Determinants of Outsourcing in the Automobile Sector in India

Santosh K. Sahu & Ishan Roy

This study involves the determination of outsourcing based on the market structure, technology imports and technical efficiency for the automotive sector in India. An important characteristic of this study is that it divides the automotive sector into two subsectors: (1) the automobile ancillaries sectors, which provides the parts and constitute the upstream firms and (2) the automobile assemblers who assemble the automobiles and sell them to the consumers. Our analysis confirms the fact that when the data is segregated in the two sectors, factors like technical efficiency of firms have opposite effect on the outsourcing tendencies.

Santosh K. Sahu is Assistant Professor, Department of Humanities & Social Sciences, Indian Institute of Technology Madras, Chennai.E-mail: santosh@iitm.ac.in. ***Ishan Roy*** is from Madras School of Economics, Chennai. E-mail:ishan.roy91@gmail.com.

Introduction

Outsourcing or in-house production is a fundamental decision faced by every firm. In the last decades, outsourcing appears to be trending upward; many activities that once were performed in house are now outsourced to external suppliers (McMillan, 1995; Abraham & Taylor, 1996; Campa & Goldberg, 1997). Outsourcing is a practice used by different firms to reduce cost by transferring portions of work to outside suppliers rather than complete it in-house. On the other hand, vertical integration has also become a problem mainly due to the cost factor. Hence, firms in general tend to outsource their work and concentrate on their main activity to gain more from specialization. Grossman and Helpman (2002b) argue "firm seems to be outsourcing an ever expanding set of activities, ranging from product design to assembly, from research and development to marketing, distribution, and after-sales services". For example, it has been estimated that the American aircraft manufacturer Boeing and its European counterpart Airbus subcontract thousands of components from different manufacturers to be assembled into their passenger aircrafts. The empirical significance of production modes with partial subcontracting (as opposed to extreme production modes with exclusive in-house production or exclusive outsourcing) can be exemplified by the telecom (mobile phone manufacturing) industry. In this industry, Nokia, Motorola and Ericsson all apply outsourcing, but at different degrees. It is estimated that 15-20 percent of Nokia's production of mobile handsets is outsourced against 30-40 percent of Motorola's production, whereas, Ericsson outsources a dominant part of its production. In contrast, the German rival Siemens is known to apply outsourcing to a very limited extent (The Economist, 2002).

Domberger (1999), Ukalkar (2000), Grossman and Helpman (2002a) and Shy and Stenbacka (2003) present a large number of additional examples of outsourcing practices from a large spectrum of different industries. Firms outsource not only their final-product-related services, but also many input-related activities, such as research and development (R&D), advertising, and the production and services of many other intermediate inputs. Most observers refer to cost savings as an explanation for the large upswing in the outsourcing of manufacturing, but other than this production cost based approach, there is a transaction cost based approach where it is said that monitoring costs increase at an increasing rate as a function of the number of outsourced component production lines. Consequently, as the fraction of outsourced production lines becomes sufficiently large, in-house production will outperform outsourcing for some components or activities despite the marginal cost advantages associated with outsourced production.

As the fraction of outsourced production lines becomes sufficiently large, in-house production will outperform outsourcing for some components or activities despite the marginal cost advantages associated with outsourced production.

There is another approach which analyses the flow of outsourcing to developed countries. It assumes if a low cost product has some sophisticated parts in it other than which the rest can be assembled or made competitively in a low technology embodied poor country then that part has to be outsourced from the technologically advanced foreign firms. From the above given facts it is clear that cost minimization and competition being factors in the outsourcing decision market characteristics like firm size and R&D which becomes entry barriers to firms and influences competition and factors like exports in competitive markets become important.

The automobile sector has one of the largest amounts of outsourcing and hence, seems quite suitable for this study. For about 50 years after the first car arrived in India, they were directly imported. During the years between the wars small start-ups for an automobile industry was made when assembly plants were established in Mumbai, Calcutta, and Chennai in India. It was towards the end of the War II that the importance of establishing an indigenous automobile industry in India was realized when Premier Automobiles Ltd. (PAL) and Hindustan Motors (HM) set up factories in the mid-40s for progressive manufacture rather than assemble from imported components.

