Quality Certification and Performance of Software Service Companies in India

Qualifier Part A paper.

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Abstract:

Significant software development is taking place offshore in countries such as India. Competitive pressures have induced many Indian software firms to apply for and receive quality certifications like the ISO-9000 and SEI-CMM. Although such quality certifications have become increasingly popular in the US and Europe, there is very little empirical evidence on the impact of quality certification on organizational performance. This study is based on a three year sample of 66 Indian software firms. We find that quality certification does not have a significant effect on the revenue per employee level, nor the growth rate of these firms. These findings suggest that Indian firms, by operating in a commodity market, have not been able to improve their efficacy in providing software services and reap the benefits of superior software quality practices.

Key Words: Quality certification, performance, revenue per employee, growth, ISO, CMM.

1. Introduction:

The computer software industry in India is in the midst of phenomenal growth. The annual growth rate of the industry has been above 50 % for the past three years, and many companies have posted a growth rate of over 100%! From an insignificant element in India's portfolio of exports, this industry, with around $2 billion in exports last year, has jumped to the fourth position, after textiles, leather goods and jewelry and gemstones. Local demand for software services is still modest and exports are 66% of the total revenues earned by the industry.

Quality is a major concern for software developers. Quality certifications, such as the International Standards Organization's ISO9000 [1] series and Software Engineering Institute's Capability Maturity Model (CMM^{SM})[2] have become increasingly popular among software vendors in Europe and the US. In Europe the ISO9000 is often required. Case studies at Hughes [3] and Raytheon [4] have shown the effect of process improvements yielding economic benefits. Rising wage cost and the desire to move up the value chain for software services has prompted many Indian firms to go in for quality certification. The Government also provides incentives to firms with such certifications.

The evidence on the impact of quality certification is still sparse. Herbsleb et. al.[5] have argued, based on user elicitation, that CMM based process improvements lead to better project management at organizations. However, there does not exist any systematic, large sample, study of whether and by how much a firm benefits from becoming quality certified [6].

In this paper, we use a dataset we have developed to analyze the impact of quality certification on the performance of 66 Indian firms. The next section discusses the measurement of software productivity, and quality certification. Section 3 introduces the Indian software industry and the status of quality certification, followed by a discussion of measures of performance in section 4. We discuss our empirical methodology and the issues regarding measurement and data collection in section 5. Section 6 contains the empirical results. Finally, section 7 discusses the policy implications and concludes.

2. Software Quality : Measurement, Metrics and Certifications

Over the past few decades, computers have become an important part of out lives. The rapid progress in hardware technology has changed the cost structure of computer systems from 80:20 for hardware: software costs in the 1970s to approximately 10:90 in the 1990s[7]. The importance of software has focused greater attention on improvements in Software engineering. According to the IEEE glossary [8], "Software Engineering is the systematic approach to the development, operation, maintenance and retirement of software". A software product is conceptual and has no physical or electrical properties like weight, color or voltage. Consequently, there are no physical or electrical laws that govern Software engineering [9]

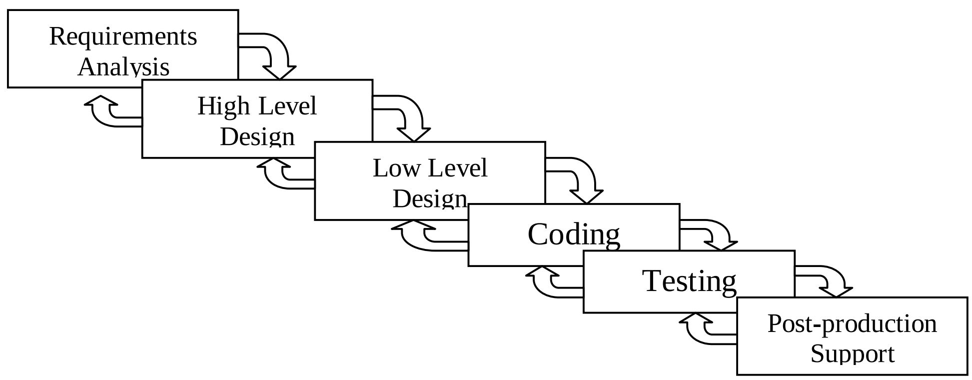

Fig1: The Waterfall Model of software development [10]

In manufacturing industry, it is easy to define quality standards and install systems or processes to ensure compliance. However, in software, defining quality standards is itself difficult. People form the critical input in software. Software engineering practices attempt to minimize the variance caused by human factors and are emerging as standards for any complex software development effort.

The Waterfall Model (Fig.1) is a popular software development framework[1]. The software development process is divided into the following sequential parts: requirements analysis, high level design, low level design, coding, testing and post-production support. Within each of these main areas, there are established sets of software engineering practices. The establishment of these processes and a method measuring them for process improvement is the essence of a quality program.

In 1987, the International Standards Organization (ISO) developed a framework for production standards, the ISO9000 series, which has since been adapted to software

[1] An alternate model of software development is the Spiral Model[10]

development. Around the same time, the Software Engineering Institute (SEI) developed a framework called the Capability Maturity Model (CMM) primarily for US defense related software vendors. (See Appendix-1 for more details on the ISO 9001 and CMM model.) The implicit assumption in these frameworks is that good processes lead to good quality of product.

