Learning across policy regimes: The impact of protection vis-à-vis competition in the Indian automotive industry

Madhuri Saripalle

University of Connecticut

2006

Learning across policy regimes:

The impact of protection vis-à-vis competition in the Indian automotive industry

Learning has been recognized as an important factor in explaining the growth of firms in both industrial organization theory and literature. However, few models have attempted to relate the learning and growth literature with the industrial policy regime, especially in economies heavily regulated by government policies. The present study attempts to apply one such model of growth and learning of firms across three different industrial policy regimes in the Indian automotive industry. It tries to analyze whether learning is promoted by a competitive or a protective policy regime. It also tries to decompose learning into several types to understand the mechanism underlying the growth process. In doing so, it relies on the growth-size distribution literature.

(Draft version, not to be quoted)

Key words: Learning, growth, policy regime, automobile Industry, India, Asia.

Madhuri Saripalle
PhD, University of Connecticut, Storrs, U.S.A.
msaripalle@yahoo.com

Introduction

It is well recognized in industrial organization theory and empirical literature that learning as a capability is a major factor in explaining inter-firm performance differences. The success of newly industrialized countries (NICs), for example, has shown that technological progress is not merely guided by changes in relative prices, nor does competitiveness depend upon relative factor endowments. It is more than acquiring the technological blue prints; involves a learning process. However, few studies have attempted to model the dynamic nature of firm learning and its impact on growth. Furthermore, it is not the specific determinants of learning, but rather the time path of learning, which is more relevant to study the growth and evolution of an industry.

This study analyzes the growth pattern of the Indian automobile Industry across three different industrial policy regimes---protection, deregulation and liberalization--to understand the volatility in the growth process and the reasons for the same. First, the study tests whether the growth pattern follows a random walk and whether Gibrat's law relating growth and size distribution holds for the industry, across different time periods. Having found evidence that contradicts the random walk hypothesis, the study next tries to relate the growth of the industry across different policy regimes, with learning by applying a model of learning, proposed by Geroski and Mazzucato (2002).

This study departs from their approach in the following way. It estimates a pooled cross section and time-series data using a fixed-effects approach for three different policy regimes. As some of the firms exited the industry in regime 3, the paper attempts to correct for attrition bias in the third regime. The model estimates dummy intercept as well as slope coefficients for each of the ten firms. The results suggest that protection does induce learning, however, only of a limited kind. This is because the only firm which displays learning in all time periods exited the industry in the post liberalization period. Further, firms learn more from output spillovers in an industry where innovation is limited. Section 1 presents a theoretical background on firm growth and size distribution, relating it to learning. Section 2 describes the model while section 3 analyses the growth rate of the firms as well as tests for the random walk hypothesis. Section 4 discusses panel data estimation which includes a discussion of preliminary hypothesis, empirical issues in estimation and finally the results of the estimation. Section 5 offers concluding remarks. Appendix I displays the quantitative results while Appendix II provides some extensions to the main results by incorporating Research & Development expenditures as a variable and provides firm-wise analysis as well.

1 Theoretical Background

The growth-size distribution literature tries to model the stochastic nature of the growth process without making assumptions about profit maximization or the nature of technology. Specifically, the theory on growth of firms asks the following question. Given the assumption that there exists a limit to the size and growth of firms in an industry, is there a size distribution to which the industry converges? A landmark contribution to the theory which triggered many other works, was known as Gibrat's Law (1931). It stated that the expected value of the increment to a firm's size X_t in each period is proportional to the current size of the firm. In other words, firms grow at random rates conditioned by an amount proportional to a firm's existing size, making the limiting distribution of X_t lognormal.

The size of a firm at time t +1 is taken to be a function of its size at time t subject to random variation. Taking xi to denote firm size, the size of firm i is governed by the following equation:

$X_{i(t)} = \alpha + \beta_i X_{i(t-1)} + \varepsilon_{i(t)}$,

Where, $X_{i(t)}$ is the log size of firm i at time t ,and α is a growth component common to all firms. Gibrat's law assumes that ε is an i.i.d random variable and for all i, and βi =1 (that is, the expected rate of growth is independent of the present size). The principal result in such models is that although firms might begin ex-ante with equal growth prospects, differences in initial conditions and the presence of random events cause firms to soon diverge in size and market shares, causing a skewed size-distribution (log-normal) to emerge. Gibrat applied his theory to income distributions and to plant sizes in manufacturing and obtained a very good fit for the data.

Later developments tried to incorporate the effect of entry and exit on size distribution of firms and asked whether Gibrat's law applies to all firms in an industry or only to firms conditional on their survival. Research led to the following conclusions: the probability of survival increases with firm size, but the proportional rate of growth conditional on survival decreases with age. This meant that larger firms have lower rate of growth but are more likely to survive. But the result depended on whether it was a multi-plant firm or single plant firm. It was found that in multi-plant firms, the tendency for survival outweighed the tendency for the rate of growth to fall as age increased, implying that older firms also displayed high rates of growth, which has implications for firm learning over time.

In another recent paper, Mazzucato (2003) studies the co-evolution of industry and financial volatility by analyzing the underlying patterns of volatility in growth rates and stock prices in the automobile and the PC industry. She tests the unit root hypothesis for the growth of firms in both the industries and finds that growth rates for the automobile industry are volatile and exhibit a unit root in the pre-war period as compared to post war, whereas the opposite is true for the PC industry. She concludes that Gibrat hypothesis better describes the statistical process of growth during the *early* phase of industry evolution. This is most likely because this early phase is characterized by higher rates of entry and exit, rapidly evolving technology and a general expansion of the market (creating opportunities for some and disadvantages for others).Once changes in technology and demand settle down and concern shifts more towards economies of scale and process innovation, firm growth rates tend to be more stable and structured[1].

The studies discussed so far analyze the relationship between firm size and growth to study the evolution of an industry and compare different industries. However, though Gibrat's hypothesis is refuted, an explanation in terms of learning is not provided. In other words, they don't incorporate the effect of learning on the evolution of an industry. The model of learning proposed by Geroski and Mazzucato (2002) is based on the theory of growth of firms, which attempts to model the dynamics of firm size and

[1] Mazzucato (2003, pp:19)

industry evolution. It is an attempt to understand the role of learning in explaining inter-firm growth rates and their size distribution. According to the authors, while learning can be attributed to various factors, it is not directly observable. What is observable is the learning process, which can be systematic or an unsystematic stochastic process. This process can be revealed by the time path of output, which tells whether growth rate differences are explained by a systematic learning process. If they are, then learning will influence growth performances, and the industry is evolving and will or will not converge to a limiting distribution depending on the returns to learning. The model of learning nests several hypotheses about learning into a generalized model, with the null hypothesis being that learning is unsystematic. The general model explains three different hypotheses: unsystematic learning, learning through internal resources and learning through spillovers. The learning through internal resources model captures the absorptive capacity[2] of the firm by measuring the increasing returns on stock of knowledge and ability to learn; learning through spillovers captures the returns from unobservable aspects of rival firms' innovations which get passed on through rival firms' output.