Independent India classified automobiles as an industry of importance, which would be controlled and regulated by the Government. In the decade that followed the establishment of the industry in 1954, local manufacturers concentrated on import substitution and indigenization. Model changes were minimal. Winds of liberalization in the early 1980s came as a series of liberal policy changes rapidly introduced marking a crucial turning point for the automobile industry. The de-licensing of the industry in 1993 opened the sluice gates for a flood of international auto-makers that rushed into what they saw as the last remaining untapped market. The next couple of years saw an unprecedented growth in the industry with assembly lines working overtime to meet demand. Slowly, with the IT and services sector boom in India and a growing middle class the demand for small and mid-sized cars began to grow which led to several Indian and foreign firms entering and prospering in the market and ending the monopoly of Maruti in terms of market share. With the growth of Indian firms like Tata and Mahindra & Mahindra (M&M) Indian automotive sector started to spend more on R&D to not only sell in India but also to capture markets abroad. Similar sort of purchasing power in east European and certain African countries made them ideal locations for export of cars that were tailor made for Indian markets. In recent years, many foreign companies like Hyundai have also started setting up plants in India. The main automobile hubs in India are based at Chennai, Gurgaon-Manesar, Pune, Ahmedabad, Halol, Aurangabad, Kolkata, Noida and Bangalore. Chennai is the biggest hub accounting for 60 percent of Indian auto exports. The auto components industry, although largely concentrated near automobile hubs, is fairly widespread in other parts of the country too. Table 1 presents the turnover and asset for 2014 for the select automotive firms in India.

Most of the companies which are included in the above table invest in their in-house R&D units. Indian companies like Tata Motors Ltd, Mahindra & Mahindra are at par with foreign multinational companies. From 2001-2002 to 2005-2006, the Indian automobile sector has grown at an average annual rate of over 18 percent in terms of output at constant 1993-1994 prices and the auto-component sector has grown at about 26 percent. During the same period, in terms of domestic sales in numbers, two-wheelers segments have grown at over 13 percent per annum; three-wheelers at more than 15 percent, commercial vehicles at about 25 percent and the number of passenger vehicles by 17 percent per annum. There are two distinct sets of players in the Indian auto industry, (1) automobile component manufacturers and (2) the vehicle manufacturers, which are also referred to as Original Equipment Manufacturers

(OEMs). While the former set is engaged in manufacturing parts, components, bodies and chassis involved in automobile manufacturing, the latter is engaged in assembling of all these components into an automobile unit.

Table 1 Turnover & Assets for Select Automotive Firms in India

Rank	Company	Profit(Rs.Cr)	Assets(Rs.Cr)
5	Tata Motors Ltd.	13991.02	141453.53
17	Mahindra & Mahindra Ltd.	4666.93	69184.97
30	Maruti Suzuki India Ltd.	2852.90	23961.00
49	Hero Moto Corp Ltd.	2109.80	5982.22
56	Bajaj Auto Ltd.	3380.08	10435.17
104	Ashok Leyland Ltd.	29.38	13277.36
120	Sundaram Clayton Ltd.	141.23	2710.16
123	Bosch Ltd.	884.70	6768.20
135	TVS Motor Company Ltd.	186.30	1951.12
162	Eicher Motors Ltd.	393.94	3252.42

Source: Economic Times (2014)

Automotive Component Sector

The Indian automotive component manufacturing sector consists of 500 firms in the organized sector and around 31,000 enterprises in the un-organized sector. In the domestic market, the firms in this sector supply components to vehicle manufacturers, other component suppliers, state transport undertakings, defense establishments, railways and even replacement market. A variety of components are exported to OEMs abroad and after-markets worldwide. The automobile manufacturing sector, which involves assembling the automobile components, comprises two-wheelers, three-wheelers, four-wheelers, passenger cars, light commercial vehicles (LCVs), heavy trucks and buses/ coaches. In India, mopeds, scooters and motorcycles constitute the two-wheeler industry, in the increasing order of market share. India is a global major in the two-wheeler industry producing motorcycles, scooters and mopeds principally of engine capacities below 200 cc. However, there are a lot of differences in terms of the two sub-sectors in the automobile sector.

The effective rate of protection on automobiles is much higher than on components. This differential rate of effective protection distorts resource allocation and investment patterns in the industry. The auto-component sector has much higher employment-generation potential and export-intensity than the auto assembly segment of the sector. The component manufacturers are now globally competitive and are also maintaining reasonable profitability levels despite a tariff protection bias. Therefore, a study which differentiates amongst these submarkets is important in order to better understand how outsourcing of the Indian automobile sector is affected by different factors. The objective of this work is to findout the determinants of outsourcing based on the market structure and technology imports. Here, we shall use a panel data framework in order to ascertain the factors responsible for outsourcing in the Indian automotive market. The other objective is to arrive at differential effects on outsourcing in the parts manufacturing and assembly sectors.

Related Literature

Elfring and Baven (1994) studied the outsourcing of technical services and the stages of development, based on an investigation of the development of two service functions, software development and engineering in the automobile industry. This inquiry revealed the importance of '*learning and leverage*', and the need for a successful combination of functional and application capabilities to achieve to competitive advantage. The study describes the evolution in the development of service functions. This has involved a gradual move from in-house development to a more autonomous status in which external clients also play a role. This often leads to the closure of the in-house unit, and in the final stage the service supplier offers a package of related services. This explanation for outsourcing seemed particularly important for determining the reasons for outsourcing of the downstream sector.