2.1 Measurement and Metrics

Difficulties in quantifying and measuring software artifacts, has been a major obstacle in introducing globally accepted standardization procedures [11]. Measurement of software has traditionally been through the measure of the source lines of code (SLOC). The rapid progress in software technology via high-level languages and newer approaches of analysis have reduced the usefulness of this metric [12]. The proliferation of newer languages and coding paradigms where several languages are used within the same software complicates this issue further. This measure also does not account for the complexity of the code.

Halstead [13] proposed metrics for length and volume of a program based on operators and operands to be used as a measure of size. (See Appendix-2 for details.) Another measure proposed by Albrecht and Gaffney[14] is the use of Function Points (FPs). This is designed to size a system in terms of its delivered functionality, measured in terms of objects such as the numbers of inputs, outputs and files. Each of these objects is assigned a weight depending on the object complexity and importance. Measures for complexity include McCabe's cyclomatic complexity [15] and Halstead's complexity measure[13]. The strength of the FP measure is that it is independent of programming language and can used at the requirements specification stage to size and cost the software [9]. However, the measure of function points is prone to human subjectivity, and requires considerable effort in estimating the total function points for large and complex systems. Finally, these measures are difficult to collect for large sample studies and many Indian firms do not collect such data.

3. The Indian Software Industry

The Indian software industry in 1997-98 had revenues of about $3Bn. Though small compared to the world market for software, it has been growing at an annual rate of about 50% for the past five years [16]. Most of the Indian firms are small and young, and are involved exclusively in software development. The median size of a firm in 1997 is 70 professionals whereas the largest firm employs about 8000 professionals.

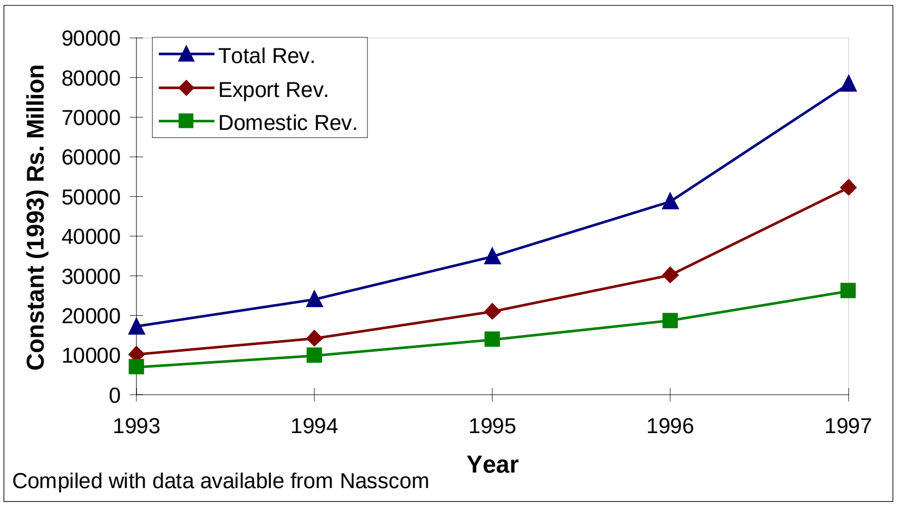

Fig. 2: Software Industry Revenues, (1$=Rs. 30)

Few firms develop software products; most provide software services that are not very specialized or exclusive. Skilled labor is the main input and firms recruit from national or regional labor pools. Most firms have evolved from maintenance of legacy systems, to lower end software development services, like testing of products and low-level design and coding of software components. In a typical export project, the clients provide the vendor with the functional specifications of the applications to be developed. The vendor does not participate in the early stages of conceptualization and high-level design. Apart from coding of the requisite modules, the Indian firms also carry out the testing, except the acceptance testing which is carried out by the client or the final customer. There are very few instances where the Indian software firm was entrusted with the development of the requirement specifications.

Exports of software services account for more than 60% of the revenue, with the US accounting for 50% of the export revenue. The labor scarcity in the US, especially for software developers and systems analysts appears to be responsible for this boom in India. The share of activities in export is shown in Fig. 3. Professional services, consultancy and data services forms about 85% of the exports. A portion of these exports comes from Year2000 related activities.

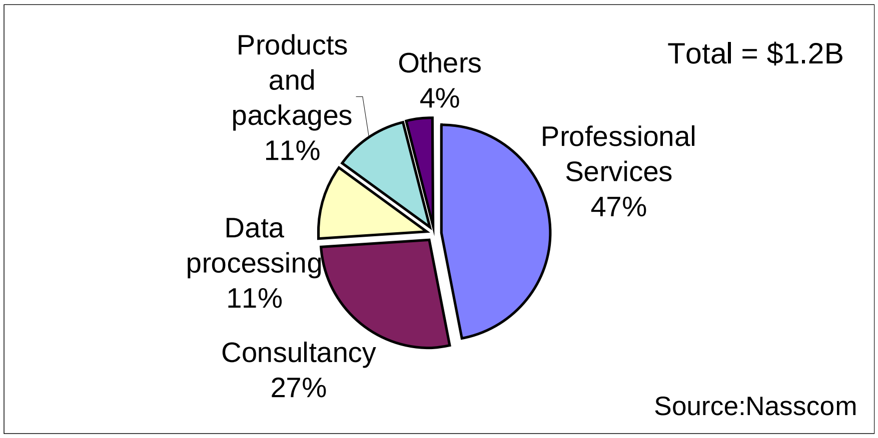

Fig. 3: Share of various activities in exports for the year 1996-97

Onsite and offshore are two modes by which companies earn their export revenues. The billing rates differ considerably between these two modes. There is a clear cost advantage -- lower wages, easy availability of labor and fiscal incentives by the government for software exports -- to offshore work (in India) [17]. Competitive pressures have induced many firms to obtain quality certification.. The government has also granted special subsidies and licenses to firms that are certified by some standard[2]. The National Association for Software Service Companies (NASSCOM), an Indian trade organization, has a self-proclaimed aim to persuade all organizations having more than 10 employees to get certified by the year 2000.