2. A model of learning based on time path of growth

The general model developed nests two models of learning in a model of unsystematic firm growth suggested by Gibrat. These two forms of learning are:

- Learning through internal resources or absorptive capacity and
- Learning through output spillovers.

Define a production function, $Q(t) = A(t)\ KN(t)^{\alpha}$, where,…………………..(1)

Q(t) is the output produced; KN(t) is the stock of knowledge with the firm and A(t) is the effect of all other inputs on the output. Taking logs and first differencing,

$\Delta \text{Log } Q(t) = \Delta \log A(t) + \alpha\ \Delta \text{Log } KN(t)$, where,………………………………………(2)

ΔLog Q(t) = growth rate of firm

ΔLog KN(t)= Rate of growth of stock of capital, which is by definition learning LE(t).

[2] Absorptive capacity is the ability to recognize the value of new external information, assimilate it and apply it to commercial ends which itself is a function of the level of prior related knowledge and is thus path dependent (Cohen and Levinthal 1990).

The model assumes that the firm maximizes profits subject to costs and demand parameters, which are in turn influenced by learning or the stock of knowledge the firm possesses. Therefore, there will be a relationship between the stock of knowledge and output rates. Further, since different types of learning will induce different time paths for KN(t) and Q(t), observing movement in Q(t) over time may cast useful light on the time path of KN(t) and on the rate of learning. The five different types of learning are summarized in Table 1. The model further assumes that the evolution of A(t) is a white noise process, driven by a large number of small idiosyncratic cost and demand shocks and also that the variance of A(t) and α, the elasticity of output with respect to knowledge is similar across firms. According to the model, corporate performance measured by the growth rate of firms is a signal of the current rate of learning. The quality of the signal in turn, depends on α and on the inherent variability in A(t).

The above model is tested for the null hypothesis of unsystematic learning in which the process of learning is random and characterized by a white noise process, more in line with the learning and forgetting hypothesis suggested by Benkard (2000). The results indicate presence of various kinds of learning depending on which of the coefficients in the model is significant. For example, when $\alpha_3 = \alpha_4 = 0$, the model reduces to learning via internal resources. When $\alpha_1 = \alpha_2 = \alpha_3 = 0$, the model shows significant learning from output spillovers and finally when there does not exist any systematic pattern of learning, none of the coefficients are significant, except for the lagged output coefficient. This result confirms Gibrat's hypothesis that growth is stochastic process statistically independent from size and the best predictor of next period growth is the current period size.

The authors test the model for the American automobile industry for the pre-war and post-war periods and find no evidence for any learning other than unsystematic learning over the entire period. The two types of learning: learning by doing and learning by innovation are also tested for based on their respective explanatory variables: cumulative output and number of innovations. Learning by innovation creates a correlation between current period growth rate of particular firms and the current and lagged innovations which they produce; learning by spillovers creates a correlation between the growth of particular firms and either the innovations produced by or the growth of their rivals; learning by doing creates a correlation between current period growth and cumulative output.

Table 1: Summary of various models on learning

	Model	Specification	Authors
1.	**Unsystematic Learning** Gibrat's law	$LE(t) = \xi(t)$ $\boldsymbol{\Delta Log Q(t)=\varepsilon(t) + \xi(t)}$	Sutton (1997)
2.	**Learning by innovation** Learning can be tied to the appearance of a particular innovation or R&D	$LE(t) = \beta I(t) + \xi(t), \beta > 0$ $\Delta Log\ Q(t) = \alpha\beta I(t) + v(t)$	Grilliches (1979)
3.	**Learning through spillovers** Relationship between the growth rate of firms i in period t and that of its rivals in t-1.	$\Delta LogLE(t)=\alpha_j \Delta LogKN_j(t-1)+\xi(t)$ $\boldsymbol{\Delta Log\ Q(t) = \lambda_j \Delta Log\ Q_j(t-1) + v(t)}$, ***where*** $\boldsymbol{\lambda = \alpha a_j}$	Grilliches (1979,1992)
4.	**Leaning by doing** Experience and focus on cumulative production	$\boldsymbol{\Delta Log\ Q(t) = \alpha\phi\ Log\ X(t) + v(t)}$ $X(t) = \sum_t Q(\tau)$ $LE(t) = \varphi\ Log\ X(t) + \xi(t)$	Spence (1981)
5.	**Learning using Internal resources** Link between stock of knowledge maintained by firm today and tomorrow.	$LE(t)=\delta LogKN(t-1)+\theta LE(t-1)+ \xi(t)$, $\boldsymbol{\Delta Log\ Q(t) = \rho Log\ Q(t-1) + \psi\ \Delta Log\ Q(t-1) + \mu(t)}$ where, $\mu(t) = \varepsilon(t) + \alpha\theta\varepsilon(t-1) + \alpha\delta Log\ A(t-1)$, $\rho = \alpha^2\delta$ and $\psi = \alpha\theta$	Evans (1987), Geroski et al (2001)

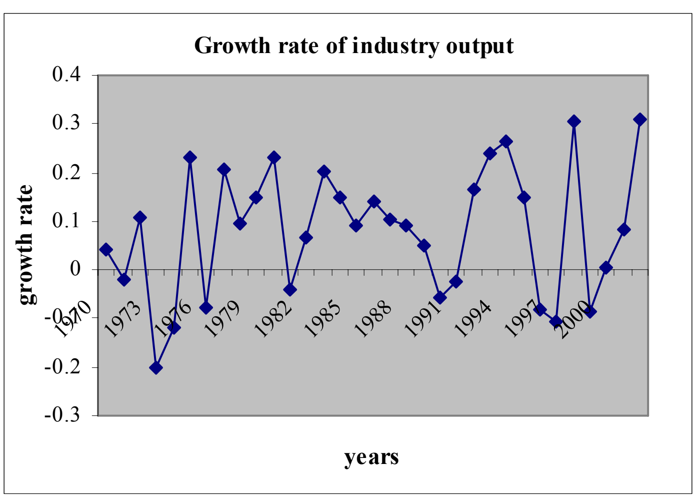
3. The growth pattern of the Indian Automobile Industry

***Description of data and methodology*:** The analysis presented in this section is based on annual production data for a sample of 10 firms in the 4-wheeler automobile industry, obtained from the Society of Indian Automobile Manufacturers and Automobile Component Manufacturers Association. The data relates to a thirty-three year time period from 1970-2003 and is divided into three industrial policy regimes: protection (1970-84); deregulation (1985-91) and liberalization (1992-2003). The ten firms in the four-wheeler segment can be broadly divided into two groups: Group one is those born in the protection period (pre-1970) and group two those born in the post-regulatory period (post-1985). A third group of firms is the multinational firms which entered after 1996. They are not included in the model because of too few time series observations.

