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Delays and Cost Overruns in Infrastructure Projects:
An Enquiry into Extents, Causes and Remedies

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ABSTRACT

Media reports abound on instances of prolonged delays and excessive cost overruns in infrastructure projects. Only a small number of projects get delivered in time and within the budget. Examples of successful project implementation, like construction of the Delhi Metro Rail, are few and appear only far in between. Indeed, the problem of time and cost overruns in India is widespread and severe. Yet, very few empirical studies exist on the subject. Even rarer are the studies based on completed projects. As a result, the extents as well as the causes behind delays and cost overruns have remained under-researched. This study investigates the various issues related to delays and cost overruns in publically funded infrastructure projects. The following questions are posed and answered: How common and how large are the time and the cost overruns? What are the essential causes behind these delays and cost overruns? Are the underlying causes statistically significant? Are Contractual and Institutional failures among the significant causes? What are the policy implications for planning, development and implementation of infrastructure projects? The study is based on, by far, the largest dataset of 894 projects from seventeen infrastructure sectors. Among other results, it shows that the contractual and the institutional failures are economically and statistically significant causes behind cost and time overruns.

KEY WORDS: Delays, Cost Overruns, Time Overruns, Infrastructure, Projects, Causes, Contractual Failures, Organizational Failures, Institutional Failures

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1. Introduction

Infrastructure projects in India are infamous for delays and cost overruns. Recently commissioned, Bandra-Worli Sea Link amply demonstrates the state of project delivery system in the country. What was planned as a Rs 300 Crore project to be completed by 2004 has actually cost Rs 1,600 crore along with a delay of five years. Indeed, very few projects get delivered in time and on cost. The delays and cost overruns have become hallmark of infrastructure projects in India. The quarterly reports of the Ministry of Statistics and Programme Implementation (MOSPI) stand testimony to a saga of unfettered delays and cost overruns. Yet, the extents and the causes behind the time and the cost overruns have remained understudied. As a result, the types of the policy interventions required to rectify the malady have also remained unidentified.

Delays and cost overruns have significant implications from economic as well as political point of view. Due to delays in project implementation, the people and the economy have to wait for the provisions of public goods and services longer than is necessary. Thus, delays limit the growth potential of the economy. Similarly, cost overruns reduce competitiveness of the economy. Services provided by infrastructure projects serve as input for other sectors of the economy. Cost overruns in these projects lead to an increase in the capital-output-ratio for the entire economy. Simply put, delays and cost overruns reduce the efficiency of available economic resources and limit the growth potential of the entire economy. Moreover, at least as of now, most infrastructure projects in India are funded by taxpayers' money. Therefore, taxpayers have right to know about how efficiently their money is utilized by officials while making provisions of public goods and services. In the absence of proper identification and understanding of the underlying causes behind delays and cost overruns, there is a risk that the perceptions will take over and misguide the policy making. For instance, the perception that the public sector is incapable of delivering public goods in time and on cost, may lead to excessive privatization of infrastructure and other public services. Indeed, inadequacy of research on the subject is somewhat surprising and a gross neglect of an important public policy subject.

The absence of comprehensive India centric studies apart, there exists a large body of theoretical and empirical literature on the subject. It suggests that delays and cost overruns are generic to infrastructure projects and a global phenomenon; India in not an exception. However, the literature also reveals that the underlying causes and, therefore, the remedies differ from country to country. Therefore, there is only so much that can be learnt from international experience, further underscoring the need for a systematic India-based study. In any case, as I will demonstrate in Section 3, the international literature is not helpful at all in explaining the nature of delays and cost overruns observed in India. In contrast, several works of Indian scholars have made interesting contributions. However, very few of these works are empirical studies; most of them are case studies. No doubt case studies are very helpful in explaining particular instances but have limited capacity to educate us about the intrinsic problems besetting the infrastructure delivery system. A review of the existing literature along with its limitations is provided in Section 3. In sum, the main causes behind time and cost overruns in India and their statistical significance have remained unsubstantiated.

In this backdrop, it is somewhat disquieting that the privatization of public services is believed to be the only way out. Indeed, the problems of delays and cost overruns with the official delivery system are being used to rationalize privatization of the supply and the maintenance of infrastructure services. The government machinery is perceived to be incapable of procuring and maintaining infrastructure facilities inefficiently. Privatization in the form of Public Private Partnerships (PPPs), in contrast, is believed to be capable of avoiding delays and cost overruns. Several commentators and policy makers share this view. So, PPPs are being pushed as politically acceptable channel for transferring management and control rights over infrastructure facilities to private firms. It is worth quoting an excerpt of a decision made in a meeting chaired by the Prime Minister:[1]

> "As regards the issue of EPC vs BOT, *it was agreed that for ensuring provision of better road services, i.e., higher quality of construction and maintenance of roads and completion of projects without cost and time overrun, contracts based on BOT model are inherently superior to the traditional EPC contracts*. Accordingly, it was decided that for NHDP Phase-III onwards, all contracts for provisions of road services would be awarded only on BOT basis..."

