The Impact of RD and Foreign Direct Investment on Firm Growth in Emerging-Developing Countries: Evidence from Indian Manufacturing Industries

Adamos Adamou
adamos@ucy.ac.cy

and

Subash S
subash@mse.ac.in

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MADRAS SCHOOL OF ECONOMICS
Gandhi Mandapam Road
Chennai 600 025
India

Phone: 2230 0304/ 2230 0307/2235 2157
Fax : 2235 4847 /2235 2155
Email : info@mse.ac.in
Website: www.mse.ac.in

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Abstract

This paper examines the impact of R&D and FDI on firm growth for a panel data of Indian manufacturing firms. We argue that besides age and size, FDI and R&D are essential determinants of firm growth. We use GMM estimation for fixed effects panel data models to control for endogenity of R&D and FDI. We find that an increase in current R&D induces higher growth across all industries; where as the effect of increase in FDI is mixed - higher growth in some industries and lower growth in some others. Furthermore, Gibrat's law is not only rejected by our main model but it is also rejected by a unit root test for unbalanced panel datasets. This provides strong evidence in favor of our model. Finally, firm growth is negatively associated with its size and it is convex with respect to its age. The fact that firm growth is not diminishing convex – but just convex – with respect to age, contradicts the Jovanovic's argument that younger firms tend to grow faster than their older counterparts. With respect to firm growth, the absence of learning-effects appears to be the main difference between emerging-developing and developed countries.

Keywords: R&D; foreign direct investment; panel data; firm growth

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1. INTRODUCTION

The widespread interest in the studies on firm growth (Gibrat's law) can be attributed to the emergence of rigorous theoretical models related to the firm dynamics in the literature on industrial organization. Earlier attempts at verifying the Gibrat's law considered only size or age as its determinants (Evans 1987a, 1987b). Subsequent studies highlighted the role of other firm specific factors like ownership structure and human capital. Very recently, the literature has started to explore the possibility of including new set of variables like R&D and foreign direct investment (FDI) as determinants of firm growth. Generally, empirical research on firm level data has revealed substantial heterogeneity between firms, and, therefore the above two variables are included in the empirical model of firm growth in recent times. Moreover, the availability of large scale panel data has made the task of the researchers relatively easy. At the same time, they are however, confronted with more complex issues related to the dynamics of firm growth. Taking into account the above outlined theoretical and empirical contributions, the objective of the present paper is to understand the role of FDI and R&D in determining the firm growth in Indian manufacturing industries**.** Therefore, we apply an extension of the Evans model by augmenting with R&D and FDI variables.

Until recently, the literature on firm growth did not include both the R&D and the FDI variables together, as determinants of firm growth. We were able to find only two papers (Dimelis 2005; Fotopoulos and Louri 2004) which use FDI as a determinant of firm growth. However, neither of them of has tried to capture the innovation effects through R&D intensity. In addition, both these papers impose the assumption that FDI has the same impact on firm growth for all the industries. We relax this restrictive assumption in order to allow for variation of the impact of FDI on firm size growth for each industry.

The selection of India for the present study was made for many reasons. India belongs to the category of newly industrialized countries (NICs) which contains countries that have outpaced their newly industrialized world counterparts, in a macroeconomic sense. During the early nineties following severe economic crisis, several liberalisation measures was undertaken. It included deregulation of Industries and special policies to attract foreign direct investment. Since then India has become one of the major destinations of multinational firms and it is one of the highest recipients of FDI inflows in the Asian region. At present, FDI is allowed up to 100% in most of the sectors except for the reserved list of small scale industries and strategic sectors. The present paper is organised as follows. Section 2 presents the theoretical framework. In section 3, formulation of the model is presented. Section 4 is devoted to explain the data along with summary statistics. Section 5 deals with the discussion of the results. In 6, concluding observations are outlined.

2. THEORETICAL UNDERPINNINGS

Gibrat's law or *Law of Proportionate Effect* states that the firm growth and size is independent. In the words of Mansfield (1962), "*probability of a given proportionate change in size during a specified period is the same for all firms in a given industry regardless of their size at the beginning of the period*". There exists a vast literature on firm

growth and the determinants of the same. A number of surveys of literature on the empirical studies on firm growth has appeared in recent years (Sutton 1997, Caves 1997). Early empirical studies have attempted to verify the Gibrat's law and have found evidence in support of the law (Hart and Prais 1956; Simon and Bonini 1958). Earlier studies consider firm size as the only influential factor in determining the firm growth. The empirical examination of other factors like R&D, finance, FDI in determining firm performance has been undertaken only recently. However, some of the recent studies have found Gibrat's law does not operate in the case of new and small firms (Sutton 1997). The lack of consensus among the results of the different studies can be attributed to the differences in the type of data (firm/plant) as well as the institutional environment.

Jovanovic (1982), in a seminal paper developed an optimizing model of firm behaviour which is now popularly known in the literature as "passive learning model" of firm growth. The model considers firm growth as a function of efficiency. According to Jovanovic's model a new entrant is unaware of the distribution of productivity shocks. In each period, the firms observe the efficiency and costs. As a result, firms which are inefficient will exit the market. Therefore, the final outcome as per the model is that the young and small firms are likely to grow faster.

Following Jovanovic's work, Pakes and Ericson (1998) developed a formal model of firm growth with "active learning". In this model, firms are aware of the productivity distribution shocks. Contrary to Jovanovic's model, Pakes and Ericson emphasised the importance of learning by undertaking innovative activities R&D. Each firm has two options: to continue production or exit from the industry. It has to decide upon how much to be invested in the R&D, if it wants to continue in the industry. The firms try to maximize the expected net cash flows. Over a period of time the difference between initial size and present size of the firm tend to diminish. The authors also provide empirical support of their model in the paper.

Klette and Griliches (2000) construct a quality ladder model to incorporate firm growth and R&D. In their model firms are characterized by product differentiation. They compete among themselves to improve the quality of the product through cumulative innovations by investing in R&D. The rival firms also invest in R&D by paying a sunk cost. The incentive to invest in R&D is due to the increased profits as a result of the improvement in product quality.

Along these lines, one set of literature has attempted to analyze the impact of R&D on firm growth. Hall (1987) tested for Gibrat's law on a sample of 1778 publicly traded manufacturing firms in the U.S. The empirical analysis was carried out for two sub-periods 1973-79 and 1976-83. The study corrected for the sample selection bias inherent in the firm growth regressions by estimating survival and growth equations in a two stage approach using maximum likelihood estimation (MLE) method. In addition to the analysis of firm size on growth, the study also investigated the role of R&D on the growth and survival of firms. The findings of the study clearly emphasise the positive effect of R&D on firm growth and survival.

