusters, and macro level innovation strategy (Howells, 2008) may also affect the R&D investments. Although we have a rich literature on determinants of R&D investments, the financing of R&D in emerging markets has been largely ignored in the literature (Sasidharan et al., 2015). However, it is apparent thatwith the growing scale of R&D investments, the financing of this has become an important issue for the finance and management scholars. A number of studies have confirmed that the financing of R&D is significantly different from the financing of other investments. Hall et al. (2016) stated that R&D is different from other forms of corporate investments for several reasons, including higher risk and uncertainty, opportunistic behaviours, moral hazards, and adverse selection. Considering this distinctive nature of R&D investment, a number of authors have examined the nature of financing of corporate R&D activities. Prominent among those are Hall (1992), Bhagat and Welch (1995), and Czarnitzki and Hottenrott (2011). However, these studies are mostly on developed markets and largely ignore the financing of R&D in emerging markets. This is against the backdrop of the significant importance of emerging markets from the context of increasing trends of R&D investments in those markets and the idiosyncratic market feature of the same. R&D Magazine (2016) reported that the growth of R&D expenditure in emerging markets is more than in developed markets. However, the financing of R&D in those countries should be different fromthe financing in developed countries due to differences in the institutional settings. Sasidharan et al. (2015) stated that frictions in financial markets in emerging

countries are more severe and therefore, should have a greater impact on R&D financing compared to developed markets. Sasidharan et al. (2015) also mentioned the inadequacy of research in exploring the financing of R&D in emerging markets. To fill this gap, this paper will examine the financing of R&D investments using firm-level data from a set of emerging countries.

One of the notable features in modern day internationalization activities is the formation and growth of strategic alliances. Narula and Martínez-Noya (2015) pointed out that over the last three decades, R&D-based strategic alliances have been rising in number and volume. Although there was a preference for higher control entry modes in the case of R&D intensive firms in earlier times of internationalization, the choice is gradually shifting towards strategic alliances, as mentioned by Martínez-Noya and García-Canal (2011) and Satta et al. (2016). As the innovation process has become more complex recently due to mergers, acquisitions, and strategic alliances, R&D managers have had to be strategic and tactical and so require more interdisciplinary knowledge. To address this requirement, firms need greater flexibility and need to be working more closely with external partners to ensure and access complementary resources, reduce costs, and reduce time to market (Martínez-Noya et al., 2012). There are specific benefits for R&D intensive firms to internationalize their activities through strategic alliances as suggested by Satta et al. (2016), and the benefits may even be greater for firms that have partners from emerging countries due to the possibility of low cost technology development, the availability of low cost talent, and the conducive environments in those emerging markets (UNCTAD, 2005; Jacob et al., 2013). As a result, the evidence shows that more than a third of global technology alliances during 2004-2008 were formed with partners from emerging markets (Jacob et al., 2013). Although the benefits of forming a strategic alliance for R&D intensive firms are well explained in the literature, we still do not know much about the financing of R&D in the case of strategic alliances. Therefore, it would

be interesting to see if there is any variation in R&D financing choices in the case of strategic alliances compared to non-alliance firms. The existence of well-functioning capital markets makes the choices for R&D financing relatively straightforward, as is evident from studies based on developed markets (Czarnitzki and Hottenrott, 2011). However, these results are not helpful to understand the financing in emerging markets, as Allen et al. (2012) pointed out that the size and role of a capital market is limited when it comes to allocating funds in emerging countries. However, Tong and Xu (2004) pointed out that in a weaker financial market, banks can be effective financing institutions, as they are able to make sure of the ex-ante screening of R&D projects, which helps to mitigate information asymmetry. Considering this fact, it would be interesting to see how firms' R&D financing behaves in a country that follows either a bank-based financial system or a capital market-based financial system.

This paper is organized as follows. Section two presents the theory and hypothesis of the study. Section three introduces the data and research method. Section four presents the results and discussion and section five provides conclusion and implication of the study.

2. Theory and Hypotheses:

Institutional theory posits that the institutional settings of a country facilitate investment by providing incentives and supports, creating a stable environment, mitigating transaction costs, and reducing risk and uncertainty (North, 1990). R&D activities as a form of investment are also sensitive to institutional quality (Waarden, 2001). Wang et al. (2015) mentioned that the innovation of a firm's activities can be influenced by institutions through laws, regulations, and policies. It has also been mentioned that institutions influence the cost of innovation inputs and protect the innovation outputs and thereby influence firms' innovation activities. The financing of R&D is different from the financing of other traditional investment activities. Hall et al. (2016) stated that R&D investment suffers from a high level of