[2] In accordance with the Provisions of Exim Policy announced by the Ministry of Commerce, Government of India, manufacturers/ processors who have acquired the quality status of ISO 9000(Series) or IS/ISO 9000 (Series) or ISO 14000 or HACCP Certification or WHO-GMP certification are eligible for the grant of Special Import License which is calculated at 5% of the FOB value of the exports.

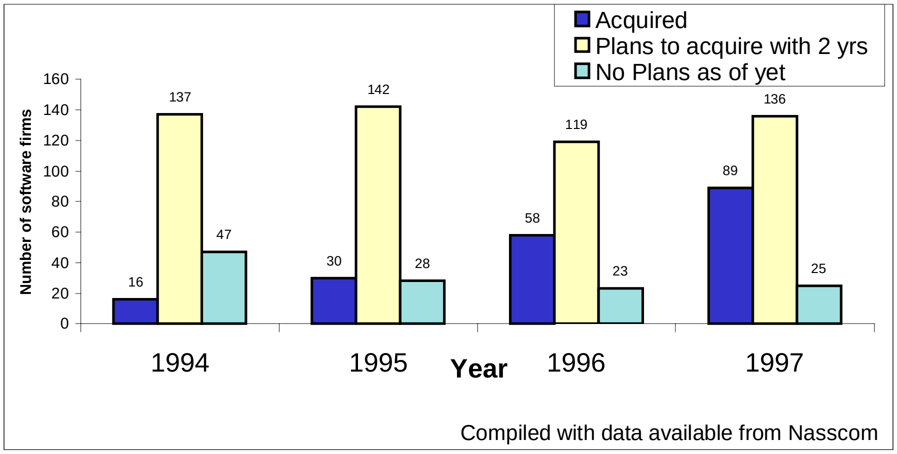

Fig. 4: Status of quality certification in India

Most Indian firms follow a typical procedure to attain a quality certification. They first develop a set of processes, based on the ISO or CMM standards. These processes are documented and adhered to by projects within the organization while delivering software services. Once process stability is achieved, independent auditing organization are called to audit the company's processes and assess adherence to ISO or CMM guidelines [18]. The initial ISO certificate is valid for two years, after which another external audit must be passed to keep the certification. There is no reassesment provision in CMM certification. The SEI's CMM is acknowledged by most firms to require a more rigorous quality program, and CMM levels 4 and 5 are a target for most companies that are ISO certified [19].

4. Measures of performance: Productivity and Growth

To evaluate the effect of quality certification on the organization, we need a measure of performance. Measures such as lines of code and function points pose problems in the Indian context. The lines-of-code measure is ineffective as Indian vendors develop software in many languages and a variety of platforms. Few Indian firms collect function point measures.

We therefore use revenue per employee (productivity) as a measure of performance for Indian companies. Since organizations recruit their employees from the same labor market, we assume that the average wage rate is approximately the same across all organizations[3]. Software companies are located in big cities where the cost of living is approximately the same.

Since skilled labor is the main input for a software service provider, [7], we can write the profit function of firm as:

$$\pi = R - \overline{w} \times L$$
$$R = f(L, T, D, \gamma)$$

Where, π is the profit, ***L*** the labor, ***w*** the average wage rate for the organization per employee and ***R*** the revenue earned. ***R*** is a function of labor, technology, domain and other factors[4](γ). One can see that profit per employee is directly proportional to the revenue per employee generated.

$$\frac{\pi}{L} \alpha \frac{R}{L}$$

Another measure for performance that we shall consider is the rate of growth (ΔR/R). This is because, even at a given level of revenue per employee (productivity), the greater the scale of operation, the greater the revenue and the greater the total profits. Thus, overall firm profits depend upon two factors - the productivity and growth.

4.1 How Quality Certification will affect Productivity and Growth

The types of contracts used in export projects in the Indian software industry are either fixed-fee, time-and-material, or minor variations of the same [20]. In a fixed-fee contract, the deliverables as well as the deadline for the project is decided. The contract may include penalty clauses for late delivery and for poor quality. In a time-and-materials contract, the client pays on a man-hour basis. The project team size is decided in consultation with the client.

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[3] Informal discussion among software professionals (companies keep their employee wages secret) suggests that the salary differentials between different companies are marginal and differences depend only on skills sets and years of experience in the same.

[4] One could argue that capital forms an important input, however, we assume that it is proportional to labor.

The process improvement brought about by quality certification should directly affect productivity(R/L) or growth rate (ΔR/R) in the following ways.

1. *Reducing overall cost:* From the perspective of a fixed-fee-contract, through increased re-use of software modules or by reduced rework through lower defects [20], the overall costs should decrease [6]. This should increase the revenue per employee earned.
2. *Increasing revenues:* Through higher quality and timely development, the bonus clauses usually incorporated in the contract should increase revenue and hence productivity [18].
3. *Through higher rates or higher value projects:* By promising to provide higher quality of services, the firms should be able to command higher rates per man-hour [21]. This would reflect in the increased productivity for time-and-material type of contracts. For fixed price projects, the vendor should be able to win higher value projects that, in some cases, should also imply a higher price.[5] [19].
4. *Bidding for new clients:* The quality certificate provides a leverage while bidding for software projects with new clients and retaining existing ones [22][23]. This should reflect in a higher growth rate for quality certified firms.
5. *Learning to bid accurately*: Through a structured methodological approach, companies are able to manage the requirements better and estimate the project better [19]. This should result in lower costs (a smaller "bench"), a greater probability of winning a project, or both. This effect should be reflected both in productivity level as well as growth rate.