Amirkhalkhali and Mukhopadhyay (1993) tested Gibrat's law for a sample of 231 US manufacturing firms during 1965-87. The main objective of the study was to examine the size-growth relationship and the distribution of firms according to the R&D intensity. The findings of the study indicate a positive relationship between R&D and firm growth.

Yang and Hung (2005) investigated the impact of R&D and size on firm growth of Taiwanese electronics industry. The study was based on a balanced panel data set of 3459 firms for the period 1992-1998. In the light of recent theoretical developments, the endogenity of R&D was controlled using generalized method of moments estimation (GMM) procedure. The empirical results reveal a strong positive effect of R&D (R&D/Sales) on firm growth.

Nurmi (2004) analysed the firm growth in Finnish manufacturing firms using an unbalanced panel data for the period 1981-1994. The study found that R&D has a positive effect on firm growth. However, the study did not attempt to endogenize the R&D variable as emphasized by the recent theoretical literature.

Yasuda (2005) investigated the impact of R&D on employment growth based on a sample of 14000 Japanese manufacturing firms. The firms are observed during two periods namely 1992 and 1998. He found that age and size is negatively related to growth. The positive effect on growth was found when the analysis was extended to a sub-sample of R&D spenders.

With regard to the Indian experience, there are not many studies which examined the relationship between firm size and growth. One study is based on a case of computer hardware industry (Das 1995), while the other focuses on manufacturing industries (Bhaduri and Shanmugham 2002). These studies have mainly attempted to analyse the firm size, age and growth relation. Unlike the previous studies on India, the purpose of the present analysis is to take a step further by including the role of R&D and FDI, besides age and size in determining firm growth. Generally, most of the studies on firm growth suffer from the problem of heterogeneity. Since the present analysis is based on an unbalanced panel data, heterogeneity problem can be controlled.

FDI and Firm Growth

In this sub-section, we attempt to explain the spillover effects of foreign direct investment (FDI) and its effect on the firm growth, followed by a brief review of related studies. The role of FDI in promoting industrial development in the host country is increasingly recognized. Of late, most of the fast growing developing economies like India, China, Brazil and other fast growing developing economies have devised special policies to attract foreign direct investment. The basis for such practice is based on the fact that foreign firms are carriers of superior technology and organizational practices (Dunning 1993). Increasingly, it has been found that foreign firms are undertaking research activities in developing countries (Kumar 2001). Therefore, the presence of foreign firms can benefit the domestic firms through learning and spillover mechanism. The above argument has been subjected to rigorous theoretical and empirical testing. Therefore, we expect that the superior firm specific

advantages of the foreign firms may be transmitted to the domestic firms through spillovers.

Large number of studies has appeared about the possible channels of spillovers effects (Smeets 2008; Gorg and Greenaway 2004 for an extensive review of literature). From the existing literature on FDI and technology transfer, we are able to identify four main channels of spillover effects. *Demonstration effect*-The entry of foreign firms may lead to introduction of new products and technology which was previously unavailable in the host country. As a result, domestic firms imitate or adopt the same technology. *Labour turnover*- domestic firms can employ the workers who were with the foreign firms or the employee of a foreign firm may set up his own enterprise. The third important channel of spillover is the vertical spillover effects through *forward and backward linkages*. The mechanism of backward linkages operates mainly through the procurement of inputs by the foreign firms from the domestic suppliers. The domestic firms are forced to improve the quality and productivity due the stringent quality requirements of the foreign firms. In the case of forward linkages, domestic firms are able to obtain quality inputs or reduced price from the foreign firms. Another important channel of spillover mechanism is through learning by *exporting* from the foreign firms.

It is interesting to note that the entry of foreign firms is not without any negative consequences. Aitken and Harrison (1999) show that the presence of foreign firms can crowd out domestic firms. The domestic firms may be forced to move up along the average cost curve due to decline in the output. Likewise, reverse labour turnover can occur from domestic firms to foreign firms. Since the foreign firms pay higher wages compared to the domestic firms, some of the workers of the domestic firms leave domestic firms and join Multinational Companies (MNCs). Similarly, foreign firms may be reluctant to establish linkages with the domestic firms. It is often observed that entry of foreign firms may be followed by an entry of their international suppliers. Therefore, domestic firms may not benefit from the presence of foreign firms.

Much has been written and said about the positive effects of FDI in the theoretical literature. However, the picture emerging from the empirical studies about the FDI spillover effects do not appear to be rosy. Due to the availability of large scale panel data, a large number of studies have examined various aspects of spillover effects from FDI both for the developed and developing countries. However, there is no consensus regarding the results of these studies. All of the studies have found either positive, negative or even insignificant effects.

However, empirical studies dealing with FDI spillover effect and firm growth is scarce. In fact, there are only two studies reported in the said respect. Fotopoulos and Louri (2003) study investigated the role of FDI in determining the firm growth based on a panel data of 2640 Greek manufacturing firms. They considered the role of other factors like finance, degree of foreign ownership and sunk costs. The firm size age relationship was estimated using a quantile regression approach. Empirical analysis provides support for the positive effect of foreign ownership and spillover

effects on firm growth especially in the case of fast growing firms. Thus, their study found strong support for the inclusion of FDI and foreign ownership as a determinant of firm growth.

In a subsequent study, Dimelis (2005) used an augmented production function to explain the firm growth for a sample of Greek manufacturing firms. In addition to the degree of foreign ownership, a sectoral FDI variable was included to capture the spillover effect. After controlling for endogenity, she found that spillover effect has a positive influence on the firm growth. In the empirical model, she assumed that coefficient is the same for all the industries. However, in our empirical analysis we relax this assumption. The evidence from the two previous studies makes a strong case for including the FDI variable in our analysis.

