Financing Constraints and Investments in R&D: Evidence from Indian Manufacturing Firms

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Abstract

This study investigates the financing of research and development (R&D) expenditure of listed firms in India. Using dynamic R&D investment model, we find significant positive relationship between a firm's R&D expenditure and internal cash flow. The cash flow sensitivity is higher for small and young firms. Further, we find significant cash flow sensitivity for both group-affiliated and stand-alone firms. Unlike their developing country counterparts, external equity financing is not positively related to R&D intensity of Indian firms even during periods of active equity markets. We do not find patterns of R&D smoothing using cash reserves and debt financing even during periods of illiquid equity market. The results of the study suggest that a plausible reason for lower R&D expenditure of Indian firms could be the non-availability of external equity to finance R&D.

Keywords: Financial constraints, Cash holding, Debt, Equity, Financing, R&D

JEL Classification: G31, G32, O32,

1. Introduction

The role of financial development in promoting economic growth is well recognized. A likely channel through which the linkage may arise is through financing of R&D (Brown et al. 2009). However, the channel through which the former influence the later has not received much empirical attention. The recent growth theorizing has put to the forefront the role of R&D in promoting growth (Aghion and Howitt 1992). The theoretical models emphasize the importance of R&D in the form of spillover effects. A related issue with regard to R&D is the financing aspect of such activities. The investment in R&D is riddled with information problems and lack of collateral value due to the uncertainty involved in R&D activities (Hubbard, 1998). Therefore, frictions are likely to arise in the case of obtaining funding for R&D. Stiglitz (1989) cites that informational problems are severe in the case of developing countries since the markets in these countries lack the capability to process and evaluate information. Thus, the financing constraints faced by the large number of firms to support their research programs are likely to hamper the economic growth in the case of emerging economy like India.

Numerous of studies have attempted to analyze the factors determining the R&D. Among the factors taken into account, financial factors have been highlighted as the crucial drivers of R&D (Hall, 1992; Bhagat and Welch, 1995; Singh and Faircloth, 2005; Bond, Harhoff and Van Reenen, 2006). The intangible nature of the R&D investment makes it more prone to financing constraints. A vast majority of the literature on the firms' financing constraints focuses on the link between cash flow and capital investment. However, studies addressing the issue of financing R&D are a recent phenomenon[1]. Ross et al. (1993) report that about 80 percent of all R&D financing is carried out with internal funds. Existing studies have tried to empirically analyze the financial constraints by testing the sensitivity of the R&D with the financial factors (Czarnitzki, 2006; Bond et al., 2006; Savignac, 2008; Brown et al 2009; Czarnitzki and Hottenrott, 2011; Hottenrott and Peters, 2012). Further, majority of the studies are confined to the experience of Anglo-Saxon countries. Lack of previous studies pertaining to the role of financing constraints in explaining R&D investment in the context of emerging economy viz India, is the primary motivation for the present study.

[1] See Hall and Lerner (2010) for an excellent survey of literature.

In this study, we examine the role of internal cash flow as well as external financing to fund the R&D expenditure of Indian firms. Our empirical analysis is based on a rich firm level data of listed firms belonging to the Indian manufacturing sector during 1991-2011. To investigate the role of financial factors in influencing the R&D investment expenditure, we use the modified dynamic R&D model developed by Bond and Meghir (1994). The estimation is carried out using the "systems" Generalized Method of Moments (GMM) estimator. In a panel setting, the systems GMM estimator has an added appeal that it takes care of the firm specific effects and the potential endogeneity problems. Our empirical analysis provides support for the important role of cash flows in explaining firms' R&D investment expenditures. Further, we do not find any evidence of R&D smoothing by Indian firms.

Our contribution to the growing body of empirical literature on the financing of R&D activities is threefold. The primary contribution of this study is to empirically document the role of internal finance on R&D investments from an emerging market perspective. India as an emerging market economy offers a number of peculiarities in order to test the role of internal finance in R&D. Since the onset of economic reforms in 1990 Indian firms are increasingly focusing on global competitiveness by way of innovation. Further, a number of multinational corporations have set up their R&D centers in India. Indian companies are entering into research collaborations and alliances with global firms. The study assumes significance in the context of the recent Science, Technology, and Innovation Policy - 2013 proposing an increase in gross expenditure on R&D to the extent of 2 percent of GDP. Further, the dataset employed for this study spans over two decades following the liberalization episode. The data availability for 20 years permits rigorous statistical analysis[2]. India, being a country with one of the largest number of listed firms in the world provides an ideal testing ground for validating the impact of financial constraints on R&D.

Second, we examine the impact of market collapse in the capital market on R&D investments. Specifically we consider the impact of two major market collapses witnessed during the study period. These shocks were the collapse of India's equity market in 1997 (Gopalan and

[2]Some of the recent studies such as Brown et al (2012) focus on the experience of listed firms in the US and European countries.

Gormley, 2013) and the recent financial crisis in 2008. By undertaking such an exercise, we contribute to a recent debate about the cyclicality of R&D (see Aghion et al 2012, Barlevy, 2007). Finally, we investigate the impact of ownership structure on cash-flow sensitivity by classifying the sample firms into group-affiliated, foreign, and stand-alone firms[3]. A unique feature of India's corporate ownership structure is the existence of business groups (Khanna and Yafeh 2007). It is often argued that business groups have internal capital markets that will reduce financing frictions. This warrants an in-depth analysis on the role of ownership structure of firms on financing choices of R&D.

The present paper is organized as follows. Section 2 provides the theoretical background and the relevant literature. Section 3 provides empirical specification and details of the estimation methods. Section 4 presents the data source and summary statistics. Section 5 discusses the key empirical results. Section 6 concludes.

2. Theoretical Underpinnings and Literature Review

The capital market imperfections are found to affect the investment decisions of a firm (Hubbard 1998). These imperfections arise due to the asymmetric information and agency problems between managers and investors (Stiglitz and Weiss 1981; Mayers and Majluf 1984). The net result is the difficulties in obtaining funds for investment in physical and intangible assets, especially in the case of financially constrained firms. In fact, the effect of financial constraints is more pronounced in the case of investments in R&D. The very nature of the R&D namely - riskiness, uncertainty, and absence of collateral together act as barrier for financing such projects (Hall and Lerner 2010). Further, Bhattacharya and Ritter (1983) emphasize that firms are hesitant to fund their R&D projects using external funds because of the possibility of disclosing the content of their innovation to the market. Therefore, the above-mentioned discussions point out that investment in R&D must be undertaken using the firm's internal financial resources.