uncertainty, adverse selection, moral hazard, and agency problems. These problems are prominent in case of R&D investments, as these investments are characterized by contract incompleteness, opaqueness, and information asymmetry between firms and investors (Hall and Lerner, 2010). As a result, firms tend to finance R&D more with internal funds, as suggested by Myers and Majluf's (1984) pecking order theory (Hall et al., 2016). External finance, and specifically debt, is not a favoured form of finance for R&D investment (Hall, 1992; Lin et al., 2017). Hall (2002) concluded that a higher level of agency problem and information asymmetry in case of R&D investments increase the cost of external financing and makes the firm more reliant on internal finance. However, there is considerable evidence that institutional quality helps to mitigate frictions like the agency problem or the information asymmetry problem in financial markets (Claessens et al., 2014). Therefore, quality institutions should reduce the cost of capital by reducing financial frictions and should encourage the firms to use more funds from external sources to finance investments, including R&D investments. Although developed markets with high quality institutions may be better off using a greater amount of external funds to finance R&D investments, emerging economies may not have a similar opportunity due to the weaker quality of the economic institutions. Claessens and Yurtoglu (2013) pointed out that corporate governance practice is particularly poor in many emerging markets. More importantly, the possibility of managerial expropriation is higher in those economies due to the weak enforcement of legal rights. Therefore, in emerging countries, it is expected that firms would use fewer external funds to finance R&D activities to avoid agency and information asymmetry problems arising out of the weaker institutional quality of those markets. However, the problem of weaker economic institutions for the external financing of R&D activities should be relatively less prominent in countries that follow a bank-based economic model rather than market-based economic models. Mayer (1990) pointed out that financial decisions of financial systems based on the

"Anglo-Saxon" capital markets model differ from those based on a "Continental-German-Japanese" banking model. The banking-based models are in favour of closer supervision of the clients, which eventually helps the firm to reduce some of the risks inherent in R&D investments. For example, Carlin and Mayer (2003) stated that a higher banking concentration would encourage more R&D investments for countries with weaker institutions. The reason behind this conclusion is intuitive. In countries where institutions are weaker, the banks help firms to screen the R&D projects ex-ante, and due to close supervision, the banks help to reduce the agency and information asymmetry problems. Demirguc-Kunt and Levine (1999) also stated that a bank-based financial system provides more credit facilities, promotes long-term relationships with firms, and resolves moral hazard problems. Thus, firms can easily obtain loans for long-term R&D investments. Based on the above discussion, this paper proposes the following hypothesis:

Hypothesis 1: *In emerging markets, where institutions are relatively weaker, a bank-based financial system would encourage firms to use more external funds to finance R&D.*

We have argued above that firms operating in a bank-based financial system would prefer to use more external funds (bank financing) as bank monitoring minimises the incidence of weaker institutional quality. However, this bias (preference for bank financing) may not be prominent in firms operating in market-based financial systems where the institutional quality is better. Strong economic and legal institutions encourage firms to raise funds from capital markets rather than relying solely on banks. Stronger institutions reduce the cost of financing by minimising the moral hazard problem and information asymmetry. They also protect both firms and investors from any potential investment and financing risks (LaPorta et al., 1998; Demirguc-Kunt and Maksimovic, 2002). However, this may not be the case for R&D investments, as it has been documented that R&D investments involve a number of

limitations that make such investments relatively riskier compared to other forms of investment (Bakker, 2013). The situation is exacerbated in emerging markets, as the institutional quality in those countries is far lower than in developed countries (Peng et al., 2008). Therefore, to avoid the enhanced level of risk associated with R&D investments in emerging markets, firms tend to depend more on internal sources of finance (Hall, 1992; Bakker, 2013). However, this heavy dependence on internal finance for R&D investments in emerging markets may not be applicable for firms that are involved in a strategic alliance. A strategic alliance brings together two or more independent firms through contractual agreements (Owen and Yawson, 2015). Todeva and Knoke (2005) pointed out that a strategic alliance helps firms to overcome the problems of weaker institutions, such as legal, political, and cultural barriers. Chou et al. (2014) stated that a strategic alliance helps firms to reduce transaction costs, accumulate more productive resources, send a positive signal to the market, reduce the information asymmetry, and reduce the cost of debt. These benefits, along with the possibility of organizational ambidexterity (Junni et al., 2013; Junni et al., 2015) in the case of strategic alliances (Lin et al., 2007), may help the firms to circumvent the barriers of weaker institutions in the emerging markets and attract exogenous lenders. Moreover, Gibson et al. (1997) concluded that the firms that benefit most from strategic alliances are bigger in general, and therefore, this creates the possibility of them seizing the opportunity to access more external funds to finance R&D investments. In addition to the greater proximity of external funds by firms involved in strategic alliances, internal funds are also prominent for those firms. An alliance is the result of resource integration among the firms, which provides new channels and opportunities to access new resources and improve such firms' competitive advantages (Das and Teng, 2000; Wang and Chen, 2015). Therefore, it is expected that they will have more internal funds to invest in R&D. Based on the above discussion, the following hypothesis is proposed:

Hypothesis 2: *As alliances have sufficient internal resources and multiple sources of funding, they use both internal and external funding for R&D investments.*

3. Data and Methodology

3.1 Data

We used the Thomson Reuter DataStream database to collect the data from 51 emerging markets[1]. To avoid sample selection bias, we considered all of the listed firms[2] in an emerging market. We primarily searched 25,251 firms on DataStream. However, there were some missing values and unrealistic figures, so we dropped these[3]. To be included in the sample, the country had to have at least 2 firms, and the firms had to have data for 13 consecutive years. Moreover, we tried to minimize gaps in or the lack of the latest data. Therefore, the sample periods were selected from 2003 to 2015. After considering the above issues, DataStream provided 302 firms from 20 emerging markets (see **Table-I**). We used balanced panel data for the sample firms because it made it possible to control for firm heterogeneity; and to give more information, more variability, and a greater degree of freedom; and to provide more efficient results. In addition, it was more suitable for identifying and measuring effects that are not detectable in pure cross-section or pure time series data (Baltagi, 2013).