3. MODEL AND VARIABLES

According to Gibrat's law, a firm's proportionate rate of growth is given by:

$$(S_t - S_{t-1}) / S_t = \varepsilon_t \qquad (1)$$

where S_t is the firm size at time t, (e.g. sales, employment or assets) and ε_t is a random variable that is independently distributed of S_{t-1}. If one assume that the initial size is S_0 and there are n steps before the final size S_n is reached, then summing up gives:

$$\sum_{t=1}^{n} (S_t - S_{t-1})/S_t = \sum_{t=1}^{n} \varepsilon_t \qquad (2)$$

For short period the value of ε_t is likely to be small, therefore equation 2 can be approximated as:

$$\sum_{t=1}^{n}(S_t - S_{t-1})/S_t \approx \int_{S0}^{Sn} dS/S \tag{3}$$

which gives:

$$\log S_n = \log S_0 + \sum_{t=1}^{n}\varepsilon_t \tag{4}$$

Considering that ε_t is relatively small and combining it with the exponential expansion makes equation 4 as:

$$S_t = S_{t-1}(1+\varepsilon_t) = S_0(1+\varepsilon_1)(1+\varepsilon_2)\ldots(1+\varepsilon_n) \tag{5}$$

One can assume that $\log S_0$ and ε_t are identically distributed with mean μ and variance σ^2, then by the central limit theorem, it follows that $\log S_t \sim N(\mu t, \sigma^2 t)$ as $t \to \infty$. Therefore, the distribution of S_t is lognormal with the condition that the expected value and variance increase over time.

Taking into consideration the fact that there are usually large number of small firms, Gibrat proposed that lognormal distribution was a good description of the observed firm size distribution. Similarly, the firm size distribution is likely to be skewed as well as in the probability density function, the probability mass is concentrated closer to the origin of the axes.

Step I

Evans (1987a, b) extended the model by incorporating the point that the firm growth relationship for firm i in period t+1 is a function of size and age, i.e.,

$$\text{Size}_{it+1} = G(\text{Size}_{it}, \text{Age}_{it})\ \text{Size}_{it}\ e_{it} \tag{6}$$

where e_{it} is a lognormally distributed error term. Equation 6 is considered as the primary step in augmenting Gibrat's Law. The equation in terms of regression framework can be written as:

$$\ln\text{Size}_{t+1} - \ln\text{Size}_t = \ln G(\text{Size}_{it}, \text{Age}_{it}) + u_{it} \tag{7}$$

where u_{it} is distributed normally with zero mean and possibly a non-constant variance, and it is independent of Size and Age.

Step II

As a second step of augmentation of Gibrat's Law, the Evan's model is extended by including R&D and FDI. In its final form the augmented equation in its operational and estimable form is given as:

$$GR_{it} = \beta_1 \text{lnsize}_{it} + \beta_2 \text{lnage}_{it} + \beta_3 (\text{lnsize}_{it})^2 + \beta_4 (\text{lnage}_{it})^2 + \beta_5 (\text{lnsize}_{it})(\text{lnage}_{it}) + \beta_6 \text{RDINT}_{it} + \beta_7 \text{lnFDI}_{it} + u_{it} \tag{8}$$

When Gibrat's law holds, this function asserts that the firm size is uncorrelated with firm growth. Based on the microeconomics of endogenous growth theories explained earlier, R&D investment is identified as a key determinant of firms' dynamics (Pakes and Ericson 1998). Therefore, many studies have emphasized the role of R&D on firm growth. However, almost all such studies treat R&D investment as an exogenous variable. The findings of such studies reveal that R&D-intensive firms tend to grow faster. In the present analysis, R&D intensity variable is included as endogenous in the model. To account for the effect of R&D activity on firm growth, there are potentially various measures on R&D activity (like R&D intensity or the number of personnel employed in R&D). Hence, based on the theoretical foundations of the models, one can justify the inclusion of R&D variable.

$$RDINT_{it} = F(GR_{it}) \qquad (9)$$

Further, due to the fact that foreign companies tend to invest in industries whose firms grow more, FDI is also considered as an endogenous variable:

$$FDI_{ijt} = \Phi(GR_{ijt}) \qquad (10)$$

Since the functional form of the equation 9 and 10 is unknown, in order to estimate equation 8, panel data GMM method is required. It is due to the fact that GMM estimation is more efficient when there are two endogenous variables. One can follow the procedure formulated by Arellano (1987) for the same. The lags of R&D and FDI are used as instruments for the estimation (first and second lag for R&D and first lag for FDI).

Step III

Since the FDI data pertain to the approvals per industry and not per firm, it is very restrictive to assume that the coefficient β_7 in equation 8 is the constant across all the industries. Therefore, to relax such a restrictive assumption, the equation 11 is used:

$$GR_{it} = \beta_1 \, Insize_{it} + \beta_2 \, Inage_{it} + \beta_3 (Insize_{it})^2 + \beta_4 (Inage_{it})^2$$

$$+ \beta_5 (Insize_{it})(Inage_{it}) + \beta_6 \, RDINT_{it} + \sum_{j=1}^{J} Y_j (InFDI_{ijt}) + u_{it} \qquad (11)$$

where j=1...26. The FDI coefficients Y_j determine the impact of FDI on firm growth for each of the industries separately.

The present study uses *sales* as a measure of size. However, the use of other alternate variables (employment or assets) is avoided since they are likely to be sticky. On the other hand, growth measure based on sales will demonstrate greater year-to-year variations. Furthermore, as firms are continually engaged in the process of redefining their boundaries by activities as outsourcing, *sales* can be regarded as a better measure of firm size.

Age is measured in years since the firm was incorporated and is also in logarithmic form. It is used as a proxy for the learning-by-doing effect on the firm dynamics as suggested by Jovanovic (1982). When output is a decreasing convex function of managerial inefficiency, Jovanovic's model implies that younger firms tend to grow faster than their older counterparts. In addition, a complete set of size and age quadratic and interaction terms are also included. GR_{it} is the size growth of firm *i* at time *t*. It is obtained by $InSize_{t+1}$ -$InSize_t$.

For the purpose of the present analysis, *R&D intensity* (RDINT) is measured as the R&D expenditure to sales ratio is used. R&D intensity measure is presumed to be a better proxy for R&D efforts since it is independent of size. The variable *FDI* is represented by FDI approvals and is used in logarithmic terms. As cited above, since the Evans model support elasticities as the interpretation of the coefficients and therefore, all the variables are transformed to the logarithm form (except for those in percentage values). Adding an extra variable in the model means that it enters as a multiplicative variable in equation 6 (in other words it enters as an additive log-variable in equation 7). Consequently, size, age and FDI are transferred into logarithms, R&D intensity remain as percentage. Due to the large scales variation in the FDI variable (ranging from 0-4600), and some industries with zero values, the variable was transformed into logarithm (natural logarithm of FDI plus one).