In sum, if there is a real benefit due to certification, with regards to improvement in process, then we expect that firms that are quality certified to have higher productivity. If certification acts as a signal, then we should observe quality-certified firms growing faster soon after obtaining the certification.

The Indian software industry is an ideal test bed for exploring the issue of quality-certification because:

[5] These projects are said to be larger, more complex, newer technologies and part of the core business of the client. In some cases, the benefits may only accrue in the more distant future.

1. Most of the software firms produce only software and revenues reflect software sales.
2. Most of the software firms deliver software services rather than products. In this sense, revenues are a good measure of "physical" output. By contrast, revenues from packaged products depend on the perceived utility of the product on advertising its compatibility with existing systems and other phenomena such as network externalities that may be present.
3. With a few exceptions, firms have more or less the same skill sets[6] and compete in the same market for their services.

5. Empirical analysis

5.1 Data: Sources and Limitations:

The information used in building our dataset is primarily drawn from the NASSCOM software directory printed every year[24]. Most other information was obtained from Dataquest, a trade journal. The background and context information was obtained from industry reports [25][26], and interviews, phone-calls and email messages.

For this study, I visited India for a month and spent considerable time at two large firms (including one that does not readily allow access to outsiders), that are now assessed at CMM level 4. We wanted to study the practices they follow and the procedures that are in place. We had an occasion to compare their practices with another firm that was not certified and not seeking such certification either. We also interviewed a firm that provides guidelines to software firms seeking a quality certificate.

The type of information available about each firm apart from its revenues and employee strength, are its quality certification status, business domains for which it provides software services, its technical areas of specialization, geographic location and legal structure. A dataset spanning a time-period of three years (1995,1996 and 1997) was thus compiled.

Criteria: We selected all firms providing software services for which complete information exists over the entire time-period. From this, we excluded that combined hardware/package sales with software services were not included, as the cost structure of

[6] Specialization in the Indian software industry is yet to emerge

those firms differ greatly from software service firms. In addition, we removed very small firms (fewer than 10 employees in any year).[7] This results in a sample of 66 firms.

5.2 Characteristics of the Sample:

The information obtained from our primary source (NASSCOM) is derived from questionnaires that the organization sends out to each of the member companies. NASSCOM member companies generate 95% of the industry revenues, so we are assured that we are not missing out any significant players in the industry. The primary source of information on firms for the year 1996 is from Dataquest and we believe it is noisier than the Nasscom data. Hence we also constructed an alternate panel of just the two years (1995,1997) to cross check results[8].

The firms in the sample are roughly similar in their technical capabilities, provide services for the same set of computer platforms but the business domains of their clients may differ. Our sample accounts for only 66 firms. However these firms accounted for 66% of the total industry revenue in 1995. Table 1 shows that the distribution of certified firms amongst the major regions of India is roughly uniform:

Table 1: Distribution of certified firms by city

City	**Firms in sample**	**No. of firms Certified**	**Percentage certified**
Bangalore	15	10	66%
Mumbai & Pune	20	12	60%
Delhi, Gurgaon, Noida	15	8	53%
Other	16	7	43%

[7] The cost of ISO certification is approximately Rs. 40,000 per day and would take 4 days for a company of size 200[22]. It is should be noted that certification can be awarded to a company of any manpower size and there is no minimum requirement. NASSCOM[24] proposes that all firms above a size of 10 employees should get certified by the year 2000.

[8] All the estimates were redone with a two-year panel dataset (1995 and 1997) to check the robustness of the three year panel results. The alternate panel for years 1995 and 1997 had more firms, but since this panel has only two time-periods, we could not measure the immediate effects of certification. The results obtained from this panel for productivity level of firms was substantially unchanged.

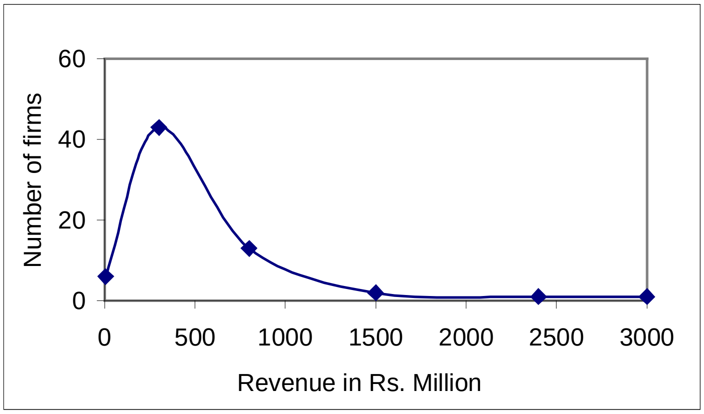

Fig.5: Distribution of Revenues (in 1995)