Insinga et al (2000) shows in today's business environment, companies are driven to conduct a few functions in-house and to obtain the rest from other sources through aggressive outsourcing. While outsourcing may seem attractive at the strategic management level, serious pitfalls are often encountered as the strategy is pushed downward into operations. At the operational level, the strategic intent tends to be lost in a hectic day-to-day, problem-to-problem business environment. Outsourcing decisions made at the operational level can easily lead to dependencies that create unforeseen strategic vulnerabilities. These pitfalls are addressed by a systematic methodology that can guide the operational level to achieve strategically appropriate actions.

Outsourcing decisions made at the operational level can easily lead to dependencies that create unforeseen strategic vulnerabilities.

From Mol et al. (2005), outsourcing of intermediate products to international suppliers is believed to improve firm performance. This paper, tests key dimensions of the decision to outsource internationally using a survey data of 200 manufacturing firms located in the Netherlands. They found that most international outsourcing is intra-regional in nature. Furthermore, international outsourcing is a consequence of a firm's ability to search and evaluate foreign suppliers, which is co-determined by its size, multi-nationality, and frequency of cross-border communications. Firm size has also been seen as an important characteristic of firms though some interpretations are different from it.

As Aghion et al. (2006) noted increased competition in the upstream markets due to an increase in the number of firms reduces the overall level of asset specificity. It also improves the ex-ante bargaining position of downstream firms and thereby minimizes their possible hold-up costs. This leads to the hypothesis "when outsourcing is the preferred organizational form, upstream markets with high asset specificity, is characterized by a high degree of competition". This was one of the first approaches that analyzed both, degree of competition and the production technology in upstream and downstream markets and related to the outsourcing decision. Since industry characteristics such as market structure and cost structure were the main focus of the analysis, this contributed to explain the cross-sectional differences in outsourcing activities. Our study is different from this in how we differentiate the industry in context. Instead of giving asset specificity importance more focus is given to exports and R&D which to a certain extent captures the nature of the market and the inter-firm competition.

Tang and Qian (2008) show that one of the product lifecycle management (PLM) tasks is to control the collaboration between the automotive OEM and its suppliers, through deciding on an appropriate supplier integration way. Meanwhile, aiming at reduction of the expenditure for partnership management and coordination i.e. the transaction costs, the automotive OEM tends to have direct connections with limited number of capable and effective suppliers, called system suppliers. Other suppliers, called sub-suppliers no longer directly communicate with the automotive OEM, but instead with a system supplier who works closer with the automotive OEM and deals with the task of sub-supplier management and coordination.

The cost advantages of outsourcing closely relate to the level of asset specificity.

Schmidt-Ehmcke (2009) develops a framework that combines insights from the neoclassical production theory and transaction cost theory considerations for the German automobile industries. More particularly, the author derives two hypotheses that consider the interplay between outsourcing, asset specificity, production technology and market structure. The derived hypotheses are tested by simultaneously estimating the production technology and the degree of competition in upstream and downstream markets. The first hypothesis was "when outsourcing is the preferred organizational form, upstream markets with low asset specificity are characterized by increasing returns to scale production technologies". It is important to note that the cost advantages of outsourcing closely relate to the level of asset specificity. In other words, if the technology becomes more specific, the aggregation of demands from different firms generates fewer savings. Further, the transaction cost theory predicts that downstream firms can be locked into hold-up problems due to high bilateral dependencies.

Grey et al. (2009) infers that outsourcing of production has escalated over the past decade due to unprecedented competition and worldwide access to low-cost labor markets and tries to examine how cost and quality priorities - two key attributes of manufacturing strategy - influence a manufacturer's propensity to outsource. This paper bridges the existing gap between research on manufacturing strategy and firm boundaries. This paper develops a theory-based model that links a manufacturer's cost and quality priorities to its plans to outsource production. The empirical analyses, based on survey data obtained from 867 manufacturing business units, control for firm-specific factors previously shown to impact outsourcing, including asset specificity, uncertainty, and current capabilities in cost and quality. It was found that the competitive priority placed on cost played an integral role in sourcing decisions, while, surprisingly, conformance quality priorities did not. The significant effect of cost priority on outsourcing shows that any theory of firm boundaries that fails to consider competitive priorities is incomplete. The findings regarding quality, which was counter to expectations, may partially explain why there is an emergence of so many nonconforming products associated with outsourcing. Taken together, the results provide theoretical insights for future research into how manufacturing managers can improve their decision making on outsourcing production.