***Endogeneity of R&D and FDI*:** Ericson and Pakes (1995) developed the foundations of dynamic Markov-Perfect Nash Equilibria model and Pakes and McGuire (1994) illustrated an algorithm for computing such equilibria. The algorithm provides insights into how markets operate and how firms make entry; exit and investment decisions in a dynamic environment. In this model, structural parameters are numerically imposed. Based on that, entry, exit and investment decisions are made to maximize the expected discounted value of future net cash flow conditional on the current information set. Bajari, Benkard, and Levin (2005), present a two-step algorithm for estimating the structural parameters of Pakes and McGuire (1994). Both of these studies highlight the importance of heterogeneity and idiosyncratic uncertainty induced by the random outcomes of investment processes. In their model, investment is decided every period generating firm heterogeneity. Additionally in Ericson and Pakes (1995), investment decisions are made in each period depending on the current situation of each firm e.g. its profitability or its growth. Therefore, we use R&D intensity variable as endogenous in our model. Additionally, due to the fact that foreign companies tend to invest

in industries whose companies grow more, FDI might be an endogenous variable in our model.

For the estimation of equation 11, panel data GMM method is used[1]. We follow Wooldridge (2002) and Arellano (1987) to achieve the same. Our results are given in the section V. The lags of R&D and FDI are used as their instruments[2].

4. DATA DESCRIPTION

The data source for this study is from the PROWESS electronic data base provided by the Center for Monitoring Indian Economy (CMIE). PROWESS provides information regarding around 7,000 firms belonging to the manufacturing sector registered with the Bombay Stock Exchange. The data is primarily drawn from the information in annual reports of the firms. Since our study is pertaining to the manufacturing industries, we obtain data regarding sales, age, and R&D. For our study, we have used an unbalanced panel data of nearly 1841 firms belonging to 26 three digit industries operating between the periods 1994 to 2005.

The FDI approval data is obtained from the various publications of Secretariat of Industrial Approvals (SIA). SIA is the sole data source in Indian providing data on the foreign approvals. We had to rely on the foreign approvals data since the actual inflows data at the sectoral level are hard to come by. Since the classification of PROWESS and SIA is different, matching of the data between the two was carried out.

[1] GMM estimation is more efficient in the case of two endogenous variables.
[2] First and second lagged for R&D and first lagged for FDI

Table 1: Summary Statistics of the Select Variables

Variable	Age	Size	R&D	FDI	Size Growth
Mean	2.944	3.965	0.324	6.31	0.143
Median	2.942	3.886	0	7.19	0.111
Perc 1%	0.693	-0.511	0	0	-0.723
Perc 99%	4.564	7.643	4.45	10.58	1.59
Obs	17120	17285	17285	17285	15426

Table 2: FDI and R&D Statistics

year	No. of Firms	% of zero-R&D Firms	% of zero-FDI Firms
1994	1039	73	42
1995	1222	71	42
1996	1308	69	6
1997	1380	65	4
1998	1462	67	13
1999	1589	68	12
2000	1684	71	9
2001	1687	71	12
2002	1675	66	7
2003	1597	65	3
2004	1429	62	0
2005	1213	62	2

Source: PROWESS Database

In table 1, the summary of the variable are presented. The size variable seems to be not following the normal distribution as claimed in the theoretical literature.[3] After testing it, Shapiro-Wilk normality test reject that hypothesis. This hints at the possibility that other variables

[3] Figures 2 & 3 in the appendix give more information about this. Additionally more FDI & R&D statistics can be found in the appendix.

can explain firm growth and not necessary the error term itself. In Table 2 we provide more statistics that explain the zero median of R&D and the zeros that our FDI variable contains. For example in 1994, 42% of our sample firms have zero FDI. Table 2 also provide additional statistics, which explain that the number of firms (in the sample) undertaking R&D is on the rise. The list of sample industries based on the technology intensity classification is presented in table 3.

Table 3: Industry Classification (based on OECD Classification)

Sl.No	Industry
1	Food Processing Industries
2	Vegetable Oil and Vanaspati
3	Sugar
4	Fermentation Industries
5	Textiles (including Dyed, Printed)
6	Paper and Pulp (incl Paper Product)
7	Chemicals
8	Dye Stuffs
9	Fertilisers
10	Drugs & Pharmaceuticals
11	Soaps, Cosmetic and Toilet preparations
12	Rubber Goods
13	Miscellan Mechanical & Engineering
14	Glass
15	Ceramics
16	Cement & Gypsum Products
17	Metallurgical Industry
18	Prime Movers other than electrical+Boile
19	Industrial Machinery
20	Machine tools
21	Earth Moving Machinery
22	Commercial, Office and Household Equipme
23	Electrical Equipments like lamps
24	Medical & Surgical Appliances
25	Scientific Instruments
26	Other Transportation Industry like Automobile ancillaries

High Tech; Medium High Tech; Medium Low Tech; Low Tech

5. RESULTS AND DISCUSSION

Estimation Procedure

As reported, some of the recent research findings lend support to Gibrat's law (Klette and Griliches 2000). Many of the previous studies have used Galtonian regression models to empirically test the law. Galtonian regression is a cross-section regression between the vectors of the logarithm of the size taken at two different and distant points of time. However, the inference derived from the cross-section data is subject to strong criticism as it can be demonstrated that a non-positive value may emerge for the coefficient δ in the growth equation (with the natural logarithm of size as the only independent variable). This can be so even if the cross-sectional distribution remains unchanged. As mentioned, the econometric approach adopted in the present testing is an attempt to explain the dimensional growth of firms on the basis of the properties of the time series of each firm. Therefore, one can test or needs to test unit root that extend the application from time series to panel data.

The Augmented Dickey Fuller (with one lag length) test can be represented as:

$$\Delta y_t = \alpha + \beta y_{t-1} + \Upsilon \Delta y_{t-1} + \varepsilon_t \qquad (12)$$

The extending test for panel data is:

$$\Delta y_{it} = \alpha_i + \beta_i y_{it-1} + \Upsilon_i \Delta y_{it-1} \quad \square \; i=1....n \qquad (13)$$

Where y_{it} is the logarithm of the sales of firm i at time t, Δy_{it} is the rate of sales growth and Δy_{it-1} the lagged rate of sales growth.