[1] The list of emerging markets may vary from one organisation to another. To avoid this problem, all emerging markets from all organisations' lists (IMF, Goldman Sachs, FTSE, MSCI, The Economist, S&P, Dow Jones, BBVA, and Columbia University EMGP - 2013) were selected for this study (see Appendix). We excluded South Korea, Taiwan and Singapore from the sample because these countries are now considered as emerged countries.

[2]We did not separate financial and non-financial firms. Although the nature of financial firms are different and may or may not offer the right products of R&D investment, the changing environment & competition drive them in innovation. Therefore, future research could solely be based on financial sectors.

[3]There are large numbers of missing values of R&D investment on DataStream. One possible reason could be that R&D investment is hidden in marketing budgets. Moreover, due to the aggregate value of R&D, it is difficult to separate the budget for R spending and D spending.

Table 1: Sample by Country[4]

Country	No. of firms	Percentage of firms	Cumulative percentage
Hong Kong	62	20.53	20.53
India	50	16.56	37.09
Turkey	29	9.60	46.69
China	22	7.28	53.97
South Africa	22	7.28	61.26
Israel	21	6.95	68.21
Bangladesh	20	6.62	74.83
Greece	19	6.29	81.13
Malaysia	13	4.30	85.43
Philippine	8	2.65	88.08
Indonesia	7	2.32	90.40
Sri Lanka	5	1.66	92.05
Brazil	4	1.32	93.38
Mexico	4	1.32	94.70
Pakistan	4	1.32	96.03
Russia	3	0.99	97.02
Chile	3	0.99	98.01
Peru	2	0.66	98.68
Poland	2	0.66	99.34
Thailand	2	0.66	100
Total	302	100	100

Source: Authors' calculation

Table II: Summary Variables

Variables	Description
R&D	R&D expenditure of the firm in a year (In log)
Internal Fund	Internal Fund is measured by the ratio of cash flows to sales
External Fund	External Fund is measured by the ratio of debt to total asset
Size	Firm size is measured by total asset (In log)
Sales growth	Annual sales growth of the firm
Export oriented	Export oriented is dummy variable that takes a value of 1 if a firm exports
Foreign ownership	Percentage of foreign shareholders to total shareholders
Alliance dummy	The alliances takes value 1 if it is Alliance firms, 0 otherwise
Country dummy	The country takes value 1 if it is market-based, 0 if it is bank-based

[4] To mitigate the potential bias from the dominant country in the sample, we separately ran regression for lower percentage of countries (Philippine, Indonesia, Sri Lanka, Brazil, Mexico, Pakistan, Russia, Chile, Peru, Poland, and Thailand). As our main interest of variables (internal fund and external fund) provides same results, we kept these countries for analysis. The results will provide upon request.

Table-II displays the definition of the variables. From the existing literature, the above listed variables have been found to have a significant effect on firms' R&D investments. In this paper, following García-Quevedo et al. (2014), R&D expenditure is considered as a dependent variable which takes the logarithm of the annual R&D expenditure of the firms. The main independent variables are internal funds (Himmelberg and Petersen, 1994) and external funds (Aghion et al., 2004). The paper has used firm size, sales growth, export orientation, and foreign ownership as control variables as suggested by Lall (1983), Connolly and Hirschey (2005) and García-Quevedo et al., (2014). All variables are standardized to a common exchange rate: USD. Some of the explanatory variables had higher scales than others. Moreover, the absolute value of the variables increases the presence of heteroscedasticity (Grabowski, 1968). In order to avoid these problems, the natural logarithm of R&D, size variables, cash flow to sales ratio, debt to total asset ratio, and percentage of shareholders to foreigners are adopted.

Table III: Summary Statistics

	(I) All firms		(II) Alliance firms		(II) Non-Alliance firms			(III) Bank-based firms		(III) Market-based firms		
Variables	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation	Diff.-in-Means	Mean	Standard Deviation	Mean	Standard Deviation	Diff.-in-Means
R&D	2.7680	1.5771	2.9453	1.5620	2.5368	1.5672	0.4085***	2.7890	1.4580	2.7533	1.6558	0.0357***
Internal fund	12.1581	18.7055	12.0960	18.9771	12.2391	18.4845	-0.1430***	11.8154	17.3549	12.3987	19.5982	-.5833***
External fund	0.2066	0.1841	0.1938	0.1678	0.2232	0.2021	-0.0294***	0.2369	0.2155	0.1853	0.1549	0.0517***
Size	5.6906	0.8915	5.8338	0.8421	5.5038	0.9193	0.3299***	5.4923	0.8947	5.8298	0.8626	-.3375 ***
Sales growth	0.2145	3.2750	0.2084	4.0068	0.2225	1.9446	-0.0141*	0.1395	0.3528	0.2671	4.2620	-0.1276
Export oriented	0.4641	0.4988	0.5431	0.4983	0.3610	0.4804	0.1821***	0.5692	0.4953	0.3903	0.4879	0.1789***
Foreign ownership	14.0609	23.8713	17.5083	26.0701	9.5646	19.7788	7.9437 ***	10.2236	21.3269	16.7546	25.1635	-6.5310***
Alliance dummy	0.5660	0.4957						0.4591	0.4985	0.6411	0.4798	-.1819***
Country dummy	0.5875	0.4923	0.6654	0.4719	0.4860	0.5000	0.1795***					