Previous empirical studies examining the role of financial frictions in influencing R&D

[3] We follow CMIE classification of firms based on ownership. Foreign firms are those that are owned by foreigners including non resident Indians.

intensity of firms has tried to examine the sensitivity of R&D to financial factors. These studies employ the standard reduced form of accelerator models of investment (Fazzari et al. 1988, Bond et al. 1997) or Euler equations (Bond and Meghir 1994). In a seminal work, Hall (1992) examined the R&D behavior of US manufacturing firms. The study reports that cash flow is a significant variable influencing R&D investment. In the similar lines, Himmelberg and Petersen (1994) report the significance of internal funds for small firms in US belonging to high-tech sector. Mulkay et al (2001) show that cash flow appears to be more important in the US firms than in France in the case of R&D investment. Following the methodology of Himmelberg and Petersen (1994), a study of Italian high-tech firms by Ughetto (2008) report that internal cash flow matters significantly for R&D intensive firms. Mohnen et al (2008) using community innovation survey for Netherlands, find that due to the financial constraints, firms are forced to abandon the R&D projects. Bond et al. (2006), in their comparative analysis of UK and German firms find that, cash flow is important for undertaking R&D in the case of UK; whereas, German firms do not show any significant influence of internal funds. In a similar vein, Czarnitzki (2006) find that West German firms are sensitive to internal and external resources while there was no evidence of financial constraints for East German firms.

Bougheas et al. (2003) investigated the effect of financial constraints on the R&D investments of Irish firms. The findings of the study provide evidence that R&D investments in these firms are subject to financial constraints. Savignac (2008) study the experience of French firms and report evidence about the role of financing constraints in the decision to undertake innovative activities. Brown et al (2009) test the R&D cash flow sensitivity of publicly traded high-tech US firms. Their results show that young firms depend on cash flow or stock issues to fund the R&D investment. Martinsson (2010) finds a positive relation between both internal and external equity finance and R&D spending in the case of UK firms. In a recent study of the European firms, Brown et al (2012) report evidence of a significant relationship between the financial factors and R&D. The relationship is found to be particularly strong when they control for endogenous R&D smoothing by including change in the cash holdings and stock issues. The authors argue that the results of the previous studies (e.g., Haroff, 1998, Mulkay et al., 2001) may be biased due to the omitted variable problem.

A related strand of literature argues that affiliation to a business group enhances the R&D activities. Two reasons are cited in the literature for the positive role of business group affiliation on the R&D efforts. First, there is a greater possibility of internalizing the positive effects of R&D spillovers within the group (Blanchard et al. 2005). Second, it is argued that business group affiliation can mitigate the problem of asymmetric information and agency problem due to the functioning of internal capital markets. Therefore, business group affiliation can reduce the financial constraints through accessing external funds and through intra-group transfer of funds. Filatotchev et al (2003) based on a firm level data for Italy found that business group affiliation is positively associated with the R&D intensity. Similarly, Cefis et al (2009) using Italian firm level data, find that firms belonging to business groups make significant investments in R&D. Blanchard et al. (2005), based on a panel of French firms, R&D by the group companies enhances the productivity of the affiliates.

A recent set of studies have highlighted two important aspects of R&D investment, vis cyclicality and firm level smoothing of R&D expenditure. Cyclicality refers to the correlation between R&D investment and business cycle. There are two contrasting views about the cyclicality of the R&D. The first view goes back to Schumpeter who pointed out the R&D is counter-cyclical. This is because of the lower opportunity costs to innovate during recessions. Another strand of literature support pro-cyclicality of R&D (Ouyang 2011), i.e., R&D increases during booms and decreases during recessions. A recent study by Aghion et al (2012), argue that counter cyclicality of R&D fails to hold if the firm is unable to obtain external finance during shocks. During a bad (firm specific or economy wide) shock, firms should give priority to short-run capital investment over long term R&D investment as short term survival is necessary to reap any benefits from innovation. As liquidity shocks are correlated with illiquid equity market, the firm has to rely on its short-term earnings, borrowings, and cash reserves to fund investments. Firms with higher financing and credit constraints exhibit pro-cyclical behavior in R&D investment. Similarly, one should expect more aggressive R&D smoothing during periods of liquidity shocks. Regarding the issue of R&D smoothing, it is argued that firms are unlikely to undertake R&D investment if they are unable to sustain similar level of investment in future. This stems from the basic nature of R&D investment that it has "high adjustment costs" (Brown et al, 2012).

In the case of India, the literature on R&D has mainly focused on its relationship with technology imports (Katrak 1997; Kumar and Aggarwal 2005) and productivity (Sharma 2012). Most of the studies on technology imports and R&D report that latter is mainly adaptive in nature. The relationship between R&D and financial factors has not received much attention.

Based on the survey of the empirical literature, we find that the empirical evidence is inconclusive. The studies that find positive evidence of internal finance - R&D link is mostly for the U.S. firms. Therefore, the current study adds to the existing literature by providing new insights about the R&D - cash flow sensitivity of Indian firms during the period 1992 - 2011. Brown et al (2012) point out that failure to account for R&D smoothing and external financing may make the estimates downward biased. In this study, we address this concern by including control variables capturing R&D smoothing, external equity and debt financing.

3. Methodology

As mentioned in the previous section, a number of empirical studies have examined the relationship between financial factors and investment in capital assets. A popular approach to capture the relationship is the investment - cash flow sensitivity (ICFS), which measures the sensitivity of investments to the availability of internal funds. However, this method may be inappropriate for R&D investment due to a number of special characteristics specific to R&D as discussed in the previous section. Further, Kaplan and Zingales (1997) express doubt about the empirical validity of the ICFS. Whited (2000) point out that measurement error of Tobin's Q may lead to unreliable estimates. Therefore, we examine patterns of R&D investments by estimating the Euler model of investment, originally proposed by Bond and Meghir (1994) in their study of capital investments. As highlighted by Brown et al. (2009), the Euler method controls for the impact of expectation of future profitability on current investments and estimated coefficients of lagged or current financial variables can be interpreted in a more straightforward manner. Recently, Brown et al (2009) proposed the following transformed specification of the Euler investment equation to study R&D.

$$RD_{i,t} = \beta_1 RD_{i,t-1} + \beta_2 RD_{i,t-1}^2 + \beta_3 S_{i,t-1} + \beta_4 CF_{i,t-1} + d_t + \alpha_i + \vartheta_{i,t} \qquad (1)$$

where $RD_{i,t}$ is the research and development expenditure of the i^{th} firm at time period t. The terms $RD_{i,t-1}$and $RD_{i,t-1}^2$ are the lagged value and the quadratic term of R&D respectively. $S_{i,t-1}$ is the lagged value of sales. The financial variable is the lagged cash flow ($CF_{i,t-1}$). The above structural approach originally proposed by Bond and Meghir (1994) and improved by Bond et al (2003). In the above equation β_1 should be slightly larger than one, β_2 should be slightly less than negative one, and β_3 should be greater than zero[4]. Interestingly, the lagged cash flow variable ($CF_{i,t-1}$) is part of the specification even without financing constraints, but the expected value of the coefficient (β_4) is negative. The above equation includes firm effects (α_i) and time effects (d_t). Year dummies are expected to control for the time varying variables like tax rates and aggregate cost of capital.