Levin and Lin (1992) proposed such a test with a major limitation that β is the same for all observations. Thus, if we denote by β_i the value of β for the i^{th} cross-section unit then the Levin-Lin test specifies the null H_0 and alternative H_1 as:

$$H_0 : \beta_1 = \beta_2 = \ldots = \beta_n = \beta = 0 \quad \& \quad H_1 : \beta_1 = \beta_2 = \ldots = \beta_n = \beta < 0$$

The null makes sense under some circumstances, but the alternative is too strong to be held in applied studies. Maddala and Wu (1999) proposed a new test that it does not require a balanced panel as in the case of the IPS test. Also, one can use different lag lengths in the individual ADF regression below:

$$\Delta y_{it} = \alpha_i + \beta_i y_{it-1} + \sum_{j=1}^{m} \gamma_{ij} \Delta y_{it-j} \quad i=1....n \tag{14}$$

Where m is the lag length. This test basically use Fisher (1932) test based on the sum of the log- p-values. That p-values are derived from Monte Carlo simulations. We perform the test for 1 and 2 lag length for logarithm of sales. In both cases the null of unit root is rejected[4].

RESULTS

In table 4 we provide the results of our firm growth model regarding to the equation 9. Only the coefficients R&D intensity, size, and FDI in certain industries (namely fertilizers, ceramics, cement and gypsum, prime movers, and machine tools) are statistically significant[5]. Table 4 also presents results of the three important tests. (i) Anderson test is used to check whether instruments are correlated with endogenous regressors (underidentification). Rejection of the test means that the

[4] The p-value is zero in both cases. Since or data span is 12 years, two lags seems to be sufficient for this testing.

[5] All the *, ** and *** in our tables denote statistical significant coefficients in 10%, 5% and 1% respectively.

model is identified but weak instruments are present. (ii) With the Cragg-Donald F statistic, one can identify the presence of weak instruments. (iii) Sargan-Hansen test is used for overidentification purposes. The joint null hypothesis is that the instruments are valid, i.e., uncorrelated with the error term, and they are correctly excluded from the estimated equation. The values of the Cragg-Donald F statistic point to the presence of weak instruments. (iv) Shapiro-Wilk normality test reject the hypothesis that error term alone cannot necessarily determine the firm growth. The results of the Shapiro-Wilk test support inclusion of other variables in explaining firm growth in the present analysis.

As per the results given in Table 4, the presence of weak instrument problems convey that fixed effects or random effects model would give better results than the ones obtained. Therefore, Hausman test revealed that fixed effects model should be accepted. The fixed effect results are presented in table 7.5. All the basic variables except R&D intensity are statistically significant. Also, the signs of the variables are the same as that of results of the panel GMM approach (Table 4).

Table 4: Results based on panel data fixed effect model with GMM estimation

Variables	Model		Variables	Model (cont.)	
Rdint	0.016	(0.007)**	FDI11	0.028	(0.056)
Lnsize	-0.435	(0.079)***	FDI12	-0.021	(0.143)
Lnage	-0.093	(0.189)	FDI13	-0.393	(0.271)
Lnagesize	0.017	(0.025)	FDI14	-0.011	(0.354)
lnagesq	0.018	(0.078)	FDI15	-0.222	(0.107)**
lnsizesq	0.010	(0.008)	FDI16	0.063	(0.035)*
FDI1	0.030	(0.142)	FDI17	0.643	(0.560)
FDI2	-0.178	(0.123)	FDI18	-0.058	(0.021)***
FDI3	0.027	(0.035)	FDI19	-0.007	(0.025)
FDI4	0.021	(0.033)	FDI20	0.134	(0.078)*
FDI5	-0.089	(0.091)	FDI21	-0.029	(0.028)
FDI6	-0.764	(0.808)	FDI22	0.004	(0.084)
FDI7	0.040	(0.267)	FDI23	0.006	(0.120)
FDI8	-0.071	(0.347)	FDI24	0.026	(0.098)
FDI9	0.065	(0.035)*	FDI25	-0.152	(0.108)
FDI10	0.027	(0.054)	FDI26	0.058	(0.085)

Anderson canon. corr. LR stat Null: underidentification 6.38 chi-sq(1) p-val = 0.04

Cragg-Donald F statistic (check for weak instruments) 0.23 (Stock-Yogo not available)

Sargan-Hansen test (overidentification) Hansen J statistic 0.13 Chi-sq(1) P-val = 0.72

No of Observations: 11512

Table 5a: Results based on panel data fixed effects

Variables	Standard Model plus lag size		Variables	Standard Model plus lag size (cont.)	
Rdint	0.002	(0.002)	FDI12	0.020	(0.015)
lnsize	-0.684	(0.011)***	FDI13	-0.051	(0.021)**
lnage	-0.412	(0.032)***	FDI14	-0.018	(0.030)
lnagesize	0.076	(0.005)***	FDI15	0.009	(0.016)
lnagesq	0.089	(0.009)***	FDI16	-0.016	(0.009)*
lnsizesq	0.016	(0.001)***	FDI17	-0.001	(0.003)
FDI1	-0.035	(0.043)	FDI18	-0.010	(0.006)
FDI2	-0.021	(0.009)**	FDI19	0.020	(0.013)
FDI3	0.002	(0.008)	FDI20	0.037	(0.025)
FDI4	-0.022	(0.005)***	FDI21	-0.016	(0.008)**
FDI5	-0.014	(0.003)***	FDI22	0.016	(0.020)
FDI6	-0.015	(0.016)	FDI23	-0.036	(0.017)**
FDI7	-0.031	(0.017)*	FDI24	-0.012	(0.012)
FDI8	-0.001	(0.012)	FDI25	-0.003	(0.025)
FDI9	-0.009	(0.008)	FDI26	-0.006	(0.003)**
FDI10	0.008	(0.012)	Constant	2.104	(0.046)***
FDI11	0.014	(0.016)			

Sigma_u: 0,647 Sigma_e:0,316 Rho:0,808 Obs Num: 15274

However by accepting the table 5a results, we somehow ignore the endogeneity of R&D and FDI which is consistent with our theory. In order to have results that support the theory, we are forced to impose the assumption that the FDI coefficient is the same across the industries. Table 5b shows these results. R&D intensity is higher if we account for endogeneity and R&D intensity is statistically significant. Its coefficient is near to the one of Table 4. Thus, the results reveal that the weak instruments were the 26 lagged industry-FDI variables. The coefficient of FDI is insignificant. Since FDI coefficient is insignificant, there is no reason to continue forcing the endogeneity of FDI. Therefore, we relax the assumption that the FDI coefficient is the same among the industries. The results are given in Table 5c.