Source: Authors' calculation

Table-III reports the summary statistics (Mean and Standard Deviation) of all the variables used for analysis. Column I shows that internal finance has a higher average than external finance, which indicates that emerging market firms tend to rely more on internal funds. Investors are more interested in emerging markets due to their growing importance. Thus, levels of foreign ownership in the emerging markets are higher. Summary statistics for the sub-samples of alliance and non-alliance firms are presented in Column II. Difference-in-means tests show that alliance firms differ significantly from non-alliance firms in all dimensions. Consistent with the findings by Levi (2005), the summary statistics show that alliance firms are more R&D intensive than non-alliance firms. The table also shows that alliance firms are bigger in size compared to non-alliance firms, as suggested by Gibson et al. (1997). Column III reports the summary statistics for sub-samples of firms from bank-based financial systems[5] and market-based financial systems. From Table III, it is also evident that firms from two different financial systems are significantly different in terms of selected variables, except for sales growth.

3.2 Model

In order to examine the financing behaviour of R&D investment, the following model is proposed. We have used a semi-logarithmic model for our analysis because sales growth contains some negative values; thus, we cannot use the logarithm of these values. Therefore, the model for our analysis is as follows:

$$In(RD_{it}) = \alpha_i + \beta_1 (Internal\ Fund_{it}) + \beta_2 (External\ Fund_{it}) + \beta_3 In(Size_{it}) + \beta_4 (Sales\ growth_{it}) + \beta_5 (Export\ oriented_{it}) + \beta_6 (Foreign\ ownership_{it}) + \eta_i + C_i + M_i + \varepsilon_{it}$$

[5]Bangladesh, Indonesia, India, Israel, Greece, Pakistan and Sri Lanka are considered to follow a bank-based financial system while Brazil, China, Chili, Hong Kong, Malaysia, Mexico, Peru, Philippine, Poland, Russia, South Africa, Turkey and Thailand are considered to follow the market-based financial systems (Demirguc-Kunt and Levine, 1999 ; Allen et al., 2012; World Bank, 1991).

Individual heterogeneity is important for this analysis because R&D investment decisions fully depend on a firm's specificity, such as strategy, firm culture, and the propensity to innovate (Hillier et al., 2011; Pindado et al., 2015). Thus, there is a probability of obtaining biased results. To obtain unbiased results, we need to control for individual heterogeneity. Therefore, we have taken η_i as the individual effects in our model and then eliminated it by taking the first differences of the variables. Besides individual firm effects, we also include the country dummies, market dummies, and time dummies in the empirical model. Country dummies capture the country-specific effects, market dummies capture the market-specific effects, and time dummies capture the time-varying effect that controls the macroeconomic variables on a firm's value. Moreover, we consider ε_{it} as the random disturbance, which is assumed to be *i.i.d* normal.

3.3. Method of Study

Some of the independent variables in the model are endogenous, which may create an endogeneity problem. For example, firm size and R&D investments causality may run in both directions. Endogeneity can also arise as a result of measurement errors and omitted variables. To control the endogeneity problem, we have estimated the model using the generalized methods of moment (GMM) technique. In addition to this, Worrall (2008) stated that, within a single framework, GMM nests several estimations, such as OLS, 2SLS, and IV. For this estimation, we have used lagged levels t-1, t-2, and t-3 as the instruments for the difference equation, and one lag as the instruments for the level equation, as we applied the two-step system GMM. We applied the system GMM because it has been found to be more efficient than the difference GMM (Blundell and Bond, 1998). Moreover, the difference GMM estimation has the problem of weak instruments (Alonso-Borrego and Arellano, 1999). We performed the two-step GMM estimation on the grounds that it produces more efficient

estimates compared with the one-step estimation. In the two-step estimation, the standard covariance matrix is robust to panel-specific heteroscedasticity and serial correlation, but the standard errors are downward biased. To fix the possible downward bias, we applied the Windmeijer (2005) finite-sample corrected covariance matrix.

We included the lagged value of the dependent variable in the right hand side as a regressor. Use of the traditional fixed effect technique is biased in the presence of a lagged dependent variable as a regressor. Moreover, the presence of the lagged dependent variable may give rise to autocorrelation problems. Due to the first difference transformation, there might be first-order autocorrelation AR(1), but this would not create a specification problem with the GMM model. The results show that the null hypothesis of no first-order autocorrelation AR(1) is rejected. However, the test for second-order autocorrelation AR(2) means it is not possible to reject the null hypothesis, which indicates that there is no second order autocorrelation in our model.

However, one major issue of using the GMM technique is to find valid and relevant instruments. We used the Hansen J statistic of over identifying restrictions to test whether the instruments are valid, i.e., they are uncorrelated with the error terms. The results show that the instruments are valid and relevant in our model. In addition to this, we performed the two Wald tests: (i) z_1 is a test of the joint significance of the regressors, and (ii) z_2 is a test of the joint significance of the time dummies, suggesting that aggregate factors exert a significant influence on the relationship between R&D investments and the explanatory variables. The results show that the two Wald tests provide a good result for our model.