In the above quote the BOT model means the PPP model. In contrast, publically funded projects are executed through EPC contracts, popularly known as cash contracts. The BOT contracts are recommended as the preferred means for constructing national highways in various other official reports also.[2] In other sectors too there is tendency to privatize the supply and the management of infrastructure services, ostensibly to overcome the cost and other perceived inefficiencies of the public sector. Though, the nature and the extent of privatization differs from sector to sector.[3]

Our results imply that a change in the ownership in itself cannot mitigate the problems of delays and cost overruns. Moreover, the recent experiences with PPPs suggest that private sector will invest in supply and maintenance of only commercially viable projects.[4] Inevitably, most provisions of public goods will still have to be funded and executed through the traditional official machinery. At the same time, given the fiscal constraints faced by the Center and the State governments, public funding of infrastructure projects is under serious strain. Therefore, it is extremely important to improve the official delivery system for infrastructure projects, so as to minimize the wastage. Clearly, the remedy depends on the underlying causes. This paper, among other things, investigates the underlying causes for time and cost overruns observed in India.

The following four features set this study apart. First, it is based on by far the largest dataset on completed projects. The database includes 894 projects completed during April 1992-March 2009. It covers seventeen infrastructure sectors. Second, it explores the factors that can trigger delay and/or cost overruns during the planning, the contracting and the implementation phases of infrastructure projects. Third, it examines the nature of causal relationships for time and cost overruns along with their statistical significance. Fourth, it shows that there is simultaneity between delays and cost overruns. Therefore, it uses a *simultaneous equations model* to study them.

The econometric analysis shows that since early 1980s there has been significant decline in time and cost overruns. However, delays and cost overruns still are too frequent and unacceptably large. Across sectors, bigger projects are much more vulnerable to cost overruns. *Ceteris paribus*, delays and cost overruns are considerably higher for road,

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[1] The meeting regarding financing of NHDP was held on March 15, 2005. See GoI (2006 a).

[2] *Report of the Core Group on financing of NHDP* (2006, pp. 14 and 18) published by the Secretariat for the Committee on Infrastructure.

[3] See Kundu (2001), Nagaraj (2006), Goyal (2008), and GoI (2007).

[4] For an analysis of PPPs in road sector, see Anant and Singh (2009).

railways, urban-development, civil aviation, shipping and ports, and power sector projects. There are some regional variations with respect to the extent of delays and cost overruns. However, contrary to the common perception, the performance of rich states is no better than that of the poorer states.

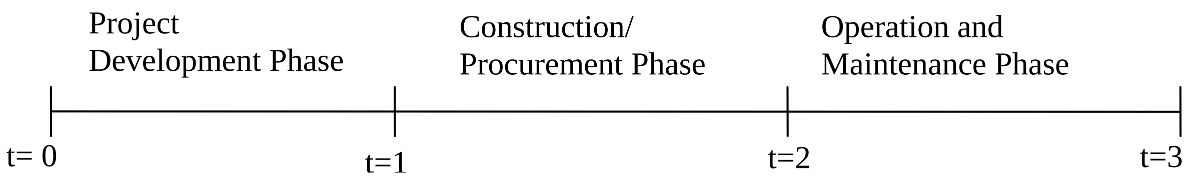
With respect to the underlying causes, I show that several hitherto neglected factors are among the major causes behind delays and cost overruns observed in India. Specifically, a deficient project planning, use of inappropriate procurement contracts and faulty contract management are some of the leading and statistically significant causes. Several kinds of organizational-cum-institutional failures also greatly add to time and cost overruns. Besides, the contractual and the institutional differences across sectors are the keys to the understanding of the observed differences regarding delays and cost overruns.

I must hasten to add that despite the above-mentioned distinguishing features and the generality of the study, it is not meant to be an omniscient account of delays and cost overruns. It has several limitations. For instance, infrastructure sectors are quite different in terms of the project types. Therefore, for each sector there are idiosyncratic factors that can cause delay and cost overruns. The present study does not explore such factors. This and other limitations are discussed in the following sections. Section 2 presents an overview of the delays and cost overruns in infrastructure projects. Section 3 shows that the existing literature is inadequate to explain the time and cost overruns observed in India. Section 4, proposes and analyses various possible factors that can cause delays and cost overruns. The model and regression results are presented in Section 5. Finally, Section 6 concludes with the findings and the policy implications.