Table 5b: Results with the assumption of same FDI coefficient among industries (FDI and R&D are treated as endogenous)

Variables	Model		Variables	Model (cont.)	
Rdint	0.017	(0.007)**	Lnagesize	0.026	(0.023)
Lnsize	-0.440	(0.071)***	lnagesq	0.128	(0.016)***
Lnage	-0.373	(0.095)***	lnsizesq	0.008	(0.008)
Lnfdi	-0.022	(0.020)			

Anderson canon. corr. LR stat Null: underidentification 107.27 chi-sq(1) p-val = 0.00

Cragg-Donald F statistic (check for weak instruments) 35.92 > 13.43 (Stock-Yog

Sargan-Hansen test (overidentification) Hansen J statistic 0.17 Chi-sq(1) P-val = 0.68o 10% critical values)

No of Observations; 11512

The coefficients of size and age are negative and statistically significant. The squared term of age reveal a positive and significant effect on growth but the square term of size is statistically insignificant. The age/size interaction term is positive, but not statistically significant. These results show that the relationship between growth and age is convex. The relationship between growth and size is linear. This pattern is consistent with results in Evans (1987b), Das (1995) in all except for the convexity of age in the firm growth which is not diminishing for our entire sample. The effect of FDI varies per industry. There are negative, positive and insignificant coefficients for our 26 industries. For Rubber goods, Metallurgical Industry, Industrial Machinery, Machine tools and

Commercial, Office and Household Equipment[6], there is positive effect of FDI on firm size growth. For all the others we have negative and zero effects. This issue is discussed is detail below.

Table 5c: Results with the Assumption of Constant FDI Coefficient Across Industries

Variables	Standard Model plus lag size		Variables	Standard Model plus lag size (cont.)	
Rdint	0.017	(0.007)***	FDI11	0.017	(0.013)
Lnsize	-0.433	(0.070)***	FDI12	0.021	(0.008)**
Lnage	-0.364	(0.093)***	FDI13	-0.057	(0.019)***
Lnagesize	0.024	(0.023)	FDI14	-0.000	(0.021)
lnagesq	0.129	(0.015)***	FDI15	0.006	(0.013)
lnsizesq	0.007	(0.008)	FDI16	-0.013	(0.006)**
FDI1	-0.026	(0.032)	FDI17	0.069	(0.018)***
FDI2	-0.023	(0.007)***	FDI18	0.005	(0.005)
FDI3	0.000	(0.008)	FDI19	0.039	(0.010)***
FDI4	-0.025	(0.007)***	FDI20	0.038	(0.020)*
FDI5	0.002	(0.007)	FDI21	-0.011	(0.008)
FDI6	-0.005	(0.014)	FDI22	0.046	(0.023)*
FDI7	0.029	(0.023)	FDI23	-0.038	(0.020)*
FDI8	0.013	(0.009)	FDI24	-0.000	(0.023)
FDI9	-0.008	(0.009)	FDI25	-0.010	(0.025)
FDI10	-0.014	(0.009)	FDI26	-0.097	(0.017)***

Anderson canon. corr. LR stat Null: underidentification 3699.05 chi-sq(1) p-val = 0.00

Cragg-Donald F statistic (check for weak instruments) 2237.98 > 19.93 (Stock-Yogo 10% critical values)

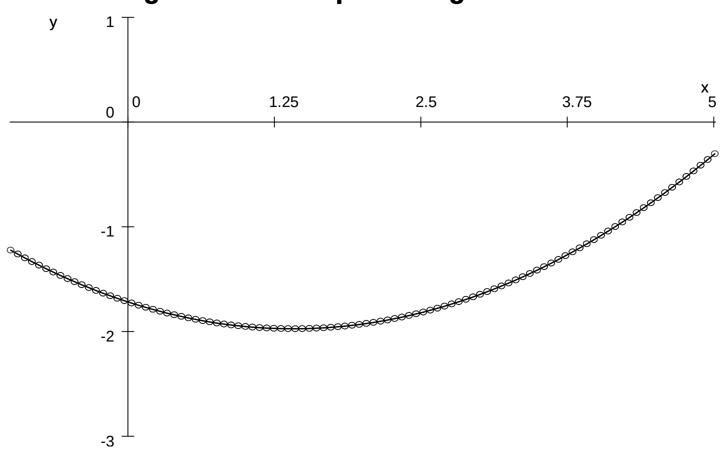
Sargan-Hansen test (overidentification) Hansen J statistic 0.12 Chi-sq(1) P-val = 0.73

No of Observations; 11512

[6] This category mainly includes computer and air-conditioning systems.

Finally, for the purpose of comparison between developed and emerging developing economies, we discuss in brief about the likely impact of age on firm growth. Figure 1 is constructed by taking zero impact of R&D intensity and FDI on growth[7]. The impact of the other significant variables except age (lnsize) is evaluated at their sample mean values. Our results reject the Jovanovic argument that younger firms tend to grow faster than their older counterparts. As age varies from 0 to 5, we have a negative growth for all of our firms. The older firms have less negative growth than the younger ones. We can accept Jovanovic argument only if age varied from 0 to 1.41 for our entire sample. This is the range where age is convex and diminishing. For example, if some variables like R&D intensive cause the curve to shift upwards then indeed the younger firms will tend to grow faster. However, less than 5% of our sample lies within this range, so it is obvious that the present case do not support the argument. A similar effect is found by Das (1995) for the computer hardware industry in India .

Figure 1: The Impact of Age on Growth



[7] Since 15 γ_j 's are insignificant and median of R&D intensity is zero.

Relaxing linear assumption of R&D on firm growth

So far, our results are based on equation 8 which is an extended version of Evans (1987) model. However, this model has been created by assuming linear relation of R&D and FDI on firm growth. By relaxing this assumption, we have firm growth as a G function of not only size and age (Eq.7) but also as a function of R&D and FDI. Because of our data constraints, we are unable to assume different coefficient of FDI across industries. The only way to do that (if we want to impose the different coefficients) is to enter only R&D inside the G function. In other words, we can now estimate a model that also contains R&D square, and R&D interactions with size and age. Using these as instruments, the lags of these new terms are used to re-estimate our model. Therefore, we abandon the idea of the endogenous FDI as there is no evidence to support the argument The results are presented in table 6.