4. Results and Discussion

Table-IV presents the econometric results of the GMM estimation. In column I, as can be seen, R&D investment is highly persistent in the emerging markets. This implies that about 81% of past R&D behaviour affects the current level of R&D investments. The result is consistent with the R&D smoothing idea and is similar to findings from Sasidharan et al. (2015). The results from column I also confirm our general prediction that emerging market firms do not tend to use external funds to finance R&D, as is evident from the statistically significant negative coefficient for the variable. This is consistent with the general prediction that, due to information asymmetry, adverse selection, and agency problems, R&D investments tend to be riskier than other forms of investment and therefore, it becomes hard to find external funds to finance R&D in emerging markets. The result is consistent with earlier findings by Brown et al. (2012) and Hall et al. (2016). Control variables, such as firm size, sales growth, and export orientation, are found to be important determinants for R&D investments. Firm size has a significant positive impact on R&D investment in the emerging markets. The results indicate that larger firms make greater R&D investments. Lall (1983) found similar results. Sales growth increases a firm's probability of engaging in R&D investments. This indicates that the greater the market demand, the greater the percentage of the expenditure will be allocated to R&D. Firms with a higher export orientation are more likely to engage in R&D investments. Outward-oriented firms will be more aware of new technologies and will also strive harder to keep their technologies more competitive (Lall, 1983). Anwar and Sun (2013) reached the same conclusion based on Chinese electrical appliances and industries.

Table IV: Results

	(I)	(II)		(III)	
Variables	**All Firms**	**Bank-based**	**Market-based**	**Alliance**	**Non-Alliance**
$R\&D_{t-1}$	0.8113***	0.7700***	0.7388***	0.6631***	0.9060***
	(0.0332)	(0.0575)	(0.0511)	(0.0631)	(0.0287)
Internal fund	0.0002	-0.0008	0.0026*	0.0016*	-0.0008
	(0.0010)	(0.0018)	(0.0015)	(0.0018)	(0.0011)
External fund	-0.3097**	0.3325**	-0.4637**	0.2815*	-0.2745**
	(0.1024)	(0.1549)	(0.2342)	(0.2790)	(0.1156)
Size	0.1579**	0.1950**	0.2013**	0.2837**	0.0746*
	(0.0497)	(0.0679)	(0.0838)	(0.0995)	(0.0430)
Sales growth	0.0420**	0.1341**	0.0417**	0.0575*	0.0428**
	(0.0147)	(0.0682)	(0.0152)	(0.0323)	(0.0206)
Export oriented	0.1864*	0.3497**	0.0440	0.3317**	0.0021
	(0.1070)	(0.1443)	(0.1629)	(0.1807)	(0.0809)
Foreign ownership	0.0001	-0.0033**	0.0031**	0.0027**	-0.0002
	(0.0010)	(0.0013)	(0.0014)	(0.0014)	(0.0010)
Market dummy	Yes	Yes	Yes		
Country dummy	Yes			Yes	Yes
Year dummies	Yes	Yes	Yes	Yes	Yes
Total observations	3542	1459	2083	2009	1533
AR(1)	-5.23	-4.35	-3.83	-4.16	-4.75
P-value	0.0000	0.0000	0.0000	0.0000	0.0000
AR(2)	1.31	1.66	0.99	1.33	-0.39
P-value	0.19	0.108	0.324	0.259	0.696
z_1	191.35(9)	89.07(8)	65.77(8)	44.17(8)	321.27(8)
P-value	0.0000	0.0000	0.0000	0.0000	0.0000
z_2	2.5(12)	2.93(12)	1.84(12)	1.63(12)	1.79(12)
P-value	0.0038	0.0013	0.0805	0.0872	0.0559
Hansen	287.59 (270)	98.83(268)	168.41(258)	159.21(263)	120.7(259)
P-value	0.221	0.857	0.912	0.989	0.991

Significance levels: * <0.10, ** <0.05, ***<0.01; Standard errors in parenthesis.

Column II reports the results for bank-based and market-based finance. We hypothesized that firms from a bank-based financial system should use more external finance due to the possibility of enhanced monitoring and reduced agency and information asymmetry

problems. The results are consistent with the general prediction stated in hypothesis 1. We found a statistically significant positive coefficient for external finance in case of bank based financial system. This is consistent with earlier results of Demirguc-Kunt and Levine (1999), Carlin and Mayer (2003), and Davydov (2016). The results also show that firms from a market-based system rely more on internal sources rather than external sources to finance R&D due to the fact that in emerging markets, the cost of borrowing from capital markets would be higher due to weak financial institutions (Booth et al., 2001; Demirguc-Kunt and Maksimovic, 2002). With regard to the other regressors, firm size, sales growth, and foreign ownership in both bank-based and market-based finance systems significantly affect R&D investments. Moreover, both bank-based and market-based finance firms show higher persistence rates in R&D investments.