3.a *Analysis of Growth Rates*

The table on compound annual average growth rates (CAGR) shows different results for firms born in different periods. Of the firms born in the pre-1985 period, four of the six firms (Ashok Leyland, Hindustan Motors, Mahindra and Bajaj Tempo) had growth rates highest in regime I, declining in regime II and improving marginally in regime III for two of the four firms. The other two firms (Tata and Premier Auto) fared better in regime II, with growth declining in regime III. Overall, one can say that firms belonging to pre-1985 era had highest growth in the protection phase and partial liberalization phase until 1991. Firms born in post 1985 period showed the highest growth in that period, with growth declining in regime III, though above the industry average. In regime III, multinational firms had the highest growth rates.

To summarize, regime I was driven by growth in the commercial vehicle segment, with firms like Ashok Leyland, Tata, Mahindra and Bajaj Tempo displaying above average industry growth rates. Regime II and III were driven by growth in the passenger car segment, with the entry of Maruti Udyog Limited in 1985 and multinational players in mid 1990s. The overall industrial growth has been the highest in regime III, the main drivers of which are the multinational firms in the passenger car sector. These results are very different from those of Narayana (1998), who uses growth in sales as well as a shorter time frame for regimes I and III.



Correlations between growth of firms in various regimes (Tables 5A-7A): An analysis of growth rates in different regimes shows high correlations between growth rates of different firms in the third regime as compared to first and second regimes. Growth rates of Tata and Ashok Leyland have always shown high correlations in all regimes. High correlations in regime III as compared to I and II could mean that competitive forces are pulling the growth of all firms in the same direction in regime III as compared to regime I when firms were insulated from competition and had assured market for growth.

Correlation between recent past and current growth (Table 8A): Correlations between current and recent past growth rates indicate that performance differences persist over time, especially across the various policy regimes. In the current sample, the results show significant positive correlations for five out of the ten firms: Tata, Mahindra, Premier Auto, Bajaj Tempo and Eicher Motor Limited. Two firms have high correlation between the growth rates of regime I and II; two others between regime I and regime III; and one firm shows high correlation between growth rates in regime II and III. A surprising result that emerges is that Premier Auto shows positive correlation between regime I, a period when its growth was positive, and regime III, when it exited the industry. It suggests that exit of the industry was not related to its growth performance, which was positive, but to other reasons.

Table 3 Growth Rates in different policy regimes

	Regime 1 1970-84				**Regime2 1985-91**				**Regime 3 1992-2003**				Overall 1970-2003
	CAGR	Mean (year to year growth)	C.V	SW w stat	CAGR	Mean (year to year growth)	C.V	SW w stat	CAGR	Mean (year to year growth)	C.V	SW w stat	SW w stat
Tata Motors	6.060	5.71%	281.63	0.89	11.830	11.83%	66.60	0.93	8.83	16.02%	186.22	0.94	0.95
Ashok Leyland	9.660	8.95%	188.83	0.96	9.430	7.40%	135.95	0.90	4.60	11.44%	199.83	0.92	0.76
Hindmotors	0.810	4.88%	700.74	**0.83**	-3.950	-5.33%	-327.31	0.88	-2.75	-1.91%	-824.76	0.93	**0.86**
MUL					56.570	16.70%	119.82	**0.73**	10.07	13.71%	120.16	0.93	**0.27**
Mahindra	7.450	10.32%	221.60	0.93	5.110	3.50%	300.39	0.90	5.83	8.53%	172.92	0.95	0.92
PAL*	1.980	8.38%	439.44	**0.78**	5.160	2.82%	596.02	0.96	-47.21	-23.70%	-233.53	0.96	***0.92***
BT	10.780	11.16%	152.58	0.96	1.490	1.12%	1499.64	0.92	-6.68	4.44%	754.42	0.92	0.99
Eicher					24.940	42.97%	178.70	*0.79*	14.12	18.15%	90.42	0.91	**0.74**
DCM*					7.02	-2.28%	-1121.22	0.95	-34.75	-24.56%	-178.82	0.92	0.94
Swaraj					18.860	21.53%	167.93	0.96	11.6	16.75%	122.84	**0.85**	0.97
HMIL									43.46	44.96%	53.81		
TKMIL									65.62	61.01%	74.55		
FIL									52.24	45.57%	58.32		
GMIL									10.71	10.10%	223.48		
Industry	6.450	7.42%	194.61		8.320	0.07505	95.65		9.05	13.22%	134.41		

**Growth rate for PAL for Regime 3 is from 1992-2000 and for DCM it is from 1992-1999.*
The firms in italics are multinationals in the passenger car segment that entered in the mid nineties. SW statistic is Shapiro Wilk statistic for normality of growth rates. Bold figures imply 5% level of sig.

3b. Testing for Random Walk hypothesis

The study first analyzes the growth pattern and tests whether the time series data supports the random walk hypothesis, by testing for unit root in the time series data. The hypothesis is tested for absolute growth rates of individual firms as well as the entire industry. Dickey Fuller tests are carried out to test the presence of unit root in the series. Dickey and Fuller considered the following three different equations to test for the presence of unit roots:

$\Delta Y_t = \theta Y_{t-1} + \varepsilon_t$ (no constant, no trend, level of differencing =1)

$\Delta Y_t = a_0 + \theta Y_{t-1} + \varepsilon_t$ (constant, no trend, level of differencing =1)

$\Delta Y_t = a_0 + \theta Y_{t-1} + a_2 t + \varepsilon_t$ (constant, trend, level of differencing =1)

The results for Dickey-Fuller tests show that in regime 1, with the exception of Mahindra and Bajaj Tempo (BTL) the series exhibits random walk after first differencing. That is the series exhibit I (1) process. In regimes 2 and 3, all the series show presence of unit root even after first differencing with the exception of Premier automobiles (PAL), which exited the industry. In regime 3, after further differencing, the series follow random walk with the exception of MUL, Mahindra and BTL. In other words, the series follow an I (2) process in the liberalised policy regimes. The series for the 33 year time period follows an I (1) process, with the exception of Maruti, Eicher and Swaraj. The industry on the whole exhibits volatility in all the three policy regimes. The results imply that there is volatility in the industry growth as a whole as well as individual firm growth.