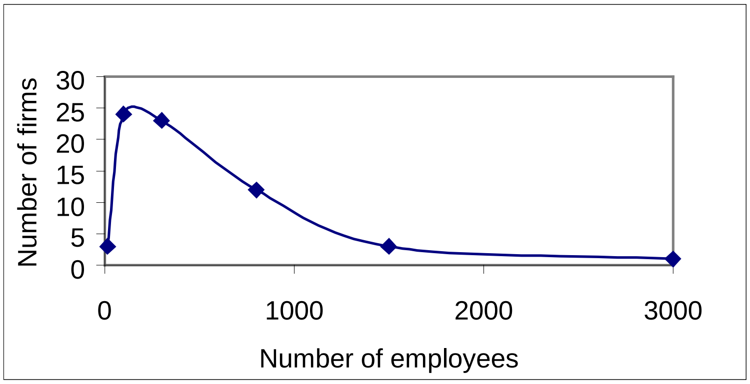

Fig.6: Distribution of Employees (in 1995)

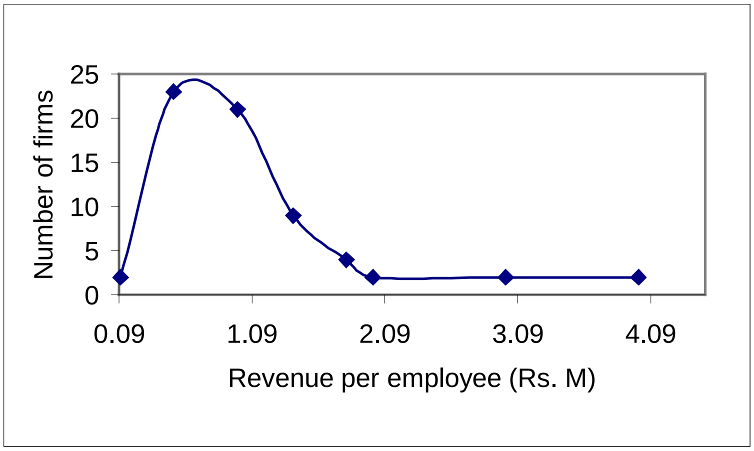

Fig. 7: Distribution of Revenues per Employee (1995)

The size distributions of firms shown above in Fig.5, Fig.6 and Fig.7 are similar for the years 1996 and 1997. The distribution of revenues and number of employees of firms is roughly log-normal[9]. Therefore, we use the logarithms of these variables in the empirical analysis. Table 2 gives the descriptive statistics for the sample.

Table 2: Descriptive statistics of the sample (Size = 66)

Year	Variable	Median	Mean	Min.	Max.
1995	Revenue (Rs. M)	78.2	265.3	1.75	3500
	Manpower	163	288	11	3970
	Quality Certified	17			
1996	Revenue (Rs. M)[3]	120.4	368.5	1.1	4808
	Manpower	172	382	11	5259
	Quality Certified	26			
1997	Revenue (Rs. M)[3]	144	461.5	1.3	6297
	Manpower	225	584	15	9000
	Quality Certified	37			

3 – Adjusted to constant (1995) Rs.

In this analysis, all revenues are adjusted to constant 1995 Rupees, using the average inflation rate of 7% for both years.

6. Analysis and Results

To analyze the effect of quality certification, we focus on productivity(R/L), and the growth (ΔR/R). We have compiled data for a period of three years (1995,1996 and 1997), enabling us to measure the performance of certified and non-certified firms over time. The Ordinary Least Squares method (OLS) on pooled data assumes that the errors are uncorrelated across firms in a given period as well as uncorrelated over time for a given firm [27]. Errors for a firm may be correlated over time, and similarly, errors may be correlated across firms in a given time period. To account for these correlations we use variance component model, the Fuller-Battese model for random effects[28]. (See appendix 3 for statistical detail of method). The model can be written as:

$$y_{it} = \mathbf{X}_{it}\beta + \varepsilon_{it}$$
$$\varepsilon_{it} = \alpha_i + \nu_t + \eta_{it}$$

Where y_{it} is the dependent variable (for observation i at time t), $\mathbf{X}_{it}$ is the vector of

[9] Empirical tests for the distribution of revenues and manpower was conducted and this assumption was confirmed.

independent variables which affect *y*, β is the vector of coefficients for each of the independent variables. The error term (ε_{it}) consists of the firm specific effect (α_i), a time specific effect (ν_t) and a random error term (η_{it}). We assume here that α_i, is not correlated with X_{it}[10].

Since revenues are approximately log-normal, we use the following specifications, where the β's are the coefficients we estimate by regression.

$$\ln(\textit{Revenue}) = \beta_1(\textit{Certification status}) + \beta_2 \ln(\textit{Manpower}) + \beta_3(\textit{Control Variables}) + u_{it} \quad \ldots (i)$$

$$\Delta\ln(\textit{Revenue}) = \beta_4(\textit{Certification status}) + \beta_5 \ln(\textit{Lagged Manpower}) + \beta_6(\textit{Control Variables}) + u_{it} \quad \ldots (ii)$$

To ensure that we are measuring the effect of certification for comparable firms, we use a number of control variables. They are:

1. *Domain*: From our field study we identified, communication software, telecommunications and year-2000 conversion services as major distinct domain areas. To account for firms working in newer areas and higher paying segments of the market, we control for firms working web-related and enterprise resource planning (ERP) software services. We use dichotomous variables, *Telecom*, *Commsoft*, *Year2000*, *Netbased* and *ERPS* which take the value of 1 if the firm provides services in that area and 0 if it does not.