In order to examine the role of financing constraints on R&D, Brown et al (2009) modified the above specification by including variables that capture both internal cash flow, external equity, and contemporaneous sales ($S_{i,t}$) as additional control variables. The modified specification is given below.

$$RD_{i,t} = \beta_1 RD_{i,t-1} + \beta_2 RD_{i,t-1}^2 + \beta_3 S_{i,t} + \beta_4 S_{i,t-1} + \beta_5 CF_{i,t} + \beta_6 CF_{i,t-1} + \beta_7 StkIssues_{i,t} + \beta_8 StkIssues_{i,t-1} + d_t + \alpha_i + \vartheta_{i,t} \quad (2)$$

where $StkIssues_{i,t}$ is the equity raised by the firm *i* during the year ending on *t*

As discussed earlier, Brown et al (2012) argue the need for controlling for R&D smoothing and debt financing by including variables such as change in cash holdings and debt issues. Further, in our final model (3), we include time dummies interacted with industry dummies that control for time dependent demand shocks at industry level[5]. We estimated the following model.

$$RD_{i,t} = \beta_1 RD_{i,t-1} + \beta_2 RD_{i,t-1}^2 + \beta_3 S_{i,t} + \beta_4 S_{i,t-1} + \beta_5 CF_{i,t} + \beta_6 CF_{i,t-1} + \beta_7 StkIssues_{i,t} + \beta_8 StkIssues_{i,t-1} + \beta_9 DbtIssues_{i,t} + \beta_{10} DbtIssues_{i,t-1} + \beta_{11} \Delta Cash\ Holdings_{i,t} + \beta_{12} \Delta Cash\ Holdings_{i,t_{i,t-1}} + \Sigma(d_t \alpha_i) + \vartheta_{i,t} \quad (3)$$

[4] For the detailed explanation, kindly refer to Bond and Meghir (1994).

[5] The similar approach was adapted by Duchin et al., 2010, Guariglia et al., 2011.

where $\Delta Cash\ Holdings_{i,t}$ is the change in cash and cash equivalents for firm i during the year ending on t, $DbtIssues_{i,t}$ is the net funds raised through debt securities by firm i during the period ending on t. In equation 3, $\Sigma(d_t \alpha_i)$ is a vector of dummy variables created by interacting time dummies with industry dummies. The firm effects ($\vartheta_{i,t}$) in the model control for all time-invariant determinants of R&D at the firm level.

We estimate the equation 3 using system GMM estimator developed by Blundell and Bond (1998) for estimating dynamic panel models. It addresses the potential endogeneity of financial variables included, by jointly estimating the equation both in differences and in levels. The system GMM estimator employs lagged levels of the variables as instruments for the regression in differences and lagged differences as instruments for the regression in levels. We primarily estimate one step system GMM and consider lagged levels (t-3 and t-4) of all independent variables as instruments for the regression in differences and lagged differences (t-2) as instruments for the regression in levels. The estimated standard errors are robust to the potential heteroskedasticity problem. To assess the presence of second order serial correlation in first differenced residuals we report p-value of M2 with the null hypothesis of no serial correlation. Further, we report p-values of Hansen J-test and Difference-in-Hansen test to investigate the validity of instruments.

4. Data Source and Sample Characteristics

The main data source for the present study is the PROWESS database provided by the Center for Monitoring Indian Economy. PROWESS provides information for over 20,000 firms belonging to manufacturing, services and other utilities. The firms included in the database accounts for 70 percent of the economic activity in the organized industrial sector and 75 percent of the corporate taxes (Goldberg et al. 2010). The database provides detailed firm level information regarding sales, R&D, exports, ownership, consumption of raw materials, and energy. Further, the dataset contains comprehensive information about the financial statements of firms such as total assets, current assets, total debt and liabilities. The information is mainly drawn from the annual reports and balance sheets of the firms. This database was previously employed by many firm level studies for analyzing the R&D investments (Sasidharan and Kathuria, 2011), testing financing constraints (Ghosh 2006), analyzing the performance of

business group firms (Khanna and Palepu, 2000), and examining impact of equity market collapse on firm financing (Gopalan and Gormley, 2013).

4.1 Sample Selection

We follow two recent studies (Brown et al 2009; 2012), in selecting our sample firms. First, we restrict our analysis to publicly traded firms belonging to the manufacturing sector. Second, we exclude firms that never reported a positive R&D expenses during the period 1991-2011. Further, we drop those firms that do not have at least one string of three uninterrupted R&D to assets observations during the period of analysis and at least six observations during the study period. Finally, we exclude firms if the sum of their cash flow to asset ratio over the sample period is less than zero[6]. The final sample consists of 5603 observations belonging to 315 R&D intensive firms. These firms account for more than 75 percent of the total R&D expenditure of all listed manufacturing firms[7]. We observe that chemical and pharmaceutical firms constitute more than 40 percent of the total observations (Appendix 1). The other major industries with more than 10% representation include automobile and machinery.

We focus on R&D intensive firms for various reasons. First, there is an increasing interest in how innovative firms finance their investments, and innovative firms are often characterized by high R&D. Second, high R&D firms are characterized by high investment opportunities, high information asymmetry, and agency problems. Investors may interpret external capital rising (instead of relying on internal funds) as a sign of overvalued equity (or) as a signal that mangers are anticipating disappointing earnings from its existing businesses (Myers and Majluf 1984). The more complex the business of the company, the more difficult and expensive it becomes to raise equity.