Table 2 : **Dickey Fuller test for sample of ten firms:**
Process = Constant, no trend A(1) =0, I (1)

Firm	Years	Sample	Asym.critical value (10 % sig.)*
Tata	All	34	-4.58
	R1	15	-3.03
	R2	7	-0.52
	R3	12	-2.45
Ashokley	All	34	-5.08
	R1	15	-2.82
	R2	7	-0.59
	R3	12	-2.35

HM	All	34	-5.26
	R1	15	-3.32
	R2	7	1.57
	R3	12	-1.76
MUL	All	34	-2.3
	R1	15	n.a
	R2	7	1.03
	R3	12	-1.48
Mahindra	All	34	-4.16
	R1	15	-1.42
	R2	7	-1.54
	R3	12	-2.08
PAL	All	34	-4.39
	R1	15	-3. 19
	R2	7	3.97
	R3	12	-3.08
BTL	All	34	-3.37
	R1	15	-2.31
	R2	7	-0.99
	R3	12	-1.72
Eicher	All	34	-2.33
	R1	15	n.a
	R2	7	-0.99
	R3	12	-1.02
DCM	All	34	-3.2
	R1	15	n.a
	R2	7	-0.95
	R3	12	
Swaraj	All	34	-2.28
	R1	15	n.a
	R2	7	1.02
	R3	12	-1.43
Industry	All	34	-3.53
	R1	15	-2.34
	R2	7	9.97
	R3	12	-2.3
* T statistic at 10 % sig level = 2.57			

Next, the study performs a fixed effects panel data analysis to estimate the general model of learning based on the time path of growth for the sample of ten automobile firms in the Indian industry. The data variables include production of number of vehicles produced and research and development expenditure. The explanatory variable are lagged output, lagged growth of output, lagged output of other firms and lagged growth in output of other firms. While the first two variables capture learning through internal resources, the latter two capture spillovers. Lagged R&D expenditure was also included in the model, but was available only from 1990-2003 (regime III).

4. Panel data Analysis

The general model is:

$Y_{it} = \alpha_0 + \beta_0 X_{it} + \sum_{i=1}^{9} D_i + X_{it} \sum_{i=1}^{9} \beta_i D_i + \varepsilon_{t,}$ where, i and t denote firm and year respectively.

To test for differences in slope coefficients, interaction terms are introduced for each explanatory variable and the dummy variables for firms and the policy regime. D_i is the firm specific dummy. The model assumes cross-section heteroskedasticity. Although the Durbin Watson test for autocorrelation in the panel data showed the presence of autocorrelation, the p-value was significant only for regime II. The model assumes similar values of ρ (RHO) for all cross-section units. This implies that the error term may be correlated across time because of effect of policy factors, but it is the same across all firms.

The dependent variable is the growth rate $\Delta \log Y_t$; and the independent variables are the following:

X_{1t-1} = lagged output of firm and X_{2t-1} = lagged output of rival firm, where the subscripts 1 and 2 denote own firm and rival firm output.

Similarly, $\Delta \log X_{1t-1}$ = lagged growth rate of own firm and $\Delta \log X_{2t-1}$ = lagged growth rate of rival firm.

4a. Preliminary hypothesis

(1) Relation between growth and returns to learning

Unsystematic learning induces a random walk in firm size; and learning from internal resources creates a correlation between the growth of a particular firm and its size lagged and / or its previous growth. There are implications for firm size and industry structure as discussed above. A negative relation between lagged output and growth means that there are diminishing returns to the stock of knowledge a firm possesses. If the coefficient on lagged output is less than zero, it implies that differences in firm performances gradually diminish and firm sizes converge to a mean. A negative coefficient of lagged output growth on the other hand means that there are diminishing returns to growth and differences in firm performances gradually diminish and firm sizes converge to a mean.

There are other possibilities as well. These include, both α_1 and $\alpha_2 > 0$**,** implying increasing returns to knowledge accumulation and learning; both α_1 and $\alpha_2 < 0$, implying there are decreasing returns to knowledge accumulation and learning; $\alpha_1 > 0$ but $\alpha_2 < 0$ implying that there are increasing returns to knowledge accumulation but decreasing returns to a firm's ability to learn; $\alpha_1 < 0$ but $\alpha_2 > 0$ implying decreasing returns to knowledge accumulation but increasing returns to firm's ability to learn.

(2) Relation between age of firm and sign of coefficient

According to the theory discussed above, older firms should have a lower rate of growth and face decreasing returns to knowledge accumulation as well as learning. This means that the coefficients of $\alpha_1$and α_2 must be negative for older firms and positive for newer firms.

(3) Effect of Policy regime

The model is tested for three time periods representing three different policy regimes. In the protection period (1970-84), competition was limited and growth was constrained by licensing and capacity restrictions. Hence, one would expect diminishing returns to knowledge accumulation but increasing returns to growth. In the partial deregulation and liberalization policy regime, relaxation in imports, capacity expansion and foreign direct investment should result in increased knowledge flows and greater opportunities for investment. Hence the returns from the stock of knowledge should be positive and the lagged output coefficient should be positive. Competition may restrict firms' ability to grow and the coefficient of lagged output growth would depend on firm's ability to learn. Output spillovers may be limited in the liberalized policy regime because of increased competition.

(4) Learning by doing and Growth

An older firm has accumulated more experience and faces lower turnover compared to a younger firm. According to the literature on job matching, labor turnover is an optimal response of firms to different labor market conditions and varies from firm to firm. At the same time, high training costs imply that a firm with high turnover rates may not survive as long as low turnover firms. There are studies (Quentin and Stevens, 2003; Lane et al 2003) that show that larger firms have lower turnover rates because of internal labor markets. Also, firms with higher survival rates have lesser turnover because firm-specific human capital is endogenous (workers endogenously decide how much firm specific human capital to accumulate and separation rates fall as workers acquire more tenure). This implies that older firms that have survived longer have higher learning by doing because of higher accumulation of skills. Hence, the coefficient for cumulative output is expected to be higher in older firms. Since the objective of protection is to accelerate learning, one would expect a higher coefficient on cumulative output during regime I. In regimes II and III (partial deregulation and liberalization), changes in organization and attempts by the firms to reduce manpower and become leaner may result in redeployment of skills and hence a disruption in the routines of the organization. Some organizational "forgetting" may take place, as a result of which one can expect a lower coefficient for cumulative output in regimes II and III. The expected variable signs can be summarized in the following table.