Column III presents the results for alliance and non-alliance firms in emerging markets. After controlling for the financial systems of a country, the results show that the financing of R&D differs in alliance and non-alliance firms. This result implies that resource access and external networks play a role in R&D financing. Alliances use both internal and external funding for R&D investments. As alliances have more internal resources and better access to finance, they may use both sources for R&D financing. Brown and Peterson's (2009) study also emphasized the use of both internal and external finance sources for R&D investments. These results support Hypothesis 2. On the other hand, the results show that external funding negatively affects non-alliance firms, meaning that non-alliance firms do not use external funding for R&D investments. This is because non-alliance firms are relatively small and find it difficult to obtain external funding for non-collateralisable and long-term R&D projects. With regard to the other regressors, the R&D investments of both types of firms depend on export performance and foreign ownership, while non-alliance firms' R&D is affected by

their size and sales growth. Moreover, both non-alliance firms and alliance firms show a higher persistence of R&D investments.

5. Conclusion and Implications

The spectacular growth of R&D investments in emerging economies in recent times made us consider the sources of the financing of the same. This is important, as the very nature of R&D investment differs from other traditional forms of corporate investment. Drawing on institutional theory in general, this paper has explored the sources of financing for R&D activities by emerging market firms. The study has used firm-level data from twenty emerging markets and has used the GMM estimation method to find out the effects of institutions on the financing of R&D by emerging market firms. The general conclusion is that firms in emerging markets tend to rely more on internal sources of finance to carry out R&D investments. This is consistent with the view that poor institutions in emerging markets make external financing costly. The study has also found that firms from countries that follow a bank-based financial system rely more on external funding (mostly bank borrowing) to finance their R&D activities. This is consistent with the notion that bank finance reduces information asymmetry and agency problems through an enhanced level of monitoring (Davydov, 2016). The results also show that alliance firms use both external and internal funds to finance R&D activities. Alliance firms have greater access to capital markets due to their ability to create several benefits including the creation of resources, the lower cost of debt, and sending a positive signal to the market (Chou et al. 2014). The findings of this study have important academic and policy implications. The study contributes to the academic literature by identifying the preferred sources of R&D financing for firms operating in emerging markets. The results of this study particularly suggest that due to institutional weakness, emerging market firms rely more on internal funds to finance R&D. We have found two exceptions to this general finding. First, if the financial system is primarily bank

based, firms tend to rely more on bank financing to support R&D activities despite the existence of weaker institutions. Second, firms from emerging markets with weaker institutions may create strategic alliance with foreign firms to enable them to raise funds from capital markets to support R&D investments. The results of this study should provide guidance to the policy makers to create a conducive environment for supporting R&D investments. It is widely accepted that R&D is mostly financed by internal sources. However, internal finance has its own limitations (Hottenrott and Peters, 2012). Therefore, to support firms to use cheaper external sources of financing, policy makers should seriously think of making the institutions stronger. Moreover, as we have found that creating strategic alliance enables firms to access external funds, more support should be provided to local firms so that the formation of alliances becomes easier.

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References

Aghion, P. Bond, S. Klemn, A. and Marinescu, L. (2004). Technology and financial structure: Are innovative firms different? *Journal of the European Economic Association*, vol. 2, pp. 277-288

Allen, F. Gu, X. and Kowalewski, O. (2012). Financial crisis, structure and reform. *Journal of Banking & Finance*, vol. 36, pp. 2960-2973

Alonso-Borrego, C. and Arellano, M. (1999). Symmetrically normalized instrumental-variable estimation using panel data. *Journal of Business and Economic Statistics*, vol. 17, pp. 36-49

Anwar, S. and Sun, S. (2013). Foreign entry and firm R&D: Evidence from Chinese manufacturing industries. *R&D Management*, vol. 43, pp. 303-317

Bakker, G. (2013). Money for nothing: How firms have financed R&D-projects since the industrial revolution. *Research Policy*, vol. 42, pp.1793-1814

Baltagi, B.H. (2013). *Econometrics Analysis of Panel Data*, Chichester: Wiley

Bhagat, S. and Welch, I. (1995). Corporate research and development investments: International comparisons. *Journal of Accounting and Economics*, vol. 19, pp. 443-470

Blundell, R. and Bond, S. (1998). Initial conditions and moment restrictions in dynamic panel data models. *Journal of Econometrics*, vol. 87, pp. 115–143

Booth, L. Aivazian, V. Demirguc-Kunt, A. and Maksimovic, V. (2001). Capital structures in developing countries. *Journal of Finance, vol.* 56, pp. 87-130.

Brown, J. R. Martinsson, G. and Petersen, B. C. (2012). Do financial constraints matter for R&D? *European Economic Review*, vol. 56, pp. 1512–1529

Brown, J. R. and Petersen, B.C. (2009). Why has the investment-cash flow sensitivity declined so sharply? Rising R&D and equity market developments. *Journal of Banking & Finance*, vol. 33, pp. 971-984

Carlin, W. and Mayer, C. (2003). Finance, investment, and growth. *Journal of Financial Economics*, vol. 69, pp. 191-226

Chonnolly, R.A. and Hirschey, M. (2005). Firm size and effect of R&D on Tobin's q. *R&D Management*, vol. 35, pp. 217-223

Chou, T. K. Ou, C.S. and Tsai, S.H. (2014). Value of strategic alliances: Evidence from the bond market. *Journal of Banking & Finance*, vol. 42, pp.42-59

Claessens, S. and Yurtoglu, B. (2013). Corporate governance in emerging markets: A survey. *Emerging Markets Review*, vol. 15, pp. 1-33