4.2 Summary Statistics

Since we selected the final sample through a rigorous screening process, it is important to identify the distinct features of the sample firms in comparison to the other listed firms. Table-1

[6]Allayannis and Mozumdar (2004) report that inclusion of firms with negative cash flow may lead to spurious results, since negative cash flow firms are financially distressed.
[7]There are more than 5000 listed manufacturing firms in India

provides summary statistics of R&D intensive and non-R&D firms[8]. We report all the regression variables as well as additional variables such as total assets, capital expenditure (Capex) and measures like Tobins Q and market leverage. The definition of all the variables included in the study is given in Appendix 2. All the variables are reported after scaling with total assets as employed in the regression analysis. We winsorize the variables at one and ninety nine percentile of their empirical distribution to eliminate the effect of extreme observations. We obtain similar results with trimming instead of winsorizing the data. From the table 1, we note that the mean R&D for the entire sample is 1.5 percent of total assets which is more than the estimates reported by studies from other emerging markets[9]. The final column in the table 1 provides p-values based on the t-test for the means and the Mann Whitney test for median, comparing the sample and non-R&D firms. We observe that the mean R&D for the sample firms is five times that of the non-R&D firms, where as the median value is eight times bigger than non- R&D firms. It is apparent that sample firms are more profitable and have better asset utilization ratio during the study period. These patterns may not support the popular perception that R&D intensive firms are small firms with a potential for future profits. This popular view may be true about unlisted firms; but listed R&D intensive firms have better profitability and revenue generating ability compared to firms that are not actively engaging in R&D. Further, R&D firms in our sample exhibit a lower leverage ratio and lower debt financing compared to non R&D firms. Though the proportion of equity issues as a percentage of external financing is more; the median values are not statistically significant. We find that mean cash holdings for the sample firms is 9.2 percent which is significantly higher than 7.1 percent observed in the case of matching firms. Two possible explanations can be made for the high value of the cash holdings. First, the excess cash holdings may provide liquidity and can be interpreted as negative debt that reduces financial risk as R&D intensive firms have lower tangible assets. Second, these firms may be building stocks of internal liquidity as that can be used to buffer R&D investment during negative shocks to internal finance (Brown et al 2009).

[8]non-R&D firms are selected following the same data requirement that of sample firms in order to avoid any bias that may arise during the sample selection process. Specifically, non R&D firms are listed manufacturing firms not forming part of R&D intensive firms. Further, we removed firms without at least one string of three uninterrupted sales to assets observations and at least six observations during the period 1993-2012.

[9]Crisostomo et al (2011) report that the mean R&D relative to sales is 0.41% In the case of Brazil.

Further, we classify the sample firms on the basis of the year of listing and asset size. Firms that are listed on stock exchanges after 1992 are classified as "young" firms and firms whose asset size is less than the median value for the corresponding year is considered as small. These young and small firms are expected to be financially constrained. From the table 2, we observe that young and large firms are more R&D intensive. However, the level of capital expenditure is similar across the sub-samples. Looking at the various sources of finance, the internal finance and stock issues are similar for young and mature firms. We notice that debt finance is more prevalent among Indian firms and young firms raise significantly more money through this route. Unlike the case of advanced economies like US, where new debt financing is nearly zero and equity financing is the preferred source, we observe opposite pattern in the case of Indian firms. Perhaps these contradicting results may be due to the fact that Indian financial system is predominantly bank based (Allen et al 2012) and firms do keep a high leverage level compared to their counterparts in US. The market leverage ratios are high for young and small firms; probably reflecting a poor market valuation of these firms as evidenced by the low Tobin's Q value.

A similar sub-sample analysis is carried out on the basis of ownership pattern (Table 3). In contrast to the positive effect of business group affiliation on the R&D intensity proposed by the previous studies, we find a lower value for R&D expenditure. In the case of foreign firms, we observe three interesting trends: (i) foreign firms are more profitable compared to the domestic firms as evidenced by the high cash flow ratio; (ii) they go for lower debt financing compared to other two sub-samples; and (iii) the liquidity is quite high as the stock of cash holdings is twice that of stand-alone firms. Table 4 presents the summary statistics during equity market phases. As expected, the equity market collapse is associated with lower capital expenditure, internal cash flow and equity financing. However, the figure supports the sticky nature of R&D investment as firms report similar numbers during equity market collapse.

5. Results and Discussions

In this section, we report the results of the empirical analysis. The empirical analysis addresses three broad questions. The first part of the analysis examines financial factors affecting R&D investment. We also perform sub-sample analysis based on the classification according to size and age that are supposed to be correlated with financial constraints. In the second part, we

test the hypothesis whether business group affiliation reduces the impact of financial factors on R&D investment. Finally, we explore the effect of financial market crisis and business cycles on R&D investment.

5.1 Full sample estimates

Table 5 presents the system GMM estimates for the R&D intensive firms with various specifications by including the financing variables to the base line model. We find persistence in R&D in all our specifications since the sample estimates for lagged R&D is positive and slightly larger than one and lagged quadratic R&D is negative. In these specifications, the *p* value for the m1 statistic indicates first order serial correlation but the *p* value for the m2 cannot reject the null hypothesis of no second-order autocorrelation. In the Column 1, we provide the estimates of baseline Euler model with no financing variable. The expected negative coefficient for lagged cash flow is not observed in the case of the sample firms.

Further, we augment the base model by including financing variables such as contemporaneous cash flow as a measure of internal funds, stock issues, debt issues, and change in cash holdings. In column 2, current year cash flow is entering in the model significantly with a value of 0.04; the sum of the cash flow coefficients (0.0187) is also statistically significant. The results indicate a strong impact of internal finance on R&D. Our subsequent results indicate that the inclusion of additional financing variables results in a rise in the sum of the estimated cash flow coefficients from as much as 0.0187 to 0.026. Our results support Brown et al (2012) who pointed out that not controlling for cash flow smoothing and external financing may underestimate the investment cash flow sensitivity.

The results in the column 3-5 indicate that external financing in the form of debt or equity is not significantly affecting R&D investment. The results are not surprising given the fact that external equity is not a popular option among the Indian firms in financing R&D[10]. Further, we do not observe evidence of active R&D smoothing using cash holdings. One of the major reason for such a finding is the lower level of liquidity maintained by the Indian firms. The average cash

[10] From table 1, it is evident that the mean (median) stock issues to total assets of Indian firms is 0.018 (0.00) in comparison with the 0.204 (0.006) as reported in the case of US firms (Brown et al., 2009) and 0.108 (0.00) for the European firms (Brown et al., 2012).

holding of our sample firms as a percentage of total assets is 9.2 percent as against 22.3 percent for the European firms (Brown et al., 2012).

5.2 Sample Splits: Age and Size

It is apparent from the literature discussed previously that we should expect a stronger link between R&D investment and financing variables among the group of firms that are most likely to be financially constrained. In other words, the magnitude of the estimated cash flow coefficient should be higher for these categories of firms. Hadlock and Pierce (2010) suggested that age and size are the two most significant variables reflecting the existence of financial constraints. Therefore, we categorize the sample firms into young and mature based on the year of listing on a major stock exchange in India. Young firm observations belong to firms that are listed on stock exchanges after 1992.

We classify firm observation as 'large' if it belongs to a firm whose value of assets is above that of the median of the sample firms during that year. Observations belonging to firms with total assets less than the median asset value of the sample firms in a year are classified as 'small'. It is often cited that small firms encounter higher information asymmetry, floatation costs for equity and thereby encounter higher financial constraints.