Data & Methodology

Based on the literature mentioned above and the objective of this paper in this section, we present the concept of downstream firms (firms that assemble parts such as brakes, tyres, seats etc. from other suppliers) and upstream firms (firms that produce the specific parts that act as inputs for the downstream firms). They are important to differentiate, as they are evidently different in nature, and can be an important factor in explaining the nature and extent of outsourcing. Following the National Industrial Classification (NIC) 2008 codes we differentiate downstream and upstream firms from the two digit classification. Data is collected from the Center for Monitoring Indian Economy (CMIE) Prowess online corporate database. Data has been chosen from the Indian automobiles and ancillary suppliers industry. It has an upstream sector comprising final assemblers such as Eicher Motors, and downstream section comprising small and large parts suppliers. Data are collected for the 2002-2013 annually, of around 465 firms operating in the Indian market, of which finally we have used the data on 99 firms. Of these, 9 firms are upstream while the rest 90 are downstream. The main objective of choosing this time frame relates to the recent market scenario post information and technology (IT) revolution in the new open and booming Indian economy. The indicators of interest from the CMIE database for this study include R&D expenses, firm age, firm size, export, technology import and outsourcing at firm level. The definitions of the variables, are presented in Table 2.

Now, we describe the estimation of the technical efficiency and the financial internal rate of returns. A stochastic fron-

Table 2 Definitions of the Variables

Sl. No	Variable	Definition
1	Outsourcing intensity	Ration between sum of outsourcing manufacturing and professional jobs to net sales
2	Firm age	Subtraction between year of study to year of incorporation of the firm
3	Firm size	Natural log of net sales
4	R&D intensity	Ratio between R&D expenses to net sales
5	Export intensity	Ratio between export to net sales
6	Technical efficiency at firm level	technical efficiency calculated from production function with inputs such as capital, labour, energy and raw materials at firm level
7	Financial internal rate of returns	financial return on investment of income generation activity at firm level
8	Technology import intensity	Ratio of sum of royalty paid, capital goods import, technical knowhow fees to net sales at firm level

tier production function can be expressed as follows:

$$Y_{it} = f\left(X_{it}, t; \beta\right) e^{v_{it} - u_{it}}$$

Where Y_{it} is the output of the i[th] firm (i = 1,…, N) in period t = 1,…,T; $f\left(X_{it}, t; \beta\right)$ represents the production technology; X_{it} is a (1 × K) vector of inputs and other factors influencing production associated with the i[th] firm in period t; β is a (K × 1) vector of unknown parameters to be estimated; v^{it} is a vector of random errors that are assumed to be iid $N(0,\beta^2_v)$; and u_{it} is a vector of independently distributed and nonnegative random disturbances that are associated with output-oriented technical inefficiency. Specifically, u_{it} measures the extent to which actual production falls short of maximum attainable output. If the firm is efficient, the actual output is equal to potential output. Thus, $Y_{it} - Y^*_{it} = u_{it}$, where, u_{it} = inefficiency. The technical efficiency of a producer at a certain point in time can be expressed as the ratio of actual output to the maximum potential output and the technical efficiency can be calculated as.

$$TE_{it} = \frac{Q_{it}}{f\left(X_{it,} t; \beta\right) e^{-u_{it}}} = e^{-u_{it}} \text{ ....(1)}$$

The error term representing technical inefficiency is specified as:

u_{it} = exp (-η(t-T)) ....(2)

Under this specification, inefficiencies in periods prior to T depend on the parameter η. As t tends to T, u_{it} approaches u_T. Inefficiency prior to period T is the product of the terminal year's inefficiency and exp (-η(t-T)). If h is positive, then exp (-η(t-T)) = exp (η(t-T)) and it is always greater than 1 and increases with the distance of period t from the last period T. The positive value of η indicates inefficiencies fall overtime, whereas negative value of η indicates inefficiencies increase overtime. The above model can be estimated by the maximum likelihood estimates (MLE). Restricting $\mu = 0$ in the model, it reduces the model to the traditional half normal distribution. If μ is not restricted then μ follows truncated normal distribution. If $\eta = 0$, then technical efficiency is time-invariant i.e., firms never improve their efficiency. The value of $\gamma = \sigma^2_u/\sigma^2$ (where $\sigma^2 = \sigma^2_u + \sigma^2_v$) will lie between 0 and 1. If u_{it} equals zero (which indicates full technical efficiency) then γ equals zero and deviations from the frontier are entirely due to noise v_{it}. If γ equals one all deviations from the frontier are due to technical inefficiency. Besides on the above rationality, the following Cobb-Douglas specification of functional form is employed to specify the parameters of the model to estimate the efficiency since it is widely used one in efficiency studies. The functional form in present case is:

$$InQ_{it}=\beta_{it}+\beta_2 InC_{it}+\beta_3 InL_{it}+\beta_4 InM_{it}+\beta_5 InE_{it}+\nu_{it}-\eta_{it}u_{it} \quad \ldots\ldots(3)$$