Table 3: Expected signs of coefficients

Variable	Age	R I	R II	R III
Δ log X_{1t-1}	(-)	(+)	(+)	(+/-)
Log X_{1t-1}	(-)	(-)	(+)	(+)
Log X_{2t-1}	(-)	(+)	(+)	(+)
Δ log X_{2t-1}	(-)	(+)	(+)	(+/-)
Cum.Out	(+)	(+)	(-)	(-)

4b. Empirical issues in estimation

1. Lagged R&D expenditures and cumulative output as explanatory variables

Since the data on R&D expenditures were available only from 1990-2003, the model was tested only for regime III. Lagged R&D expenditures were included in the general model described above as well as regressed individually against growth rate of firms. The results are discussed in Appendix II. Cumulative output was regressed separately on the growth rate of firms, to test for learning by doing. That is,

$\Delta Y_t = \alpha + \beta_0 \log X_{it-1} + \log X_{it-1} \sum_{i=1}^{9} \beta_i D_i + \varepsilon_t$, where,

ΔY_{it} = growth rate of firm and X_{it-1} = lagged R&D expenditures/cumulative output and ε_t, is the stochastic disturbance term; D_i is firm specific dummy so that i and t denote firm and year respectively; $\beta_i D_i$ is the interaction term. The regression on cumulative output did not yield any significant results and hence not reported.

2. Unbalanced panel and attrition bias

As mentioned above, the model is estimated for three policy regimes. Regime I consists of the period 1970-1984 and the data set for the first policy regime consists of six firms. Regime II consists of the period 1985-91, and the data set consists of ten firms, out of which four firms entered in the late eighties, making it an unbalanced panel. Regime III consists of the time period 1992-2003, and the data set consists of ten firms out of which two firms exited the industry, again resulting in an unbalanced panel.

An unbalanced panel resulting from attrition can result in a sample-selection problem. That is, firms' decision to drop out is systematically related to the response variable, biasing the coefficients of the model upwards or downwards. The present study tries to take care of selection bias because of attrition in the following way. A two stage least squares estimation is required, with the first stage calculating the probabilities of firm survival conditional on size or some other explanatory variable uncorrelated with the error terms in the growth equation. The probability that a firm will survive to the end of the period such that its growth variable is observed is given by a probit model, with the latent variable a function of firm characteristic.

$S_{it} = 1[Wit\delta t + v_{it} > 0]$, $v_{it} | \{Wit, S_{it-1} = 1\} \sim \text{Normal}(0, 1)$

In the second stage a pooled OLS is performed on the following:

$Y_{it} = \alpha_0 + \beta_0 X_{it} + \rho_t\lambda (W_{it}\delta_t) + \varepsilon_t$, where

λ denotes the inverse Mills ratio obtained from the pooled probit in the first stage.

Attrition problem has been empirically examined by Hall (1987), who estimates the relationship between firm size and growth in the U.S. manufacturing sector. According to him, small firms grow faster than large firms and this may bias the estimated growth rates upwards. A two stage least squares regression is performed taking the probability of survival as an explanatory variable in the growth equation to account for the attrition bias. After correcting for heteroskedasticity the coefficient of probability of survival (λ) is negative and significant, suggesting the presence of attrition bias. The author finds that firms exiting the sample are those that have been acquired and that Tobin's Q (the ratio of market value to the book value of firm) is a better predictor of firm survival than size. Moreover, the estimate of the size coefficient is larger, which means that growth rates for the smaller firms are underestimated if attrition is not corrected for. However, the overall direction of the results does not change. In other words, a firm that grows faster than predicted by its size is more likely to exit from the sample, holding size and Tobin's Q constant.

The results of the present study point in a similar direction, with the sample exhibiting similar characteristics. For example, in the present sample, two firms exited the industry in the nineties: DCM Toyota and PAL. Both firms were taken over by multinationals, Daewoo in case of DCM and Fiat in the case of PAL. PAL exited from the industry after a failed partnership with Peugeot of France, and was taken over by Fiat. In the case of DCM, after Toyota exited from partnership, Daewoo stepped in to acquire a majority stake and finally took over complete ownership of the firm. The results are discussed in the next section.

4b. Results

1. Results for learning through internal resources: Old versus new firms (Table 9A)

The results of the econometric exercise vary depending on the age of firm, that is, on whether it was born prior to 1984 or post 1984. As stated earlier, firms born in the 70's can be termed as "old" and those born after 1984 can be termed "new". The results suggest that for the older firms, growth through internal resources and spillovers was significant for all the firms in regime I. In regime II and III the coefficient signs varied for firms. Among the new firms, except for Maruti, none of the other firms has any significant result.

Some of the main conclusions that can be drawn from Table 3.4.b are the following:

1. **<u>Lagged Output and Lagged growth in Output</u>**

1. The coefficient on lagged output is always negative in all the three regimes for all firms. It is significant for all firms in regime I and regime II, but not significant for some firms in regime III.
2. The coefficient on lagged growth rate is negative for old firms in regime I, turns positive for some firms in regime II. It is not significant for any firm in Regime III.

- ***There was learning from internal resources during the protection period and to some extent in the regulatory period as well. Moreover the coefficient sign indicates that returns to learning were decreasing in regime I; but in regime II, some firms faced increasing returns from the ability to learn[3].***

2. **<u>Lagged output and lagged growth in output for rival firms</u>**

- The coefficient on *lagged output for rival firms* is positive and significant only for the old firms and for one new firm--Maruti in the first two regimes. Tata Motors is an exception.
- The coefficient on *lagged growth of rival firm output* changes sign depending on the policy regime as well as the firm. It is positive for some old firms and negative for others in regime I, changing sign in regime II and reversing back to positive in the third regime. Amongst new firms, only Maruti has a positive coefficient in regime III while Swaraj has a negative coefficient.

[3] These firms are HM, Mahindra and PAL.

- ***In terms of the model, this would imply that there was substantial learning from spillovers in all regimes, the maximum in regime I. In regime II, the returns to spillovers are decreasing for most of the old firms. In regime III, only two firms show increasing returns from spillovers. These results are also heavily biased towards the old firms, except for one new firm--Maruti.***

3. <u>Constant term</u>

The constant term is significant for all firms in regime III signifying the role of other factors like demand variables. Although the time path of output is used to identify learning patterns, the model suffers from failing to assign a more specific role to factors like demand, which show up in the constant term as positive and significant.