The results of the sub-sample analysis are reported in Table 6. For brevity, we present the sum of the financial coefficients only. Along the expected lines, the estimated coefficients for financial factors are large for the constrained group. Further, the coefficients of the lagged R&D are smaller (in absolute value) for this group. However, in contrast to the results from the developed markets, we observe that large firms are involved in cash flow smoothing. The sum of the coefficients on Δ cash holdings is negative and significant in case of large and mature firms. The magnitude of the coefficient is -0.011 for large firms which is negligible compared to -0.14 as reported in the case of pooled European sample firms (Brown et al., 2012).

5.3 Ownership and Financial Constraints

In table 7, we provide results from sub-samples based on ownership. The sample firms are classified into business group affiliated, stand alone, and foreign firms. As mentioned earlier,

one should expect lower cash flow sensitivity for business group and foreign firms. In India, business group affiliation can ameliorate the potential financial constraints due to the functioning of the internal capital market (Khanna and Yafeh 2007). Foreign firms in our sample are generally subsidiaries of MNCs which have deep pockets to support the investment needs of the affiliates. Therefore, we expect lower coefficients for the cash flow variables for business group affiliates and foreign firms.

We find only marginal difference in the case of estimated coefficients for the sum of cash flows in the case of business group affiliates compared to stand alone firms. This result cast doubt about the existence of internal capital markets and fund transfer among business group affiliates. A recent study by George et al (2011) using Indian dataset reported similar results for capital investments. Interestingly, investment in R&D by foreign firms are unaffected by internal finance. Therefore, among the three categories of firms included in the sample, we observe that foreign firms are able to reduce the agency and information problems and are least financially constrained.

5.4 Market liquidity and financial constraints

To add to the recent debate on the cyclicality of the R&D investment, we investigate the effect of stock market liquidity on R&D investment. As discussed earlier, we identified two time periods during our study period when Indian equity market was inactive. The result from this analysis presented in Table 8, indicate the investment cash flow sensitivity is lower and insignificant during the inactive phase of the business cycle. This complements the evidence reported in table - 4. From table – 4, it is evident that sample firms incur similar R&D expenditure during inactive market face even though their profitability and external financing have declined sharply. The present findings are in consonance with the view that R&D investment opportunities are counter cyclical and innovative firms may find it indispensible to carry out R&D investment during market downturns.

6. Conclusions

The present study is an attempt to unravel the financing of R&D by the listed firms in India by using dynamic R&D investment models. We find a significant relationship between internal finance and R&D expenditure. Our results are robust to inclusion of control variables

like stock issues, debt issues, and change in cash holdings. We do not find any significant relationship between both forms of external financing viz debt and equity and R&D. Therefore, the present results undermine the importance of external equity financing in financing R&D in India, even though the same is highlighted by previous studies from U.S. and Europe. In contrast to the recent results from US market (Brown et al 2012), we do not find pattern of R&D smoothing even during periods of economic shocks.

The evidence about the absence of external capital market to finance R&D and firms' inability to build and utilize liquidity to finance R&D during economic downturns may be hampering the R&D investments in emerging markets like India. Perhaps, the extremely low level of R&D investment observed among our sample firms may be partly explained by the above factors. A major concern for the policy makers may be the finding that small and young firms are facing financing constraints even during periods when R&D is supposed to be most productive.

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Table 1. Summary Statistics: Sample Firms Vs Matching Firms

Variable and Statistic	R&D Intensive	Matching Firms	P value
Capex/TA			
Mean	0.084	0.084	0.667
Median	0.051	0.036	0.000
R&D/TA			
Mean	0.015	0.003	0.000
Median	0.008	0.001	0.000
Sales/TA			
Mean	1.205	1.135	0.000
Median	1.110	0.967	0.000
CF/TA			
Mean	0.125	0.079	0.000
Median	0.115	0.071	0.000
Stock issue/TA			
Mean	0.018	0.020	0.141
Median	0.000	0.000	0.391
Debt issues/TA			
Mean	0.041	0.054	0.000
Median	0.015	0.022	0.000
Proportion of stock issue			
Mean	0.145	0.114	0.004
Median	0.000	0.000	0.296
Cash holdings/TA			
Mean	0.092	0.071	0.000
Median	0.045	0.033	0.000
Q			
Mean	1.643	1.160	0.000
Median	1.200	0.970	0.000
MLEV			
Mean	0.382	0.516	0.000
Median	0.350	0.532	0.000
Total Assets			
Mean	693	475	0.000
Median	157	67	0.000
Number	5603	15578	

Table reports the summary statistics of the sample firms and their matched counterparts. Matched firms are listed manufacturing firms not forming part of R&D intensive firms. Further, we removed firms without at least one string of three uninterrupted sales to assets observations and at least six observations during the study period 1993 – 2012. All the variables included are winsorized at one as well as at ninety nine percentile to eliminate the effect of extreme values. We employ paired t-test and Mann Whitney test to statistically validate the mean and median differences respectively. The definition of variables is provided in Appendix – 2

Table 2. Summary Statistics: Sample Splits by Age and Size

Variable		Age		Size	
		Mature firms	Young firms	Small	Large
Capex/TA	Mean	0.083	0.086	0.074	0.085
	Median	0.051	0.054	0.041	0.055
R&D/TA	Mean	0.013	0.021	0.013	0.018
	Median	0.008	0.011	0.006	0.010
Sales/TA	Mean	1.264	1.060	1.167	1.208
	Median	1.171	0.984	1.060	1.087
CF/TA	Mean	0.125	0.124	0.099	0.150
	Median	0.117	0.109	0.093	0.133
Stock issue/TA	Mean	0.017	0.018	0.015	0.017
	Median	0.000	0.000	0.000	0.000
Debt issues/TA	Mean	0.035	0.057	0.034	0.040
	Median	0.010	0.027	0.015	0.009
Cash holdings/TA	Mean	0.092	0.090	0.069	0.121
	Median	0.048	0.040	0.032	0.069
Δ Cash holdings/TA	Mean	0.004	0.001	0.001	0.005
	Median	0.000	-0.001	0.000	0.000
Q	Mean	1.730	1.439	1.185	2.230
	Median	1.258	1.064	0.994	1.648
Pro. of stock issue	Mean	0.135	0.170	0.097	0.158
	Median	0.000	0.000	0.000	0.000
MLEV	Mean	0.371	0.408	0.463	0.283
	Median	0.331	0.387	0.477	0.193
Total Assets	Mean	754	549	38	2225
	Median	168	125	23	872
N		3923	1680	1266	1367