Where, Q = Output; C = Capital; L = Labor; M= Material; and E = Energy

The parameters of the stochastic frontier model, defined in equation (4), is estimated by using the FRONTIER 4.1 computer program under the 'production function' option, developed by Coelli (1996). For estimating productive efficiency and technical change specified above we have used data drawn from the Center for Monitoring Indian Economy. In this study, gross output at constant prices is used as a measure of real output. Prowess reports gross output data in value terms (Rs. Lakhs). Nominal values of gross output are deflated by the wholesale price indices for industrial goods. Wages and salaries of employees are considered for the labour input. Unlike other factors of production, capital is used beyond a single accounting period and measuring capital stock input is rather problematic. For capital stock we have followed, perpetual inventory method (PIM), as followed in Goldar et al. (2004) and many other studies on Indian manufacturing sector. The mean technical efficiency of the sample is calculated at 0.95. Further, the financial internal rate of returns (FIRR) are calculated by equating the present value of investment costs (as cash out-flows) and the present value of net incomes (as cash in-flows) using the following equation:

$$I_0 + \frac{I_1}{(1+r)^1} + \frac{I_2}{(1+r)^2} + \ldots + \frac{I_m}{(1+r)^m} = \sum_{n=0}^{m} \frac{I_n}{(1+r)^n} \quad \ldots\ldots(4)$$

Where, I_0 is the initial investment costs in the year 0 and $I_1 \sim I_m$ are the additional investment costs for maintenance and rehabilitation for the entire project life period from year 1 to year m. This calculation of FIIR allows us to investigate whether these sample firms have increasing return to scale.

Table 3 presents the descriptive statistics of the sample firms that also dif-

R&D is higher for the upstream firms whereas technology import is lesser which shows that upstream firms in the automotive sector are much more innovative through in-house R&D.

Table 3 Descriptive Statistics

Statistics	R&D intensity	Technology import intensity	Efficiency	Outso-urcing	FIRR	Firm age	Firm size	Export intensity
Full sample								
Mean	0.215	0.24	0.398	0.191	5.255	24.904	7.512	0.998
SD	2.908	1.086	0.131	1.472	1.529	14.358	1.642	4.82
P10	0	0	0.259	0	3.441	9	5.589	0
P50	0	0.012	0.371	0.008	5.254	23	7.448	0.068
P75	0.017	0.077	0.47	0.044	6.354	30	8.474	0.367
P99	3.293	4.955	0.781	1.916	8.694	72	12.365	32.664
Upstream firms								
Mean	0.23	0.235	0.41	0.054	5.144	24.896	7.508	0.39
SD	3.048	1.067	0.13	0.149	1.509	14.593	1.672	1.221
P10	0	0	0.272	0	3.363	9	5.572	0.001
P50	0	0.013	0.383	0.008	5.166	23	7.444	0.058
P75	0.016	0.083	0.48	0.045	6.297	30	8.463	0.304
P99	3.35	4.02	0.823	0.729	8.325	73	12.403	5.371
Downstream firms								
Mean	0.062	0.283	0.278	1.561	6.365	24.981	7.553	7.083
SD	0.249	1.263	0.069	4.662	1.272	11.798	1.31	14.198
P10	0	0	0.173	0.001	4.621	11	5.984	-0.111
P50	0.003	0.008	0.278	0.014	5.948	19.5	7.508	0.325
P75	0.023	0.03	0.333	0.039	7.1	32.5	8.589	3.385
P99	1.577	5.912	0.427	20.004	8.694	51	10.745	56.303

Source: Data collected from CMIE prowess database; Note: SD, refers to Standard deviation, P 10, P 50, P75 and P99 refers to percentile distribution at 10, 50, 75 and 99 percentiles, respectively

ferentiate between the upstream and the downstream firms. R&D is higher for the upstream firms whereas technology import is lesser which shows that upstream firms in the automotive sector are much more innovative through in-house R&D. This might be due to the fact that the downstream firms which are mostly the exporters to the developing countries and usually cater the lower-end domestic market. In these segments, there are lesser needs for more sophisticated products that require higher R&D. Protection from direct high technology imports in the form of high import duty might be a reason why these firms have neglected the R&D front. For technology import the mean is not that different between the two sub-categories. This is indicative of the fact that R&D intensity is not merely for the trajectory changes that are mainly there for absorbing the technological imports. The upstream firms are seen to be moderately more efficient. This might be due to the fact that these firms are slightly smaller in size than the downstream ones and focus on one product rather than diversifying in to different products. Export intensity, however, is higher for downstream firms indicating that the ancillary industries cater to the domestic automotive firms. Firm age and size, are not that different amongst the two groups, though we see large variance for both the sectors in terms of firm size. This is especially the case of the upstream firms.

Determinants of Outsourcing

Followed by the descriptive statistics, we have performed equality of mean tests individually to verify the differences between the two groups. The results show that while the groups are different in terms of some variables they are similar for the remaining variables. However, with all the variables, the multivariate test of mean equality confirms that the groups are statistically different (Appendix 1). Table 4 reports the correlation matrix of the variables of interest. As we observe from the above table, the export intensity is positively related with outsourcing intensity which might be due to specialization in products. Firm size has a negative relation with outsourcing intensity. Technical efficiency is negatively related to outsourcing intensity, as efficient firms tend to carry most of the activities themselves and are less likely to outsource.