2. *Legal structure*: Firms such as Texas Instruments India, and Citicorp Overseas Software Ltd., are subsidiaries of foreign firms and have different payment schemes for their services. We control for this kind of arrangement by using a dummy variable, *Captive*, that takes a value 1 for these types of firms and 0 for all other firms.

3. *Age*: More established and older firms may perform better. We code age a set of categories: firms of 1-4 years, 5-7 years and more than 8 years of age[11].

4. *Onsite and offshore services*: Billing rates per man-hour differ considerably between onsite and offshore services [17]. To control for this, one would ideally use the percentage of exports earned onsite/offshore. However, this information is available only

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[10] Another model used on panel data is the fixed effects model, which was found to be not suitable for our panel.
[11] We also coded age as a continuous variable, and the results remained qualitatively unchanged.

for a few firms. The data-communication bandwidth of the firm to its client sites is correlated with the percentage of work done offshore. We use this as a rough proxy for offshore percentages.

Quality certification: Quality can be represented in a couple of ways. In one specification, quality certification is coded as a simple binary state variable, *Qcert*, that takes a value of 1 if the firm is certified, and 0 if not. Its coefficient measures whether the average productivity or growth for quality certified firms is different from that of non-certified firms. However, it leaves unanswered the question of causality, namely whether quality certification is directly responsible (causes) for the differences, or whether the differences arise from other factors.

Although we cannot definitely answer the question, we can exploit the time-series nature of the data to probe this issue. In essence, instead of merely comparing certified and non-certified firms, we can also compare the performance of certified firms before and after certification. We construct two variables *Qcateg1* and *Qcateg2*, that are defined as : *Qcateg1* takes a value of 1 if the firm has been certified for a period of one year and 0 otherwise and *Qcateg2* takes a value of 1 if the firm has been certified for a period of two years and 0 otherwise. *Qcateg1* measures the average productivity increase of a firm, one year after certification and *Qcateg2* measures the average productivity increase of a firm, two years after certification as compared to a firm that has never been certified. Further, since exploratory analysis suggested that there may be significant differences across firms depending when the firm obtained certification, we categorize the certified firms into three categories based on the year of certification. The three groups are: i) *Qyr94* - firms certified in 1994[12], ii) *Qyr95* - firms certified in 1995, and iii) *Qyr96* - firms certified in 1996.

We shall use two specifications for each of the equations *(i)* and *(ii)*. In one specification, we shall use the simple variable *Qcert*, and in the second specification, we use *Qyr94*, *Qyr95*, *Qyr96*, *Qcateg1* and *Qcateg2*. (See appendix 4 for details about dummy variables used.) The results are shown in Table 3. Standard errors are given in parenthesis beside the coefficient value.

[12] Two firms that were certified before 1994 were also considered part of this group.

Table 3: Results

Specification	1	2	1	2
Variable	**ln(Revenues)**	**ln(Revenues)**	**Δln(Revenue)**	**Δln(Revenue)**
Intercept	-0.78(0.44)*	-0.30(0.46)	0.42(0.34)	0.49(0.35)
ln($Manpower_t$)	0.93(0.09)***	0.86(0.09)***	-	-
ln($Manpower_{t-1}$)	-	-	0.05(0.07)	0.03(0.08)
% from export	0.01(0.05)	-0.01(0.05)	-0.19(0.2)	-0.19(0.20)
Captive	0.73(0.36)**	0.66(0.37)*	-0.08(0.25)	-0.11(0.26)
Datacom	-0.10(0.05)**	-0.07(0.05)	-0.06(0.06)	-0.06(0.06)
Telecom	0.03(0.26)	-0.04(0.27)	0.05(0.18)	0.04(0.19)
Commsoft	0.19(0.21)	0.22(0.22)	-0.20(0.15)	-0.21(0.15)
Year2000	-0.11 (0.24)	-0.20(0.25)	-0.07(0.17)	-0.07(0.17)
Netbased	0.14(0.23)	0.16(0.24)	0.02(0.16)	0.04(0.17)
ERPS	0.52(0.22)**	0.53(0.22)**	-0.11(0.15)	-0.09(0.15)
Age (1-4yrs)	0.05(0.2)	0.06(0.21)	0.10(0.19)	0.06(0.21)
Age (5-8yrs)	-0.14(0.14)	-0.12(0.15)	0.03(0.14)	0.001(0.16)
Qcert	**0.33**(0.15)**	-	-0.05(0.18)	-
Qyr94	-	0.71(0.31)**	-	0.17(0.25)
Qyr95	-	0.17(0.34)	-	0.13(0.30)
Qyr96	-	0.41(0.32)	-	0.13(0.25)
Qcateg1	-	**0.18**(0.12)	-	**0.05**(0.24)
Qcateg2	-	**-0.08**(0.15)	-	**-0.29**(0.22)
Degrees of Freedom	186	181	119	115
Adj. R-square	0.59	0.60	0.05	0.07

*** - p<0.01, ** - p<0.05, * - p<0.1

In specification 1, the estimated value of coefficient β_2 is 0.33. This means that, quality certified firms had an average productivity, 1.39($e^{0.33}$) times that of comparable non-certified firms (significant at a 5% level). From column 3, the coefficient on *Qcert* in the growth equation is small and insignificant. This implies that quality certified firms, on an average, did not grow any faster than, comparable non-certified firms. The higher productivity(R/L) observed may however be the result of other characteristics of the firm that obtained certification, and not an effect of the quality certification *per se*. We thus need to study the differences in the productivity and growth of firms *before and after* the certification exercise.