Table 6: Results after relaxing linear assumption of R&D and adding FDI square

Variables	Relax linear assumption of R&D / add FDI square	
rdsize	0.010	(0.004)**
Rdint	0.066	(0.025)***
rdage	-0.024	(0.010)**
Lnsize	-0.423	(0.080)***
Lnage	-0.425	(0.170)**
Lnagesize	0.019	(0.027)
lnagesq	0.147	(0.045)***
lnsizesq	0.007	(0.008)
FDI2	0.100	(0.042)**
FDI2sq	-0.025	(0.008)***
FDI17	-0.875	(0.261)***
FDI17sq	0.060	(0.017)***
FDI19	0.110	(0.048)**
FDI19sq	-0.014	(0.009)
FDI23	-2.255	(0.636)***
FDI23sq	0.114	(0.033)***

Anderson canon. corr. LR stat Null: underidentification 1045.03 chi-sq(1) p-val = 0.00

Cragg-Donald F statistic (check for weak instruments) 182.61 > 12.20 (Stock-Yogo 5% maximal IV relative bias)

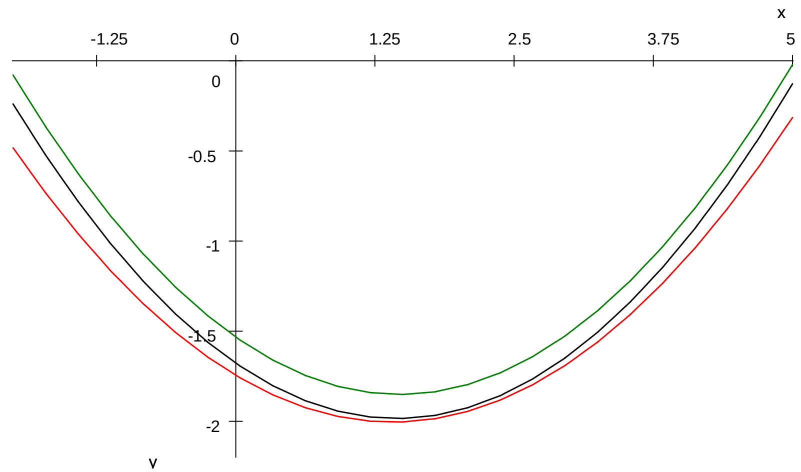
Sargan-Hansen test (overidentification) Hansen J statistic 5.50 Chi-sq(1) P-val = 0.138

As FDI and FDI square capture a combination of FDI and industry dummies, we are using them only as control variables here to see how our results varies[8]. We find that R&D intensity is in most of the cases

[8] We have excluded the FDI coefficients which turned out to be insignificant

positive. The negative effect is found for old firms with low sales. The signs of the rest explanatory variables remain the same as before. This reveals that smaller firms grow faster and that we have a similar impact of age on growth (see figure 2).

Figure 2: Non-linear relation of R&D on firm growth



Notes:

Black line: based on linear assumption of R&Dint as before (Figure 1),
Red line: non-linear R&D with R&D intensity equal to zero,
Green line: non-linear R&D with R&D intensity equal to the variable mean.

Impact of FDI on firm growth

In the extension of the Evans model discussed earlier, the industry dummies were excluded. This is due to the panel data fixed effects. Therefore, the FDI variable could be picking up some of those. In order to address this issue, there are three possible options: *Firstly*, use estimation for each industry separately. In the present case, it could not be carried out due to the limited sample (for each industry using lags as instruments). *Secondly*, regress the FDI to the industry dummy variables and use the residual as the FDI. But the new industry-independent-FDI variable is no longer a random variable since it is a generated variable. Therefore, standard errors need to be defined to correct this generated variable problem. *Thirdly*, test if the beta coefficients of equation 7.8 are same across industries. The results of the test according to the third procedure cited, reveals that except for the coefficients FDI, age, size square and the interaction of size with age, are not the same across industries. Once the assumption that coefficients of age, size square and age/size are the same across industries and the linear relation of R&D on firm growth are relaxed, one can account for FDI coefficients that are independent from industry dummies in the general case.

Table 7: Impact of FDI on firm growth

Variables	Standard Model plus lag size		Variables	Standard Model plus lag size (cont.)	
Rdsize	0.009	(0.005)*	FDI11	0.020	(0.012)*
Rdint	0.061	(0.022)***	FDI12	0.020	(0.008)**
Rdage	-0.022	(0.009)**	FDI13	-0.053	(0.019)***
Lnsize	-0.469	(0.081)***	FDI14	-0.005	(0.021)
Lnage	0.393	(0.457)	FDI15	0.012	(0.014)
Lnagesize	-0.192	(0.114)*	FDI16	-0.013	(0.006)**
lnagesq	0.147	(0.046)***	FDI17	0.046	(0.021)**
lnsizesq	0.079	(0.079)**	FDI18	0.019	(0.007)***
FDI1	-0.019	(0.031)	FDI19	0.052	(0.011)***
FDI2	-0.015	(0.010)	FDI20	0.040	(0.020)**
FDI3	0.004	(0.008)	FDI21	-0.012	(0.008)
FDI4	-0.025	(0.007)***	FDI22	0.048	(0.023)**
FDI5	0.001	(0.008)	FDI23	-0.039	(0.023)*
FDI6	0.021	(0.019)	FDI24	-0.005	(0.022)
FDI7	0.004	(0.032)	FDI25	-0.025	(0.024)
FDI8	0.009	(0.008)	FDI26	-0.136	(0.017)***
FDI9	-0.004	(0.008)	trend	0.0004	(0.006)
FDI10	-0.029	(0.012)**			

Anderson canon. corr. LR stat Null: underidentification 990.99 chi-sq(1) p-val = 0.00

Cragg-Donald F statistic (check for weak instruments) 171.8 > 12.20 (Stock-Yogo 5% maximal IV relative bias)

Sargan-Hansen test (overidentification) Hansen J statistic 4.68 Chi-sq(1) P-val = 0.197

In table 7, results without the interactions of age, size square and age/size with industry dummies are presented. Based on the said results, it can be observed that there is a zero or negative impact of FDI on firm growth is not uniform (i.e negative for low tech industries, zero or positive impact for medium low-tech, medium high- tech and high-tech industries).

VI. CONCLUSION

This paper is an attempt to understand the role of R&D and FDI, in determining firm growth. Empirical research on firm level data has revealed substantial heterogeneity between firms, so we include the latter two variables to control for it. Using fixed effects panel data models with GMM estimation to control for endogeneity of R&D and FDI, one of our major findings is that an increase in current R&D induces a higher growth, whereas, an increase in FDI induces higher growth in some industries and lower size growth in some others. FDI do not seem to provide the required stimuli across all industries.