Firm size has a negative relation with outsourcing intensity.

The idea is to arrive at the determinants of outsourcing intensity for the sample of firms for the full and the subsamples. Initially this exercise is carried out with OLS estimation and the results are presented in Appendix 2. Given the data is panel in nature, the tests for heteroskedasticity, multicollinearity and autocorrelation were further carried out. The statistics for the Breusch-Pagan/ Cook-Weisberg test for heteroskedasticity is found to be (Chi^2 = 14153.31***) that refers to the presence of heteroskadasticity in the sample. Further, multicollinearty test is carried out using the variance inflation factor (VIF) and the Wooldridge test for auto correlation in panel data is used to test for the autocorrelation. VIF shows the absence of multicollinearity, and Woolridge's test shows that the test is significant and hence, serial autocorrelation is present in the sample.

In order to see the effects without heteroskedacticity, OLS with Robust estimate is further estimated (Appendix 2). We also draw separate estimates for the two groups in this case. However, given the structure of the data in use, we estimated the Fixed and the Random Effects model. The Hausman test is carried out which confirmed the efficiency of the Random Effects model. The results are however not satisfying and may be due to the serial correlation amongst the variables. Therefore, we need to use a model that takes into account the serial correlation and heteroscedasticity to provide robust, consistent and efficient estimates. The nearest model is the multi-stage Parks method.

However, the multi-stage Parks method has dangers. Beck and Katz (1995) have two major arguments on this. First, the estimates of the β's are more inefficient (higher variance) than OLS, and the second is the estimates of the

Table 4 Correlation Matrix

	Outsourcing Intensity	Firm age	Firm size	R&D intensity	Export intensity	Technology import intensity	Technical efficiency	FIRR
Outsourcing intensity	1							
Firm age	0.139	1						
Firm size	-0.093	-0.014	1					
R&D intensity	0.007	-0.026	-0.076	1				
Export intensity	0.421	-0.002	-0.174	0.004	1			
Technology import intensity	-0.019	0.022	-0.157	0.007	0.206	1		
Technical efficiency	-0.191	-0.001	0.506	-0.068	-0.267	-0.104	1	
FIRR	0.245	0.012	-0.758	0.078	0.305	0.143	-0.71	1

Source: data collected from CMIE prowess database

variances of the β's from the last stage GLS are biased downwards. This happens because the estimate of Ω is never exactly equal to Ω The basic argument is that the process of repeatedly estimating band Ω can "*compound*" inaccuracy in the standard error of β estimates. The estimates of the standard errors do not take into account uncertainty of the Ω estimates, but rather just take the estimates and plug them in.

One of the feasible solutions to overcome this problem is to use the method proposed by Beck and Katz (1995), i.e., the panel-corrected standard errors (PCSE). The attractiveness of this approach, according to them, is that common techniques applied to time-series cross-section (TSCS) data produce incorrect results, in particular with regard to the accuracy of standard errors. This method makes it possible to test the hypothesis of interest while also taking into consideration the high degree of heterogeneity across firms. This method unlike the computable general equilibrium method does not impose any assumptions on the possible values of the coefficients and relies on more flexible hypotheses.

One of the advantages of PCSE is that it overcomes the well-known problem from OLS estimates in panel-data techniques, when one or more Markov assumptions are not satisfied. Initially, PCSE comes from an earlier work by Parks (1967), where the presence of temporal and spatial correlation in the error term as well as heteroskedasticity is explicitly taken into account and is estimated by Generalized Least Squares (GLS). However, the use of this method can lead to dramatic underestimates of parameter variability in the common research, due to the assumptions made on the structure of the error term. The alternative, often used by researchers, is to apply Feasible Generalized Least Squares (FGLS), which relaxes the assumption of known errors structure and uses an estimate of the error process. However, this method is not free from objections because when there are a large number of parameters to estimate. FGLS underestimates the standard errors of the coefficients between 50 percent and 300 percent, according to Monte Carlo Simulations (Beck & Katz, 1995). Knowing these drawbacks, Beck and Katz (1995) proposed some modifications on Parks' estimator in the formula for the sampling variability of the OLS estimates, which make more efficient estimates. Thus, following Beck and Katz's approach, the standard formulation of Time Series Cross-Sectional (TSCS) models or Panel data models under the assumption of poolability is as follows:

$$y_{it} = x_{it}\beta_{it} + \lambda_i + \lambda_t + \varepsilon_{it}; i = 1....n, t = 1...T ..(5)$$

$$e_{it} = \lambda_i e_{it-1} + \lambda_{it} ....(6)$$

Where x_{it} is a vector of k exogenous variables and observations indexed both by firms (i) and by time (t). y_{it} denotes the vector of observations on the dependent variable and, λ and λ are the individual and time effects respectively. The covariance matrix of the errors (NT x NT) has the common element $E(e_{it}, e_{js})$ by λ v_{it} is the error term independently distributed across time, while λ_i indicates the first-order serial correlation. On using this model we formulate the following regression equation to be estimated.

$$OI_{it} = \alpha_{it} + \beta_1 FA_{it} + \beta_2 FS_{it} + \beta_3 RD_{it} + \beta_4 EI_{it} + \beta_5 TII_{it} + \beta_6 TE_{it} + \beta_7 FIRR_{it} + \varepsilon_{it} ....(7)$$

Where, OI refers to outsourcing intensity, FA refers to firm age, FS presents the firm size, RD represents R&D intensity, EI refers to export intensity, TII refers to technology import intensity, TE refers to technical efficiency and FIRR is financial internal rate of returns at firm level. The results of equation (7) are presented in Table 5.