These are shown in columns 2 and 4. The results suggests that the higher productivity level for certified firms in specification 1 may be driven by the superior performance of firms that were certified in 1994. If so the question is whether this superior performance is causally related to quality certification. The coefficients of *Qcateg1* (0.18) and *Qcateg2* (–0.08), are small in magnitude and statistically insignificant. The signs on the coefficient mean that the estimate on productivity moves up after the first year and then falls in the second year in comparison to similar non-certified firms[13]. This suggests that the long-term effect of certification on productivity is also **not** significant. Similarly in the growth equation (column 4) we see that effect of one or two years of certification on growth is not significantly different from that of non-certified firms. This implies that certification does not seem to have an effect on the growth rate of the firm either.

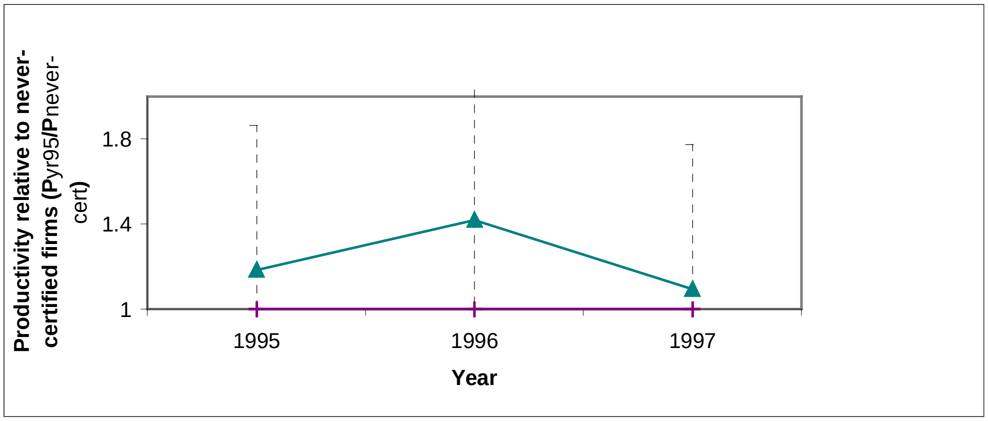

Fig.8: Productivity level of firms certified in 1995 relative to never-certified firms

To understand the coefficients in column 2, take for example firms that were certified in 1995[14] (Refer to Fig.8 and column 2 of Table 3). The estimate of the coefficient for *Qyr95* is 0.17. Hence, the estimate of productivity (*P*) is $e^{0.17}$ times the productivity of a firm that was never certified ($P_{cert-95} = e^{0.17} X\ P_{never-cert}$). This means that, on an average, the revenues earned per employee by a firm certified in 1995, was 1.2 times that of a firm that was never certified (not significant). One year after certification (1996), the estimate of productivity relative to non-certified firms is $e^{0.35}$ or 1.4 times that

[13] The sample size to estimate *Qcateg1* is 37 (17+9+11) and *Qcateg2* is 26 (17+9).
[14] For firms certified in 1994 and 1996, we do not observe the firms before and after certification, respectively

of firms never certified.[15] In 1997, the productivity level falls to $e^{0.09}$ or 1.09 times the productivity of non-certified firms. This shows that certification does not increase the productivity level of the firms certified in 1995 *after* certification.

Since the productivity level of certified firms does not increase significantly after certification, our result does not support the notion that, certification results in higher rates per man-hour, larger bonuses for performance or even lower overheads through better project management. We also do not see a significant increase in growth rate of certified firms, as compared to non-certified firms. Thus, our result does not support the hypothesis that firms with a quality certification have a greater probability of obtaining winning a new contract.

Firms that were certified in 1994 may perform better for a variety of reasons. The largest firms in the industry, namely TCS, Wipro, Satyam and Infosys belong to this group. Our field research suggests that the absolute size of the firm (in revenues as well as number of employees) appears to be important in receiving contracts. From our interviews, we learnt that many clients demand a large number of professionals be committed to their projects. Only the large firms are to be able to provide this[16]. From Table 4 we see that firms that were certified in 1994 are also somewhat older than the other firms.

[15] 0.35 is obtained by adding the coefficient of *Qcateg1* (0.18) to the coefficient on *Qyr95*(0.17). It is not statistically significant.

[16] It is interesting that a couple of large lucrative projects from American clients were turned down by these large companies in the recent past due to the significantly large requirements of professionals for the project.

Table 4: Summary statistics of firms in 1995

Group (Number)	Variable	Median	Mean (Std. Dev.)	Minimum	Maximum
Certified in 1994 (17)	Revenues	322.8	590.6 (820)	22.5	3500
	Manpower	287	665 (942)	85	3970
	Age	9	11 (6)	3	27
Certified in 1995 (9)	Revenues	131.4	143.3 (122)	21	352
	Manpower	195	288 (210)	50	600
	Age	4	5.5 (4.6)	2	17
Certified in 1996 (11)	Revenues	120	345.3 (578)	3.8	1987
	Manpower	226	245 (173)	17	600
	Age	4	4 (1.5)	1	6
Never Certified (29)	Revenues (Rs. M)	26	82.2 (146.3)	1.75	588.7
	Manpower	50	83 (87)	11	409
	Age (years)	6	6.3 (3.3)	1	16