Table provides the summary statistics of the sample firms classified based on their age and size. Sample firms that listed after 1992 are classified as 'young' firms and remaining are considered as 'mature' firms. The value of firms' total assets is considered as the measure of the size. Firms with less than median asset value in a corresponding year are considered as 'small' firms. All the variables included are winsorized at one as well as at ninety nine percentile to eliminate the effect of extreme values. The definition of variables are given in the Appendix – 2

Table 3. Summary Statistics of sample observations classified based on their ownership

		BG firms	Indian stand-alone	Foreign firms
Capex/TA	Mean	0.0873	0.0884	0.0756
	Median	0.0541	0.0576	0.0449
R&D/TA	Mean	0.0148	0.0171	0.0138
	Median	0.0081	0.0090	0.0088
Sales/TA	Mean	1.1866	1.1545	1.3676
	Median	1.0807	1.0519	1.3135
CF/TA	Mean	0.1231	0.1154	0.1525
	Median	0.1131	0.0999	0.1501
Stkissues/TA	Mean	0.0174	0.0177	0.0191
	Median	0.0000	0.0000	0.0000
Debt issues/TA	Mean	0.0429	0.0540	0.0236
	Median	0.0177	0.0284	0.0000
Cash holdings/TA	Mean	0.0858	0.0698	0.1432
	Median	0.0449	0.0334	0.0813
Δ Cash holdings/TA	Mean	0.0028	-0.0020	0.0101
	Median	-0.0004	-0.0004	0.0028
Q	Mean	1.6324	1.2260	2.5154
	Median	1.1994	1.0063	1.9379
Pro. of stock issue	Mean	0.1427	0.1355	0.2100
	Median	0.0000	0.0000	0.0000
MLEV	Mean	0.4021	0.4542	0.1884
	Median	0.3780	0.4640	0.1037
Total assets	Mean	785	187	836
	Median	239	49	244
N		3,137	1,467	1,160

Table provides the summary statistics of the sample firms classified based on the their ownership. We consider the PROWESS classification of firms into business group affiliated, standard alone and firms with foreign origin. All the variables included are winsorized at one as well as at ninety nine percentile to eliminate the effect of extreme values. The description of variables is provided in Appendix – 2

Table 4. Summary Statistics of sample observations classified as active and inactive equity market periods

		Active equity market					Inactive market				
Variable		All	Mature	Young	Small	Large	All	Mature	Young	Small	Large
Capex/TA	Mean	0.094	0.091	0.101	0.090	0.097	0.076	0.075	0.077	0.072	0.079
	Median	0.058	0.055	0.067	0.052	0.062	0.047	0.048	0.045	0.043	0.051
R&D/TA	Mean	0.016	0.013	0.023	0.015	0.017	0.015	0.012	0.019	0.014	0.015
	Median	0.008	0.008	0.012	0.008	0.008	0.008	0.008	0.010	0.008	0.009
Sales/TA	Mean	1.291	1.338	1.138	1.295	1.289	1.127	1.187	1.010	1.119	1.136
	Median	1.204	1.252	1.062	1.190	1.215	1.029	1.081	0.928	1.037	1.020
CF/TA	Mean	0.135	0.133	0.142	0.123	0.146	0.116	0.117	0.112	0.098	0.133
	Median	0.125	0.125	0.123	0.110	0.137	0.105	0.108	0.100	0.089	0.120
Stock issue/TA	Mean	0.024	0.024	0.023	0.024	0.024	0.012	0.010	0.015	0.012	0.012
	Median	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Debt issues/TA	Mean	0.050	0.042	0.075	0.050	0.050	0.034	0.028	0.045	0.033	0.034
	Median	0.019	0.016	0.030	0.024	0.016	0.011	0.006	0.024	0.015	0.009
Cash holdings/TA	Mean	0.096	0.093	0.104	0.082	0.107	0.088	0.092	0.081	0.076	0.100
	Median	0.049	0.050	0.046	0.041	0.057	0.043	0.046	0.036	0.035	0.049
Δ Cash holdings/TA	Mean	0.007	0.007	0.005	0.007	0.006	0.000	0.000	-0.001	-0.001	0.001
	Median	0.001	0.001	0.001	0.001	0.001	-0.001	-0.001	-0.001	0.000	-0.002
Q	Mean	1.848	1.910	1.670	1.570	2.100	1.448	1.538	1.274	1.127	1.763
	Median	1.397	1.451	1.288	1.240	1.610	1.027	1.059	0.978	0.943	1.177
Proportion of stock issue	Mean	0.171	0.170	0.174	0.146	0.193	0.122	0.099	0.167	0.102	0.142
	Median	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MLEV	Mean	0.329	0.325	0.340	0.376	0.287	0.434	0.421	0.456	0.489	0.379
	Median	0.284	0.279	0.295	0.345	0.234	0.444	0.416	0.478	0.510	0.345
Total Assets	Mean	479	503	409	67	851	896	1023	649	126	1653
	Median	121	122	117	42	335	201	237	130	65	542
N		2732	2031	701	1296	1436	2871	1892	979	1424	1447

Table provides the summary statistics of sample firms, subdivided based on the activity in Indian equity market.

Table 5. Dynamic R&D Regressions

	1	2	3	4	5
R&D_t-1	1.071***	1.018***	0.943***	0.909***	0.817***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
R&D_sqr_t-1	-2.827**	-2.277**	-1.680	-1.394*	-1.289
	(0.026)	(0.048)	(0.114)	(0.073)	(0.118)
Sales_t		0.002	0.001	-0.002	-0.001
		(0.376)	(0.601)	(0.235)	(0.578)
Sales_t-1	-0.002**	-0.004*	-0.004*	-0.001	0.000
	(0.027)	(0.074)	(0.070)	(0.663)	(0.781)
CF_t		0.044***	0.048***	0.059***	0.059***
		(0.000)	(0.000)	(0.000)	(0.000)
CF_t-1	0.001	-0.025***	-0.026***	-0.035***	-0.033***
	(0.858)	(0.001)	(0.000)	(0.000)	(0.000)
Stk_t			0.006	0.003	0.001
			(0.569)	(0.692)	(0.930)
Stk_t-1			0.002	-0.001	0.000
			(0.825)	(0.846)	(0.994)
debt_issue_t				0.012***	0.010***
				(0.001)	(0.006)
debt_issue_t-1				-0.009***	-0.009***
				(0.001)	(0.009)
ΔCash_holdings_t				-0.002	-0.003
				(0.797)	(0.651)
ΔCash_holdings_t-1				-0.006	-0.007
				(0.114)	(0.180)
Time dummies	Yes	Yes	Yes	Yes	
Time* Industry Dummy					Yes
M1	0.000	0.000	0.000	0.000	0.000
M2	0.122	0.081	0.071	0.181	0.451
Sum of CF (p-value)		**0.001**	**0.000**	**0.000**	**0.001**
Sum of stk issue (p-value)			0.558	0.898	0.962
Sum of debt issue (p-value)				0.563	0.797
sum of ΔCash (p-value)				0.210	0.207
Hansen-test (p-value)	1.000	1.000	1.000	1.000	1.000
Diff-Hansen (p-value)	0.079	1.000	0.751	1.000	0.271
Observations	3665	3665	3665	3261	3261

***,**, and * refer to 1%, 5%, and 10% significance level.

Table presents the findings from estimating equation (3) using one step system GMM. We considered third and fourth lag of all the independent variables as the potential instruments. The numbers in the parenthesis are corresponding p-values. The definition of variables is provided in Appendix – 2.