Table-5 Determinants of Outsourcing Intensity

Variables	Full Sample	Upstream firms	Downstream firms
Firm age	0.013***	-0.001	0.189**
Firm size	-0.046	-0.010**	-1.529***
R&D intensity	0.003*	0.004***	-0.163
Export intensity	0.093***	0.030***	0.028
Technology import intensity	-0.098***	-0.030***	-0.083
Technical efficiency	-0.216	-0.107*	20.737**
FIRR	0.097*	0.019**	1.249**
Constant	-0.285*	0.083*	-5.514*

Note: *Significant at 10%level: **5% level: ***1%level
Source: Data collected from CMIE prowess database

It is evident that older firms have higher outsourcing intensity and this is similar for the downstream firms.

From the results, it is evident that older firms have higher outsourcing intensity and this is similar for the downstream firms. One possible reason might that older firms have survived for a longer time in the market and specialize in as assemblers and have long term relations with parts and services suppliers. This is quite similar to the Japanese system of production. Firm size has an insignificant impact for the full sample, but negatively associated when taken individually. This might be a result of the obvious fact that a large firm probably has all the assets needed for manufacturing of all the components that need to be produced in house. However, the smaller sized firms in both downstream and upstream groups have less outsourcing intensity.

R&D intensity has a positive impact on outsourcing intensity. This might be because a firm which carries out R&D is more focused towards its own product and hence, leaves other jobs to be outsourced. It has a negative impact for downstream firms but appears to be insignificant. This might be due to the fact that not much R&D is carried out by firms downstream as evident from the descriptive statistics as well. Export intensity has a positive and significant impact on all the firms, separately as well as when taken together. This again can be attributed to the fact that firms that exports tend to be more competitive and specialized and hence, they concentrate on their major product leaving other jobs to be outsourced. Technology import intensity seems to have a significant negative impact on outsourcing intensity. This might indicate that a firm which is not at the forefront of technology import is not so focused on the outsourcing activities

Technology import intensity seems to have a significant negative impact on outsourcing intensity.

either. In terms of technical efficiency the results are quite interesting. For the upstream firms the more technical efficient firms are involved in higher outsourcing, while the result is opposite for the downstream firms. This might be due to the fact that an assembler, if it has to produce everything itself cannot be efficient and hence, has to outsource to stay efficient, while ancillaries are more focused on one product and usually building it from scratch.

Conclusion

It may be concluded from the analysis that in general at industry level more experienced firms that participate actively in competitive markets through exports are more likely to outsource so as to concentrate on their main product and leave the non-essential jobs to the other firms. These firms are not afraid of the transaction costs and possibly negate that by forming long term associations with their outsourcers. These firms are in general characterized by their R&D activities, which they conduct to remain competitive in the market and depend less and less on already market available standard technology. However, these industry characteristics require some further probing by dividing the industry into its two main and quite different subsections, the upstream parts suppliers and the downstream assemblers. A closer inspection of the industry in terms of comparing the two subsections reveals that on average slightly smaller upstream section carries out a lot of R&D and is not dependant on the experience of the firm. They specialize and are fiercely competitive and outsource to focus on their main product. Therefore, in all we find two different motives that force the two types of firms in the same industry. While one is driven by competition, being forced to outsource to focus on their major activity the other outsources only when it is not large enough to do everything on its own and can assimilate all the outsourced goods effortlessly and efficiently. The different nature of two subsegments of the Indian auto industry warrant further research into how the two subsegments have grown, given their different operating nature and where this growth will take them once this heavy growth stabilizes. The Indian automotive sector is now facing extreme pressure from foreign players who boast of large R&D units. On the other hand the "Make in India" initiative promises some growth prospective for the Indian players either alone or in a joint venture format.