4. <u>Lambda</u>

The coefficient for lambda (λ) is negative and significant, implying significant attrition bias. The coefficient sign implies that given that size is a predictor of survival, the probability of survival is higher for firms that grow more slowly. Conversely, firms that grow faster have a higher probability of exiting. It was also found that size is positively related to the probability of survival. Therefore, the model seems to predict that smaller firms that grow fast have a higher probability of exiting the industry than larger firms that grow more slowly. However, the firms that exited the industry belong to both the large (PAL) and small (DCM) categories, which require an alternative explanation, in terms of learning.

5. Conclusion

The economic success of emerging economies in the late seventies sparked off debates on several issues like the role of government versus the private sector, export oriented strategy versus import substituting industrialization and a combination of the two. In this context, this thesis undertakes a case study of the growth of the Indian automobile Industry across three policy regimes, focusing on learning and capability acquisition. The objective has been to study whether policy regime can influence firm level learning. If so, then it provides a justification to the infant industry argument from a developing country perspective as well as highlights the lessons to be learnt from successful learners. The study relies on a qualitative case study approach, complemented by quantitative techniques.

While the literature on technological capability acquisition is rich in documenting the empirical details of the process and sequence of capability acquisition, it suffers from subjective classification of capabilities and a static analysis of capabilities that are changing over time. The study has tried to integrate empirical case studies with the literature on learning by applying a dynamic model of learning to the Indian industry, based on the model by Geroski and Mazzucato (2002). The study examined the dynamic nature of learning process by looking at the time path of output across ten major automobile firms. The model is estimated for the Indian industry for a sample of ten four wheeler firms across three policy regimes, divided into twelve year, seven year and ten year period. The study departed from Geroski and Mazzucato (2002) by using a fixed effects panel data estimation, with intercept and slope changes and also obtained significantly different results from their study. It also tried to correct for attrition bias in the third regime.

The study found that learning varies according to age, policy regime and by firm. It changes from systematic learning in regime I to unsystematic learning in regime III, with firms displaying either type of learning in regime II. The study also found that results were significant only for all the older firms and only one new firm. However, despite learning, amongst the older firms, one firm had to exit the industry in the third regime. Thus, the results show that learning and capability acquisition is not related to survival.

To summarize,

1. Learning varies according to the age of firms. In this case however, older firms show more learning than newer firms.
2. Learning strategies differ by firms in each policy regime, varying between the extremes of systematic learning in regime I and unsystematic learning in regime III with a combination of the two in regime II. Whereas the protection period was more favorable to growth through internal

resources as well as spillovers, in the liberalized regime, firms seem to be growing mostly through spillovers.

3. The returns to learning or the coefficient sign of the lagged output variable changes depending on policy regime as well as being firm specific, with only two firms displaying increasing returns to learning in regime II.

Table 4 Summary of learning strategies

	Regime I				Regime II				Regime III			
	Inter.resources	Spill overs	Both	Unsystematic	Internal resources	Spill overs	Both	Unsystematic	Internal resources	Spill overs	Both	Unsystematic
Tata			√		√							√
ALL			√					√				√
HM			√		√							√
MM			√				√					√
PAL			√				√			√		
BTL			√			√						√
MUL			√		√					√		
Others								√				√

To conclude, the paper finds that the Indian automobile industry exhibited volatility in all three policy regimes and does not support the random walk hypothesis. This is contrary to the size-growth distribution literature. The paper also demonstrates that learning does vary by the age of firm and the policy regime as well. Learning is also firm-specific, defined by the technology strategy and capabilities of the firms, which is not captured by the traditional industrial organization theory. From a policy perspective, while protection encourages acquisition of production capabilities of, it does not equip the firm with coordination capabilities necessary for survival in a competitive environment. This is shown by the fact that some of the firms that acquired learning also exited the industry in a liberalized policy regime, unable to face the competition. These conclusions also give pointers to further research to incorporate the impact of quality and coordination capabilities in the model of learning.

Appendix I

Table 5A Correlations
REGIME I: 1970-84

	Tata	ALL	MM
Tata p-value		0.667 (0.009)	0.513 (0.061)
ALL p-value	0.667 (0.009)		
MM p-value	0.513 (0.061)		

Table 6A Correlations
REGIME II: 1985-91

	MM	PAL	Swaraj
ALL p-value	0.76 (0.044)		
HM p-value		0.91 (0.004)	
DCM p-value			0.851 (0.006)

Table 7A Correlations--REGIME III: 1992-2003

	Tata	ALL	HM	MUL	MM	PAL	BTL	EML	DCM	SML
Tata p-value		0.825 (0.001)		0.749 (0.005)			0.546 (0.066)	0.712 (0.009)		0.627 (0.029)
ALL p-value	0.825 (0.001)			0.796 (0.002)			0.628 (0.029)	0.780 (0.003)		0.665 (0.018)
HM p-value							0.545 (0.067)			
MUL p-value	0.749 (0.005)	0.796 (0.002)			0.752 (0.005)					
MM p-value		0.563 (0.057)		0.752 (0.005)						
BTL p-value		0.628 (0.029)						0.497 (0.100)	0.864 (0.027)	0.666 (0.018)
EML p-value	0.712 (0.009)	0.780 (0.003)					0.497 (0.100)			0.809 (0.001)
DCM p-value							0.864 (0.027)			0.836 (0.038)
SML p-value	0.627 (0.029)	0.665 (0.018)					0.666 (0.018)	0.809 (0.001)	0.836 (0.038)	

Table 8A Correlation between current and recent past growth rates			
	Regime I	Regime II	Regime III
Regime I		MM—0.757 (0.049) BTL—0.664 (0.100)	Tata---0.514 (0.087) PAL—0.634 (0.092)
Regime II			EML—0.865 (0.058)

MM: Mahindra; BTL: Bajaj Tempo Limited; PAL: Premier Automobiles Limited; ALL: Ashok Leyland; EML: Eicher Motor Limited; DCM: DCM-Toyota JV; SML: Swaraj Motor India Limited.