Table 6. Dynamic R&D Regressions: Sample Splits by Age and Size

	Age		Size	
	Young	Mature	Small	Large
R&D_t-1	0.746***	0.861***	0.723***	0.878***
	(0.000)	(0.000)	(0.000)	(0.000)
R&D_sqr_t-1	-0.140	-2.145*	-1.459	-1.083*
	(0.521)	(0.078)	(0.174)	(0.086)
Sales_t	0.002	0.000	-0.001	0.004
	(0.521)	(0.862)	(0.415)	(0.116)
Sales_t-1	-0.003	-0.001	-0.001	-0.004
	(0.109)	(0.522)	(0.406)	(0.033)
Dummy (Industry* Time)	Yes	Yes	Yes	Yes
M1	0.000	0.000	0.000	0.000
M2	0.905	0.453	0.830	0.113
Sum of CF	0.034***	0.022***	0.042***	0.023***
	(0.000)	(0.000)	(0.000)	(0.000)
Sum of stk issue	-0.009	0.007	-0.008	0.006
	(0.462)	(0.538)	(0.469)	(0.460)
Sum of debt issue	0.003	0.001	0.001	0.005
	(0.550)	(0.769)	(0.854)	(0.275)
sum of ΔCash	-0.016	-0.015**	-0.016	-0.011*
	(0.144)	(0.013)	(0.105)	(0.065)
Hansen-test (p-value)	0.905	1.000	1.000	1.000
Diff-Hansen (p-value)	0.905	0.907	1.000	1.000
Observations	933	2328	1427	1834

***,**, and * refer to 1%, 5%, and 10% significance level.

Table presents the findings from estimating equation (3) employing one step system GMM. We considered third and fourth lag of all the independent variables as the potential instruments. The presented results are computed considered the subsamples classified based on their age and size. The numbers in the parenthesis are corresponding p-values. The definition of variables is provided in Appendix – 2

Table 7. Dynamic R&D Regressions: Sample Splits by Ownership Group

	BG firms	Stand-alone	Foreign
R&D_t-1	0.771***	0.786***	0.88***7
	(0.000)	(0.000)	(0.000)
R&D_sqr_t-1	-0.883	-1.043	0.312
	(0.293)	(0.307)	(0.763)
Sales_t	0.001	-0.003	0.005
	(0.764)	(0.223)	(0.021)
Sales_t-1	-0.002	0.001	-0.005
	(0.334)	(0.751)	(0.045)
Dummy (Time*Industry)	Yes	Yes	Yes
M1	0.000	0.000	0.000
M2	0.760	0.893	0.244
Sum of CF	0.031***	0.037***	0.003
	(0.000)	(0.000)	(0.353)
Sum of stock issue	0.006	-0.023**	0.000
	(0.557)	(0.028)	(0.993)
Sum of debt issue	0.006	-0.009*	0.005
	(0.188)	(0.053)	(0.434)
Sum of ΔCash	-0.021***	-0.025*	-0.004
	(0.006)	(0.067)	(0.563)
Hansen-test (p-value)	1.000	1.000	1.000
Diff-Hansen (p-value)	1.000	1.000	1.000
Observations	1844	864	620

***,**, and * refer to 1%, 5%, and 10% significance level.

Table presents the findings from estimating equation (3) employing one step system GMM. We considered third and fourth lag of all the independent variables as the potential instruments. The presented results are computed considered the subsamples classified based on the type of their ownership. The numbers in the parenthesis are corresponding p-values. The definition of variables is provided in Appendix – 2

Table 8. Dynamic R&D Regressions: Sample Splits by Market Phase

	All	Active	Inactive
R&D_t-1	0.817***	0.849***	0.716***
	(0.000)	(0.000)	(0.000)
R&D_sqr_t-1	-1.289	-2.528	-0.468
	(0.118)	(0.230)	(0.700)
Sales_t	-0.001	0.000	-0.002
	(0.578)	(0.892)	(0.353)
Sales_t-1	0.000	-0.005*	0.003
	(0.781)	(0.081)	(0.120)
Dummy (Industry* Time)	Yes	Yes	Yes
M1	0.000	0.293	0.000
M2	0.451	0.730	0.484
Sum of CF	0.025***	0.044***	0.012
	(0.001)	(0.001)	(0.123)
Sum of stock issue	0.001	0.002	0.005
	(0.962)	(0.932)	(0.699)
Sum of debt issue	0.001	0.001	-0.002
	(0.797)	(0.898)	(0.773)
Sum of ΔCash	-0.010	-0.002	-0.012
	(0.207)	(0.884)	(0.125)
Hansen-test (p-value)	1.000	1.000	1.000
Diff-Hansen (p-value)	0.271	1.000	0.042
Observations	3261	1308	1953

***,**, and * refer to 1%, 5%, and 10% significance level.

Table presents the findings from estimating equation (3) employing one step system GMM. We considered third and fourth lag of all the independent variables as the potential instruments. The presented results are computed considered the subsamples, divided based the phase on the active and inactive phases of Indian equity market. The numbers in the parenthesis are corresponding p-values. The definition of variables is provided in Appendix – 2

Appendix 1. Sample distribution by industry classification

No	Industry	No. of observations	No. of firms
1	Food and Beverages	206	12
2	Chemicals	1,256	69
3	Pharmaceuticals	1,123	70
4	Rubber and plastic products	304	16
5	Non matallics	168	9
6	Basic metals	195	10
7	Electronics and Computer hardware	206	14
8	Electricals	405	21
9	Machinery	782	41
10	Automobiles	836	46
11	Diversified	122	7
	Total	**5603**	**315**

Appendix 2. Description of Variables

$R\&D_t$: Research and Development expenditure for the period ending on t normalized by the beginning of the period book value of assets. This data field provides the total outlay of the company on research and development during the year and it is the sum of both capital and current expenditure. Prowess database obtain this information from the annexure to the director's report. Research and development expenses information is mostly furnished by manufacturing companies and its disclosure is mandatory as per section 217 of the Companies Act. If this data field is missing, current expenses on research and development incurred and reported by the company in the profit and loss statements or in the schedules forming a part of the profit and loss statements is considered.