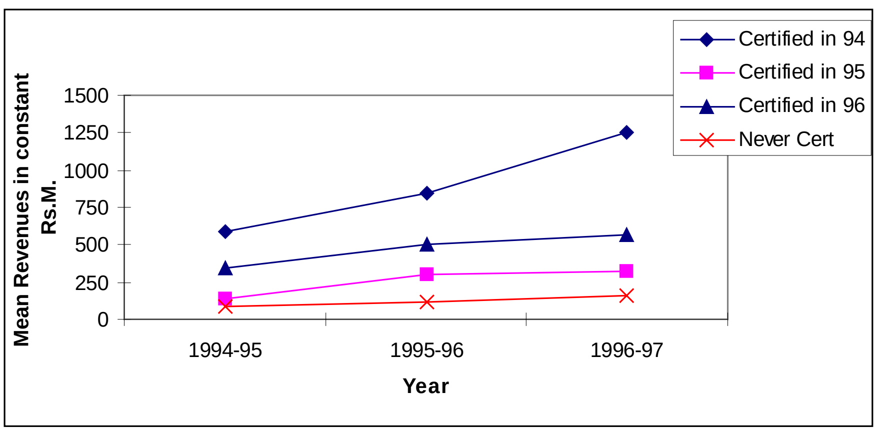

Fig.9: Revenues of firms by groups (Rs. 1M=$31K)

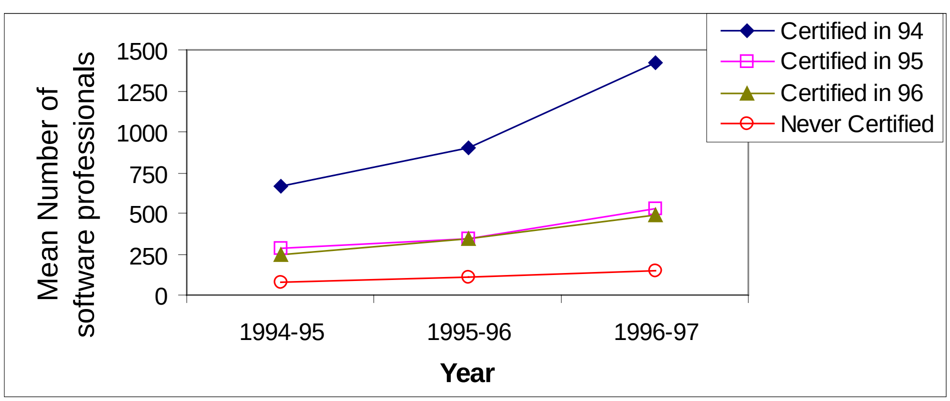

Fig.10: Employment of firms by groups

The results suggest that the firms that were certified in 1994 have been able to get comparatively higher rates for their services (revenue per employee). It is also possible that these firms have benefited from economies of scale, by better management of "bench time".

6.2 Future Work

The research thus far has raised certain issues that we plan to address in our future work. One area of concern is the lack of data about specific characteristics about firms. We have developed and mailed a questionnaire[17] from which we hope to get 120 to 150 responses. Since quality certification is a matter of choice for the companies, in future research we can use information (like revenue, employment, export share of revenues) from an earlier period to predict when firms get quality certified. This too requires systematic data from earlier years. Specifically we plan to collect data on:

1. *Earlier years*
2. *Skill composition workforce:* In this study, we have assumed a uniform distribution of skills across firms. We plan to better control for the skill composition of the workforce.[18]
3. *Project types and sizes*: Our questionnaire should provide more information on the types and sizes of export projects. This will help us better control for differences in specialization and task complexity.
4. *Onsite-Offshore development*: Direct measures instead of the rough proxy currently used will improve the precision of our estimates.

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[17] The questionnaire can be accessed at http://www.heinz.cmu.edu/project/india/

[18] This includes the graduating institutes and type of degrees like BS, MS, PhD, etc.

7. Policy Implications and Conclusions

The pursuit of certification by the Indian software vendors and the incentives given by the government to obtain such certificates assumes that quality certification improves economic performance. Our analysis suggests that the benefits may be modest. The firms in our sample that got certified, were in the first place, doing better than the firms that were never certified. The change in productivity levels for these firms after certification is not significant. There seems to be no effect to the growth rates either.

It appears that Indian firms, by opting for the lower end of the software services market have excluded themselves of the substantial benefits from certification. However, in a broad policy framework, it does not mean that superior practices and quality certification should be abandoned. However, they should form part of a broad policy framework that encourages firms to move up the value chain for software services. Large software service firms in the US, like Computer Sciences Corp.(CSC), provide "solutions". This involves development of more complete and complex software systems. In these "high-value" projects, the firms are responsible for the complete lifecycle of the product. Due to the mission criticality and complexity of these systems, a good methodology is very important. We note that CSC, which generates about $150,000 per employee[19], has been assessed at CMM level 5, and is ISO certified.

The ability to execute large and complex projects depends on the following factors:

i) A high level of capability and process maturity to instill confidence in the clients,

ii) Easy access to better-trained and qualified, professionals and managers,

iii) Adequate infrastructure facilities like reliable high speed data-communication links to provide reliable offshore support,

iv) A low attrition rate to maintain a high level of experience and retention of domain expertise while executing such projects.

To address the issues of maturity, institutes to train professionals in software engineering methodology are needed. Certification alone would not compensate for lack of better academic training in Software engineering. One also needs innovative policies to protect

[19] for 1998

intellectual property rights and help firms develop and build domain experience and specialization. Without an adequate increase in Indian infrastructure, in communications, in trained human resources and innovative government policies to protect intellectual property rights, India may find it difficult to significantly gain from the large global market for software.

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