Table 9A Panel Data Analysis

	General Model						**Learning by Doing**		
	Regime I constant	$\Delta \log X_{1t-1}$	$\log X_{1t-1}$	$\log X_{2t-1}$	$\Delta \log X_{2t-1}$		Regime I	constant	cumout
Tata	0	**-0.499**	**-0.6377**	**0.546**	*0*		Tata	*0*	*0*
ALL	**2.49**	**-0.499**	**-0.6377**	**0.546**	**0.5691**		ALL	**0.9167**	**-0.076**
HM	**6.85**	**-0.499**	**-0.9009**	**0.546**	**0.9419**		HM	0	*0*
Mahindra	0	**-0.499**	**-0.5399**	***0.7556***	**0.6827**		Mahindra	0	*0*
PAL	0	**-0.499**	**-0.6377**	**0.546**	*0*		PAL	**0**	**0**
BTL	0	**-0.6244**	**-0.6377**	**0.546**	**0.9487**		BTL	0	0
MUL	N.E	N.E	N.E	N.E	N.E		MUL		
Eicher	N.E	N.E	N.E	N.E	N.E		Eicher		
Swaraj	N.E	N.E	N.E	N.E	N.E		Swaraj		
DCM	N.E	N.E	N.E	N.E	N.E		DCM		
RSq=0.58	**S.E=0.14**	N.E: Non Existent					RSq.=0.43	SE.=0.99	
	Regime II constant	$\Delta \log X_{1t-1}$	$\log X_{1t-1}$	$\log X_{2t-1}$	$\Delta \log X_{2t-1}$		Regime II		
Tata	0	**-0.7390**	**-1.16**	0	*-2.019*		Tata		
ALL	0	0	*-0.55*	***0.399***	0		ALL		
HM	**24.37**	**2.3393**	*-2.95*	**0.201**	0		HM		
Mahindra	0	**0.8880**	**-1.29**	**0.4387**	**-0.6049**		Mahindra		
PAL	0	**1.2035**	**-1.889**	*0.877*	**-2.3533**		PAL		
BTL	*16.15*	0	**-4.426**	***1.828***	***2.069***		BTL		
MUL	0	***-0.3208***	**-1.15**	*0.640*	0		MUL		
Eicher	*3.14*	0	**-1.16**	0	0		Eicher		
Swaraj	*3.14*	0	**-1.16**	0	0		Swaraj		
DCM	*3.14*	0	**-1.16**	0	0		DCM		
RSq=0.946	**S.E=0.942** Regime III						Regime III		
	constant	$\Delta \log X_{1t-1}$	$\log X_{1t-1}$	$\log X_{2t-1}$	$\Delta \log X_{2t-1}$		**λ**	**-2.42**	
Tata	0	0	**-1.499**	**1.12**	0		Tata	***0***	***0***
ALL	**7.044**	0	**-1.433**	0	0		ALL	*0*	0
HM	*7.817*	0	*-0.67*	0	0		HM	*0*	*0*
Mahindra	0	0	0	0	0		Mahindra		***0***
PAL	0	0	0	*-2.58*	**8.99**		PAL	*62.488*	*-4.7436*
BTL	**14.44**	0	**-0.647**	***-0.602***	0		BTL	0	0
MUL	**7.09**	0	**0.566**	**-1.08**	**1.679**		MUL	***0***	**0**
Eicher	***5.17***	0	0	0	0		Eicher	**0**	**0**
Swaraj	*4.32*	0	0	0	**-0.784**		Swaraj	**0**	**0**
DCM	***10.72***	0	**-0.461**	0	0		DCM	**18.845**	***-1.8251***
λ	**-2.08**								
RSq=0.75	**S.E=0.32**						RSq = 0.36		S.E=0.977

Appendix II

I. Learning through innovation (Table 10A)

When the model of learning by innovation is tested for separately, with growth rates as a function of lagged R&D expenditure, the coefficient of R&D is significant for only two firms: PAL and DCM—the two firms which exited the industry; and it is *negative*. This suggests that for the firms that exited the industry, the marginal contribution of R&D to growth was negative. A similar result follows for learning by doing when it is tested for separately against cumulative output of firms. Since the overall results are not significant, they are not presented here.

When R&D is included as an explanatory variable in the general model, the model shows significant results for learning through internal resources, although displaying decreasing returns from learning. Only two firms--Tata and Mahindra (MM)-- show increasing returns from learning in regime III. The lagged R&D variable is significant at less than 5% level for Tata, Mahindra, PAL, BTL, Eicher and Swaraj. For the other three, it is negative and significant at less than 10% level. Figures in bold represent 5% level of significance and in italics, 10% level of significance.

Table 10A Regime III: R&D as an explanatory variable						
	constant	$\Delta logX_{1t-1}$	$logX_{1t-1}$	$logX_{2t-1}$	$\Delta logX_{2t-1}$	Log RD_{t-1}
Tata	**6.08**	**0.79**	**-1.64**	**0.87**	0	**0.31**
ALL	**7.51**	**-0.00026**	**-1.39**	***0.53***	0	*-0.13*
HM	**15.97**	**-0.00026**	**-1.11**	***-0.44***	0	*0.35*
Mahindra	**6.57**	**0.83**	**-0.98**	**-1.06**	0	**0.11**
PAL	**34.8**	**-0.42**	**-0.62**	**-2.48**	**5.75**	**0.72**
BT	**22.15**	**-0.00026**	**-0.95**	**-1.13**	**1.63**	**0.51**
MUL	**7.30**	**-0.00026**	*-0.25*	**-1.02**	**1.60**	*-0.13*
Eicher	**7.63**	**-0.00026**	*-0.25*	**-0.40**	**-0.74**	**0.25**
DCM	**16.7**	**-0.00026**	*-0.25*	**-1.06**	0	*-0.13*
Swaraj	**8.96**	**-0.00026**	*-0.25*	**-0.44**	*0.77*	**0.20**
λ	**-2.95**					
RSq=0.94	**S.E=0.10**					

II. Firm-wise analysis

All old firms display significant pattern of learning in regime I, with little differences in magnitude of the coefficients. Spillovers were positive except for Tata and PAL. Constant is significant for only two firms.

In regime II, not all firms showed both types of learning. And in regime III, all of the firms show unsystematic learning, except for PAL and MUL. The sequence of learning pattern differs across the three regimes and can be grouped together for firms showing similar patterns. The time path of output shows a similar sequence for Tata and HM, with the two firms displaying both types of learning initially, then learning through internal resources and finally unsystematic learning. MUL and BTL follow a similar sequence--internal resources to spillovers. PAL and MM exhibit a similar pattern-- both types of learning in the first two regimes. But while PAL shows increasing returns to learning from spillovers, MM shows unsystematic learning.

PAL is a special case in the industry, having exited the industry despite considerable learning and despite constantly upgrading its technology. It was originally manufacturing a mid-size car based on its initial agreement with Fiat, which expired in the eighties. However, in the third regime, it went in for two new joint ventures, one with Peugeot to continue its old model and another agreement with Fiat for a smaller car to compete with Maruti. Despite its products doing well, it ran into problems with its collaborators—Fiat and Peugeot—who were also competitors. This finally resulted in the ending of the joint venture agreement between Peugeot and Premier and the take over of the other car project by Fiat.