$Sales_t$: Net sales for the period ending on t normalized by the beginning of the period book value of assets.

$Capex_t$: Capital expenditure in period t (defined as change in Net Fixed Assets (NFA) plus Depreciation and Amortization) divided by the beginning of the period book value of assets.

$Cash\ flow_t$: Cash flow during the period t divided by the beginning of the period book value of assets where cash flow is defined as profit after tax plus depreciation and amortization plus research and development expense.

$Stock\ issues_t$: Net stock issues during the period t divided by the beginning of the period book value of assets, where net stock issues are defined as change in stockholders' equity (net worth) less change in cumulative retained earnings

$Debt\ issues_t$: Net debt financing during period t divided by the beginning of the period book value of assets, where net debt financing equal to the change in borrowings

Proportion of stock issue : Stock issue / (stock issue + debt issue)

Appendix 3. Annual Average R&D Expenditure and Capital Expenditure of the sample firms across the study period

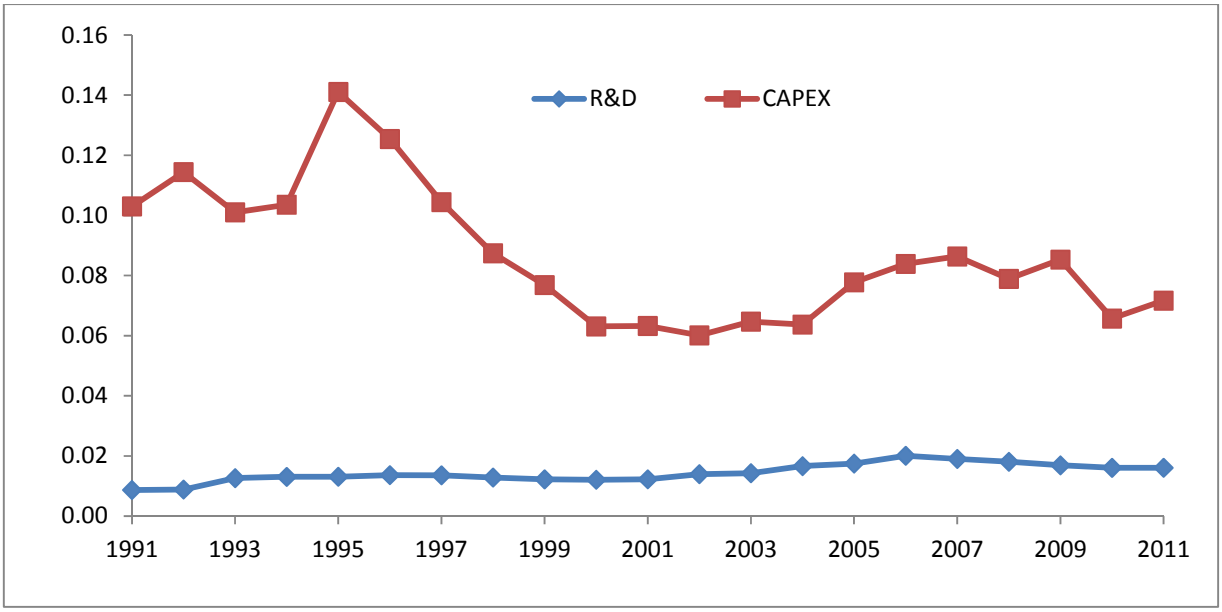

Figure plots the sample firms annual average R&D and Capital expenditure across the study period. Both the variables are scaled by their beginning of the year assets.

Appendix 4. Aggregate R&D Investment by all listed firms Vs Sample firms across the study period

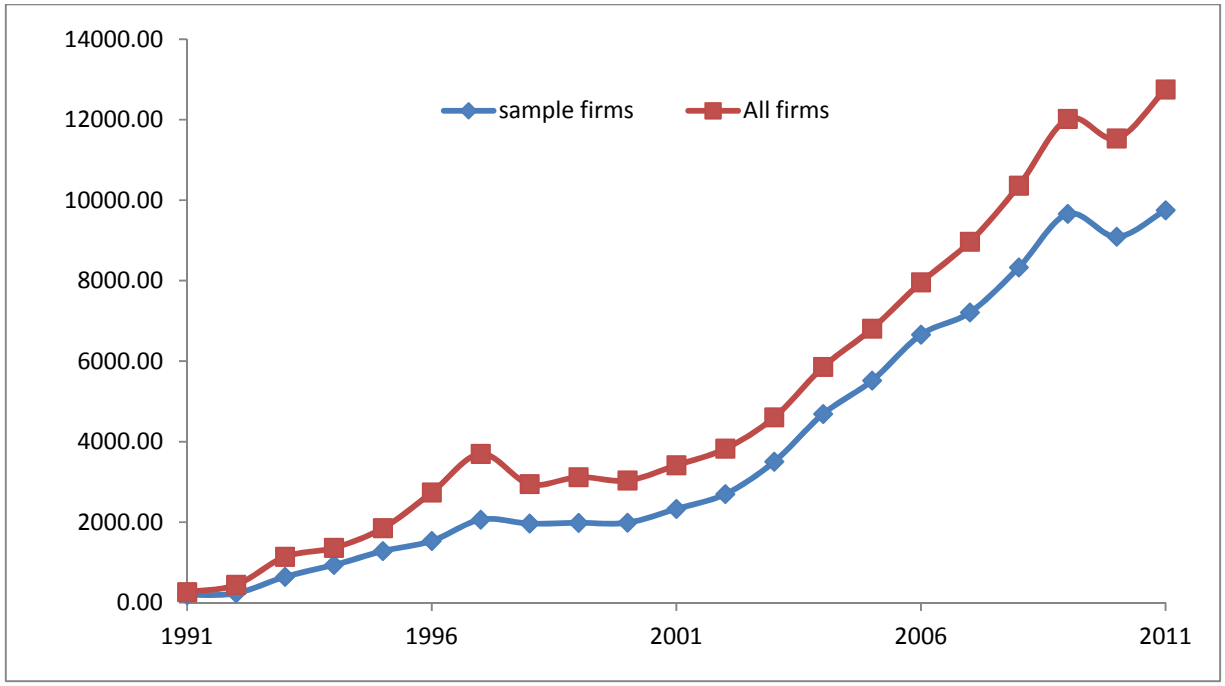

Figure plots the sample firms' as well as all the listed manufacturing firms' R&D investment during the study period. Firms' R&D investment values are presented at 2011 prices and they are in Rupee crores (one crore equal to 10 million).