Further, Gibrat's law is not only rejected by our main model but it is also rejected by an Augmented Dickey Fuller unit root test for unbalanced panel data. This provides strong evidence in favor of our model. Finally, firm growth is negatively associated with its size and it is convex with respect to its age. The fact that firm growth is not diminishing convex contradicts the Jovanovic argument that younger firms tend to grow faster than their older counterparts. As far as the firm growth is concerned, the absence of learning-effects appears to be the main difference between emerging-developing and developed countries. The results provide hint that R&D seem to be more important factor than FDI in achieving higher performance through firm growth. The Augmented Dickey Fuller unit root test also substantiates this point.

We find that FDI is found to have much influence in determining the growth rate in those industries where the domestic firms have attained equal or more capability in terms of technology. For example, FDI is found have a positive influence on the growth of firms located in the high tech sectors (like computer hardware). Based on the results, it can be found that MNCs stimulate domestic industrial development by firm growth eventhough the magnitude differs according to the industries.

APPENDIX: More Data Statistics

Table 6: Percentage of zero R&D Companies per industry per year

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
1	92	85	75	78	79	81	86	86	78	81	78	76
2	88	94	91	85	85	83	84	83	85	89	79	74
3	100	85	65	50	45	47	61	65	58	51	53	59
4	93	89	82	77	82	85	86	83	80	81	86	86
5	86	85	83	79	80	81	83	83	83	81	77	77
6	70	75	78	78	82	78	80	86	83	78	83	78
7	68	65	63	59	62	62	64	61	56	54	52	50
8	36	47	56	63	58	54	50	48	45	45	39	44
9	76	67	68	75	80	80	90	74	68	68	65	60
10	45	45	51	43	51	46	48	48	42	44	39	37
11	75	58	60	57	57	65	65	72	64	60	48	50
12	82	74	72	62	64	70	63	68	58	59	59	61
13	85	84	81	81	81	84	80	81	76	79	73	72
14	63	58	58	58	58	58	83	83	75	83	83	83
15	76	68	64	48	59	58	59	67	70	54	48	52
16	78	70	55	57	55	60	63	65	57	59	57	48
17	83	87	86	83	83	86	87	88	86	86	85	84
18	64	65	61	59	53	57	62	57	56	51	50	51
19	60	73	64	64	50	57	56	56	63	44	36	50
20	76	83	80	68	68	67	62	61	71	65	59	60
21	61	61	54	54	54	58	58	59	56	53	48	48
22	64	56	59	59	56	58	53	69	51	55	56	50
23	58	49	50	45	52	59	65	64	54	53	52	52
24	70	55	77	71	69	72	75	68	50	50	53	50
25	100	75	100	75	100	75	75	75	75	75	75	75
26	70	62	61	56	54	54	64	60	50	48	49	46

Table 7: Percentage of zero FDI Companies per industry per year

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
2	100	100	100	100	100	0	100	100	100	0	0	0
3	0	0	0	0	100	100	100	100	0	0	0	0
4	0	0	0	0	100	100	0	0	0	0	0	0
5	100	100	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	100	0	100	0	0	0	100
9	0	0	0	0	100	100	0	100	0	0	0	0
11	100	100	100	100	100	0	100	100	100	100	0	0
17	100	100	0	0	0	0	0	0	0	0	0	0
18	100	100	0	0	0	0	100	100	100	0	0	0
19	100	0	0	0	0	100	100	100	0	0	0	100
21	100	100	100	0	0	0	0	0	0	100	0	0
24	100	100	0	0	0	0	0	0	0	0	0	0
25	100	100	0	0	0	0	0	0	0	0	0	0
26	100	100	0	0	0	0	0	0	0	0	0	0

Figure 2: Size Distribution

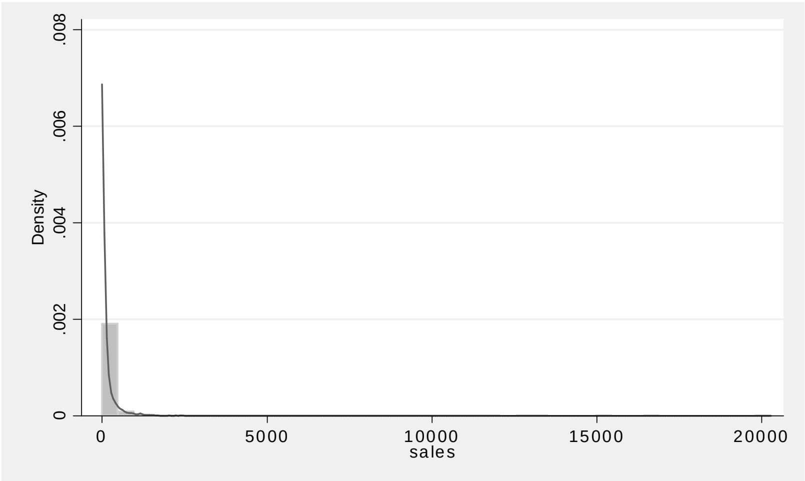
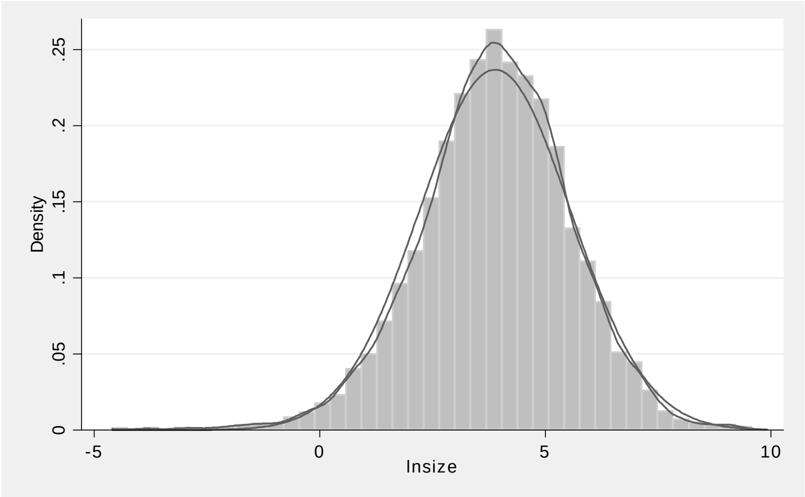


Figure 3: Natural Logarithm of Size Distribution



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