Claessens, S. Kenichi, U. and Yafeh, Y. (2014). Institutions and financial frictions: Estimating with structural restrictions on firm value and investment. *Journal of Development Economics*, vol. 110, pp. 107-122

Czarnitzki, D. and Hottenrott, H. (2011). R&D investment and financing constraints of small and medium-sized firms. *Small Business Economics*, vol.36, pp.65-83

Das, T. K. and Teng, B.-S. (2000). A resource-based theory of strategic alliance. *Journal of Management*, vol. 26, pp. 31-61

Davydov, D. (2016). Does state ownership of banks matter? Russian evidence from financial crisis. *SSRN Working paper*

Demirguc-Kunt, A. and Levine, R. (1999). Bank based and market based financial systems: Cross country comparison. *World Bank policy working paper*

Demirguc-Kunt, A. and Maksimovic, V. (2002). Funding growth in bank-based and market-based financial systems: Evidence from firm-level data. *Journal of Financial Economics*, vol. 65, pp. 337–363

García-Quevedo, J. Pellegrino, G. Vivarelli, M. (2014). R&D drivers and age: Are young firms different? *Research Policy*, vol.43, pp.1544-1556

Gibson, B. Weaver, K. M. and Dickson, P. H. (1997). Strategic alliance use, firm size, outcome satisfaction, and partner behaviours. *Small Enterprise Research*, vol. 5, pp.3-15

Grabowski, H. (1968). The determinants of industrial research and development: A study of the chemical, drug, and petroleum industries. *Journal of Political Economy*, vol. 76, pp. 292-306

Griffith, R. Redding, S. and Van Reenen, J. (2000). Mapping the two faces of R&D: Productivity growth in a panel of OECD industries. *CEPR Discussion Paper*, 2457

Griliches, Z. (1992). The search for R&D spillovers. *Scandinavian Journal of Economics*, vol. 94, pp.29-47

Hall, B. H. (1992). Investment and research and development at the firm level: Does the source of financing matter? *NBER Working paper no-4096*

Hall, B. H. (1996). The private and social returns to research and development, In B. Smith, and C. Barfield (eds), *Technology, R&D, and the Economy*, Washington, DC: Brookings Institution and American Enterprise Institute

Hall, B. H. (2002). The financing of research and development. *Oxford Review of Economic Policy*, vol. 18, pp. 35-51

Hall, B. H. and Lerner, J. (2010). The financing of R&D and innovation. *UNU-MERIT Working paper series 2010-12*

Hall, B. H. Moncada-Paternò-Castello, P. Montresor, S. and Vezzani, A. (2016). Financing constraints, R&D investments and innovative performances: New empirical evidence at the firm level for Europe. *Economics of Innovation and New Technology*, vol. 25, pp.183-186

Hillier, D. Pindado, J. Queiro, V. d. and Torre, C. d. l. (2011). The impact of country-level corporate governance on research and development. *Journal of International Business Studies*, vol. 42, pp. 76-98

Himmelberg, C. P. and Petersen, B.C. (1994). R&D and internal finance: A panel study of small firms in high-tech industries. *The Review of Economics and Statistics*, vol. 76, pp. 38-51

Hottenrott, H. and Peters, B. (2012). Innovative capability and financing constraints for innovation: More money, more innovation? *Review of Economics and Statistics*, vol. 94, pp. 1126-1142.

Howells, J. (2008). New directions in R&D: Current & prospective challenges. *R&D Management*, vol.38, pp. 241-252

Jacob, J. Belderbos, R. and Gilsing, V. (2013). Technology alliances in emerging economies: persistence and interrelation in European firms' alliance formation. *R&D Management*, vol. 43, pp. 447-460

Junni, P. Sarala, R. M. Taras, V. and Tarba, S. Y. (2013). Organizational ambidexterity and performance: A meta-analysis. *Academy of Management Perspectives*, vol. 27, pp. 299-312

Junni, P. Sarala, R. M. Tarba, S. Y. Liu, Y. and Cooper, C. L. (2015). The role of human resources and organizational factors in ambidexterity. *Human Resource Management*, vol. 54, pp. 1-28

La Porta, R. Lopez-de-Silanes, F. Shleifer, A. and Vishny, R. (1998). Law and finance. *Journal of Political Economy*, vol. 106, pp. 1113– 1155.

Lall, S. (1983). Determinants of R&D in LDC: The Indian engineering industry. *Economic Letters*, vol. 13, pp. 379-383

Levi, M. D. (2005). *International finance*, 4th edition, Oxon: Routledge

Lin, Z. J. Liu, S. and Sun, F. (2017).The impact of financing constraints and agency costs on corporate R&D investment: Evidence from China. *International Review of Finance*, Vol. 17, pp. 3-42

Lin, Z. Yang, H. and Demirkan, I. (2007). The performance consequences of ambidexterity in strategic alliance formation. *Management Science*, vol. 53, pp.1645-1658

Martínez-Noya, A. and Garíca-Canal, E. (2011). Technological capabilities and the decision to outsource/outsource offsource R&D services. *International Business Review*, vol. 20, pp. 264-277

Martínez-Noya, A. and Garíca-Canal, E. Guillén M. (2012). International R&D service outsourcing by technology-intensive firms: Whether and where? *Journal of International Management*, vol.18, pp.18-37

Mayer, C. (1990). Financial systems, corporate finance, and economic development, In R. Hubbard (ed.), *Asymmetric Information, Corporate Finance, and Investment*, Chicago, University of Chicago Press

Myers, S. C. and Majluf, N. (1984). Corporate financing and investment decisions when firms have information that investors do not have. *Journal of Financial Economics*, vol. 13, pp.187-221

Narula, R. and Martínez-Noya, A. (2015). International R&D alliances by firms: Origins and development, In D. Archibugi and A. Filippetti, (ed.), *The Handbook of Global Science, Technology, and Innovation*, Wiley-Blackwell

North, D.C. (1990). *Institutions, institutional change, and economic performance.* Cambridge, Massachusetts: Harvard University Press.