References

1. Automobile Component Manufacturers Association (ACMA), "**Facts and Figures**", various issues.
2. Alice H. Amsden (1989), "**Asia's next giant: South Korea and late industrialization**", Oxford University Press, New York.
3. Barnes and Kaplinsky, "*Globalization and trade policy reform: whither the automobile component sector in South Africa*", ***Competition and Change***, Volume 4, No.2, 2000, pp211-243.
4. Basant, Rakesh and Pankaj Chandra (2002) " Building Technological capabilities in a liberalizing developing economy: firm strategies and public policy", **Economics of Innovation and New Technology**, Vol.11 (4-5), pp.399-421.
5. Benkard C. Lanier (2000), "Learning and Forgetting: The Dynamics of Aircraft Production," *American Economic review*, American Economic Association, vol. 90(4), pages 1034-1054.
6. Bowonder, B. (1998) "Competitive and Technology Management Strategy: case study of Telco", *International Journal of technology Management*, 15(6-7), June-July, pp: 646-681.
7. Cohen, W.M.& D.A. Levinthal (1990), "Absorptive Capacity: A new perspective on learning and innovation", *Administrative Science Quarterly*, vol. 35, 1990
8. Costa, Ionara (2001), "Ownership and Technological Capabilities in Brazil", Paper presented at the DRUID Academy winter conference.
9. D'Costa, A. P. (1995a). "The restructuring of the Indian automobile industry: Indian state and Japanese capital", *World Development*, 23(3), pp: 485-502.
10. Dosi, Giovanni.; Keith Pavitt and Luc Soete (1990) "**The Economics of Technical Change and International Trade**", New York University Press.
11. Dosi, Giovanni (1984), **Technical change and Industrial transformation**, London, MacMillan.
12. Ernst,D; Ganiatsos,T and Mytelka,L (edited 1998) "**Technological Capabilities and Export Success in Asia**", London, Routledge.
13. Evans, D.S (1987), "Tests of Alternative theories of growth of firms", *Journal of Political Economy*, 95(4), pp: 657-674.

14. Fagerberg. J (1987), "A technology Gap Approach to why growth rates differ", *Research Policy,* 16 (2-4), 87-99.

15. Figueiredo Paulo.N (2001), " Technological Capability-Accumulation Paths and the underlying learning processes: A review of empirical Studies", SPRU, University of Sussex, U.K. http://copenhagen.jibs.net/LitReview/2001/2001_1_26.pdf

16. Fransmann Martin & King Kenneth (Ed.), "*Technological Innovation, Industrial Organization and Comparative Advantages of Latin American Metalworking Industries*", **Technological Capability in the Third World**, 1984.

17. Geroski, Paul (1998), "An Applied Econometrician's View of Large Company Performance", *Review of Industrial Organization*, 13; 271-293.

18. Geroski, P., S.Lazarova, G.Urga and C.Walters (2001), "Are differences in firm size transitory or permanent?", *Journal of Applied Economics* (forthcoming).

19. Geroski, Paul; Marianna Mazzucato, (2002) "Learning and sources of corporate growth", **Industrial and Corporate Change**, August; 11;4; pp:623-644.

20. Gibrat R. (1930), "Une loi des réparations économiques: l'effet proportionnel", *Bull. Statist. gén Fr.* 19, 469.

21. Grilliches, Zvi (1979), "Issues in Assessing the contribution of R&D to productivity growth", *Bell Journal of Economics*, 10(1).

22. Hall, Bronwyn H (1987). "The Relationship Between Firm Size and Firm Growth in the U. S. Manufacturing Sector," *Journal of Industrial Economics*, Vol. XXXV, No.4, June 1987, pp. 583-606.

23. Hobday, M (1995), ''East Asian latecomer firms: learning the technology of electronics'', *World Development,* vol. 23, no. 7, (July), pp.1171-93.

24. Kathuria, Sanjay (1996), " **Competing through Technology and Manufacturing: A Study of the Indian Commercial Vehicle Industry**", OUP.

25. Katz, Jorge (1984), “Domestic Technological Innovations and Dynamic Comparative Advantage: Further Reflections on a Comparative Case-Study Program”, Journal of Development Studies, 16(2), pp.13-38.

26. Katz, Jorge ed., (1987) "**Technology Generation in Latin American Manufacturing Industries**", St.Martin's Press, NY.

27. Lane, I. Julia, Alan G. Isaac and David W. Stevens (1996), “Firm Heterogeneity and Worker Turnover”, *Review of Industrial Organization*, Vol.11, no.3, pp.275-291.

28. Langlois, Richard (1999), “Capabilities and Governance: The Rebirth of Production in the theory of Economic Organization” (with Nicolai J. Foss), *Kyklos* **52**(2): 201-218.

29. ___________ (1992) "Transaction-cost Economics in Real time *Industrial and Corporate Change* **1**(1): 99-127, reprinted in Nicolai J. Foss, ed., *Resources, Firms, and Strategies: A Reader in the Resource-Based Perspective.* Oxford: Oxford University Press 1997, pp. 286-305.

30. Narayana, K, (1998) " Technology Acquisition, De-regulation and Competitiveness: A study of Indian Automobile Industry", *Research Policy*, 27(2), 215-228.

31. Nelson, Richard R. and Sidney G. Winter (1982), *An Evolutionary Theory of Economic Change*. Belknap Press/Harvard University Press: Cambridge.

32. Nelson, Richard, (1987) " Innovation and Economic Development Theoretical Retrospect and prospect", in Katz, Jorge ed., **Technology Generation in Latin American Manufacturing Industries**, St.Martin's Press, NY.

33. Pakes, Ariel; Schankerman, Marke (1980), “An exploration into the determinants of research intensity”, NBER working paper no.438, January 1980.

34. Penrose, Edith (1959/1995), *The Theory of the Growth of the Firm*. Oxford University Press: Oxford.

35. Quentin, Erwan and John J. Stevens (2003), “Firm specific human capital versus job matching: a new test”, Finance and Economics Discussion Series, Board of Governors of the Federal Reserve System, U.S.

36. Spence, M. (1981), “The learning curve and competition”, *Bell Journal of Economics*, 12, pp.49-70.

37. Society for Indian Automobile Manufacturers (SIAM), Annual Reports, various years.

38. John Sutton, 1997. "**Gibrat’s Legacy”**, Journal of Economic Literature, American Economic Association, vol. 35(1), pages 40-59.