References

Abraham, G. & Taylor, S. K. (1996), "Firms' Use of Outside Contractors: Theory and Evidence", *Journal of Labor Economics*, 14(3): 294-42

Aghion, P., N. Bloom, P. Howitt, R. Griffith & R. A. Blundell (2006), "Competition and Innovation: An Inverted U Relationship", *Quarterly Journal of Economics*, 120(2), 701-28

Beck, N. & J. N. Katz, (1995), "What to Do (and not to do) With Time-series Cross-section Data", *American Political Science Review*, 89: 634-47

Campa, J. & Goldberg, L. (1997), "The Evolving External Orientation of Manufacturing Industries: Evidence from Four Countries", *NBER Working Paper*, No. 5958

Coelli, T. J. (1996), "A Guide to Frontier Version 4.1: A Computer Program for Stochastic Frontier Production and Cost Function Estimation", Working Paper No.07, Center for Efficiency and Productivity Analysis, University of New England, Armidale, Australia

Domberger, S. (1999), "The Contracting Organization: A Strategic Guide to Outsourcing", Oxford: Oxford University Press

Economics Times, (2014), http://economictimes.indiatimes.com/et500

Elfring, T. &G. Baven (1994), "Outsourcing Technical Services: Stages of Development", *Long Range Planning*, 27(5): 42–51

Goldar, B. N., V. S. Renganathan &R. Banga (2004), "Ownership and Efficiency in Engineering Firms: 1990-91 to 1999-2000", *Economic and Political Weekly*, 39(5):441-47

Gray, J. V., A. V. Roth & B. Tomlin (2009), "The Influence of Cost and Quality Priorities on the Propensity to Outsource Production", *Decision Sciences*, 40(4): 697–726

Grossman, S. J. & E. Helpman (2002a), "Integration versus Outsourcing in Industry Equilibrium", *Quarterly Journal of Economics*, 117 (1): 85-120

_______________ (2002b), "Outsourcing in a Global Economy", National Bureau of Economic Research (NBER), Working Paper No. 8728

Insinga, R. C. & M. J. Werle (2000), "Linking Outsourcing to Business Strategy", *The Academy of Management Executive*, 14(4):58-70

McMillan, J. (1995): "Reorganizing Vertical Supply Relationships", in Siebert, H. (ed.), Trends in Business Organization: Do Participation and Cooperation Increase Competitiveness, J.C.B. Mohr, Tübingen

Mol, M. J., R. J. M. van Tulder & P. R. Beije (2005), "Antecedents and Performance Consequences of International

Outsourcing", *International Business Review*, 14(5): 599-617

Parks, R. (1967), "Efficient Estimation of a System of Regression Equations when Disturbances Are Both Serially and Contemporaneously Correlated", *Journal of the American Statistical Association*, 62:500-09

Schmidt-Ehmcke, J. (2009), "Technology, Firm Performance and Market Structure", Doctoral Dissertation, Unpublished, available at http://d-nb.info/999909207/34

Shy, O. & R. Stenbacka (2003), "Strategic Outsourcing", *Journal of Economic Behavior & Organization*, 50: 203-24

Tang, D. & X. Qian (2008), "Product Lifecycle Management for Automotive Development focusing on Supplier Integration", *Computers in Industry*, 59 (2-3): 288-95

The Economist, (2002), "The Fight for Digital Dominance, Special Report Nokia vs Microsoft" : 67-69

Ukalkar, S. (2000), Strategic Procurement Management for Competitive Advantage, Oxford University Press, New Delhi

Appendix 1 Test for Equality of 2 Group Means

	Statistic	Prob>F
Wilks' lambda	0.735	0.000e
Pillai's trace	0.265	0.000e
Lawley-Hotelling trace	0.361	0.000e
Roy's largest root	0.361	0.000e

e = exact

Appendix 2 OLS, Robust OLS & Robust OLS for Both Sectors

Variables	OLS	OLS Robust		
		Full Sample	Upstream	Downstream
	Coefficient	Coefficient	Coefficient	Coefficient
Firm age	0.015***	0.015***	-0.001**	0 .224***
Firm size	0.139***	0.139***	-0.020***	0.223
R&D intensity	0.001	0.001	0.005***	-0.069
Export intensity	0.120***	0.120***	0.057***	0 .036
Technology import intensity	-0.158***	-0.158***	-0.062***	-0.264***
Technical efficiency	0.157	0.157	-0.145***	-27.000***
FIRR	-2.713***	-2.713***	0.269**	1.618*
Constant	-2.441	-1.987	-1.096	-1.564

Note: ***, ** and * refers to statistically significant at 1, 5 and 10 percent level respectively

Appendix 3 Comparison of Different Models

Outsourcing	OLS	Fixed effects	Random effect	Linear regression with a dummy variable
Firm age	0.014***	0.074	0.035***	0.014***
Firm size	0.105*	-0.158	-0.084**	0.105*
R&D intensity	0.002*	0.003***	0.003	0.002*
Export intensity	0.109*	0.054	0.065***	0.109*
Technology import intensity	-0.149**	-0.061	-0.070***	-0.149**
Technical efficiency	0.392*	0.808	0.148	0.392*
FIRR	0.230***	-	0.117	.230***
Constant	-2.441**	-0.841	-0.769	-2.392**

Note: ***, ** and * refers to statistically significant at 1, 5 and 10 percent level respectively