Owen, S. and Yawson, Y. (2015). R&D intensity, cross-border strategic alliance, and valuation effects. *Journal of International Financial Markets, Institutions & Money*, vol. 35, pp. 1-17

Peng, M.W. Wang, D.Y.L. and Jiang, Y. (2008). An institutional-based view of international business strategy: A focus on emerging economies. *Journal of International Business Studies*, vol. 39, pp. 920–936

Pindado, J., Queiroz, V.d. and Torre, C.d.l. (2015). How do country-level governance characteristics impact the relationship between R&D and firm value?. *R&D Management*, vol. 45, pp. 515-526

R&D Magazine, (2016). 2016 Global R&D funding forecast. Logged into: https://www.iriweb.org/sites/default/files/2016GlobalR%26DFundingForecast_2.pdf, accessed on 19 May, 2017

Sasidharan, S. Lukose, P. J. J. and Komera S. (2015). Financing constraints and investments in R&D: Evidence from Indian manufacturing firms. *The Quarterly Review of Economics and Finance*, vol. 55, pp. 28-39

Satta, G. Parola, F. Penco, L. Falco, S. E. d. (2016). Insights to technological alliances and financial resources as antecedents of high-tech firms' innovative performance. *R&D Management*, vol. 46, pp.127-144

Todeva, E. and Knoke, D. (2005). Strategic alliances and models of collaboration. *Management Decision*, vol. XLIII, pp. 123-148

UNCTAD. (2005). Transnational corporations and the internalization of R&D. *World Investment Report 2005*

Waarden, F. V. (2001). Institutions and innovation: The legal environment of innovating firm. *Organization Studies*, vol. 22, pp. 765-795.

Wang, C. Yi, J. Kafouros, M. and Yan, Y. (2015). Under what institutional conditions do business groups enhance innovation performance? *Journal of Business Research*, vol. 68, pp. 694–702.

Wang, M.-C. and Chen, M.-H. (2015). The more, the better? The impact of closure collaboration network and network structures on technology-based new ventures' performance. *R&D Management*, vol. 46 pp. 174-192

Windmeijer, F. (2005). A finite sample correc
gmm estimators. *Journal of Econometrics*, vol. 126, pp. 25–51

World Bank (1991). Wages and employment in the transition to market economy. *Policy, Research, and External Affairs working paper 736*

Worrall, J. L. (2008). The effects of local law enforcement block grants on serious crime. *Criminology & Public Policy*, vol. 7, pp. 325-350

Appendix 1: List of Emerging Countries									
	IMF	**Goldman Sachs BRICS+N11**	**FTSE**	**MSCI**	**The Economist**	**S&P**	**Dow Jones**	**BBVA**	**Columbia University EMGP**
Argentina	√						√	√	√
Bahrain							√	√	
Bangladesh		√						√	
Brazil	√	√	√	√	√	√	√	√	√
Bulgaria	√						√	√	
Chile	√		√	√	√	√	√	√	√
China	√	√	√	√	√	√	√	√	√
Colombia			√	√	√	√	√	√	
Czech Republic			√	√	√	√	√	√	
Egypt		√	√	√	√	√	√	√	
Estonia	√						√	√	
Greece				√					
Hong Kong					√				
Hungary	√		√	√	√	√	√	√	√
India	√	√	√	√	√	√	√	√	√
Indonesia	√	√	√	√	√	√	√	√	
Iran		√							
Israel									√
Jordan							√	√	
Kuwait							√	√	
Latvia	√						√	√	
Lithuania	√						√	√	
Malaysia	√		√	√	√	√	√	√	
Mauritius							√	√	
Mexico	√	√	√	√	√	√	√	√	√
Morocco			√		√	√	√	√	
Nigeria		√						√	
Oman							√	√	
Pakistan	√	√	√				√	√	
Peru	√		√	√	√	√	√	√	
Philippines	√	√	√	√	√	√	√	√	
Poland	√		√	√	√	√	√	√	√
Qatar							√	√	
Romania	√						√	√	
Russia	√	√	√	√	√	√	√	√	√
Saudi Arabia					√				
Singapore					√				
Slovakia							√	√	
Slovenia									√
South Africa	√	√	√	√	√	√	√	√	√
Sri Lanka							√	√	
South Korea		√			√			√	√

Sudan								√	
Taiwan			√		√	√		√	√
Thailand	√		√	√	√	√	√	√	√
Turkey	√	√	√	√	√	√	√	√	√
Tunisia								√	
UAE			√				√	√	
Ukraine	√							√	
Venezuela	√							√	
Vietnam		√							