2. Delays and Cost Overruns in India

Definitions: Every infrastructure project has to undergo several stages: from planning of the project, to its approval, to awarding of contract(s), to actual construction/procurement, and so on. Broadly put, a project's lifecycle has three phases; development, construction, and operation-and-maintenance phase. See Figure 1.

FIGURE 1:



In the beginning of the development phase, the project sponsoring department prepares estimates of time and cost (funds) needed to complete the project. An expected date of completion is also announced. The actual date of completion is invariably different from the expected date. We define 'time overrun' as the time difference between the actual and the initially planned (i.e, *expected*) dates of completion.[5] The time difference is measured in months. A related term used in the paper is the 'implementation phase' or 'implementation period'. It is defined as the duration in which a project is planned to be completed, i.e., the duration between the date of approval of the project and its *expected*

[5] In the terminology of MOSPI, the former is known as the *actual* date of commissioning and the latter as the *original* date of commissioning.

date of completion. Therefore, for each project we can define percentage time overrun as the ratio of the time overrun and the implementation phase for the project (multiplied by one hundred). Clearly, the time overrun and therefore the percentage time overrun can be positive, zero or even negative. Similarly, we define 'cost overrun' as the difference between the actual cost and the initially projected (i.e., expected) cost of the projects. The initially expected cost is called the *initial* project cost. This is the estimated cost of project works. It is estimated when a project is planned and generally is arrived at using current input prices. The actual cost becomes known only at the time of completion at the end of phase two. Percentage cost overrun for a project is defined as the ratio of the cost overrun and the initially projected cost of the project (multiplied by one hundred). Again, percentage cost overrun can be positive, zero or negative.

The Data and Summary Statistics: The programme implementation division of the MOSPI publishes quarterly reports on the ongoing projects. Each quarterly report also

TABLE 1: Total number of projects 895.

S. No.	ASPECT	DESCRIPTION	DATA SOURCE
1	DATE OF PROJECT START	It is the start date of the project	MOSPI reports
2	INITIAL DATE OF COMMISSIONING	It is the initially planned (i.e, expected) date of completion of the project	MOSPI reports
3	ACTUAL DATE OF COMMISSIONING	It is the actual dates of completion of the project	MOSPI reports
4	TIMEOVERRUN	The time difference (in months) between the actual and the initially planned dates of completion	OUR CALCULATIONS based on the data collected from MOSPI reports. .
5	IMPLEMENTATION PHASE	The duration in which a project is planned to be completed, i.e., the duration between the date of approval of the project and its *expected* date of completion.	OUR CALCULATIONS based on the data collected from MOSPI reports.
6	PCTIMEOVERRUN (% time overrun)	The ratio of the time overrun and the implementation phase for the project (multiplied by one hundred).	OUR CALCULATIONS based on the data collected from MOSPI reports.
7	INITIAL PROJECT COST	The initially projected (i.e., expected) cost of the project.	MOSPI reports
8	ACTUAL PROJECT COST	The actual cost at the time of completion of the project.	MOSPI reports
9	COST OVERRUN	The difference between the actual cost and the initially projected (i.e., expected) cost of the project.	OUR CALCULATIONS based on the data collected from MOSPI reports.
10	PCCOSTOVERRUN (% cost overrun)	The ratio of the cost overrun and the initially anticipated cost of the project (multiplied by one hundred).	OUR CALCULATIONS based on the data collected from MOSPI reports.
11	TIMELAPSE	It is the time (in months) that has lapsed since May 1974 to the date of approval of the project. The *first* project in our dataset was approved in May 1974.	OUR CALCULATIONS based on the data collected from MOSPI reports.
12	SECTOR	The infrastructure sector to which the project belongs	MOSPI reports
13	STATE	The state in which the project is located.	MOSPI reports and publications of the Ministry relevant for the Sector

provides some information about the projects that get completed in that quarter. According to these reports, during April 1992-March 2009, a total of 1035 projects belonging to seventeen infrastructure sectors have been completed. Most of these are publically funded and managed projects; only few road projects are PPPs. Each project is worth at least Rs 20 Crore.

TABLE 2 Summary Statistics: Delays and cost overruns in infrastructure projects during April1992-March 2009.

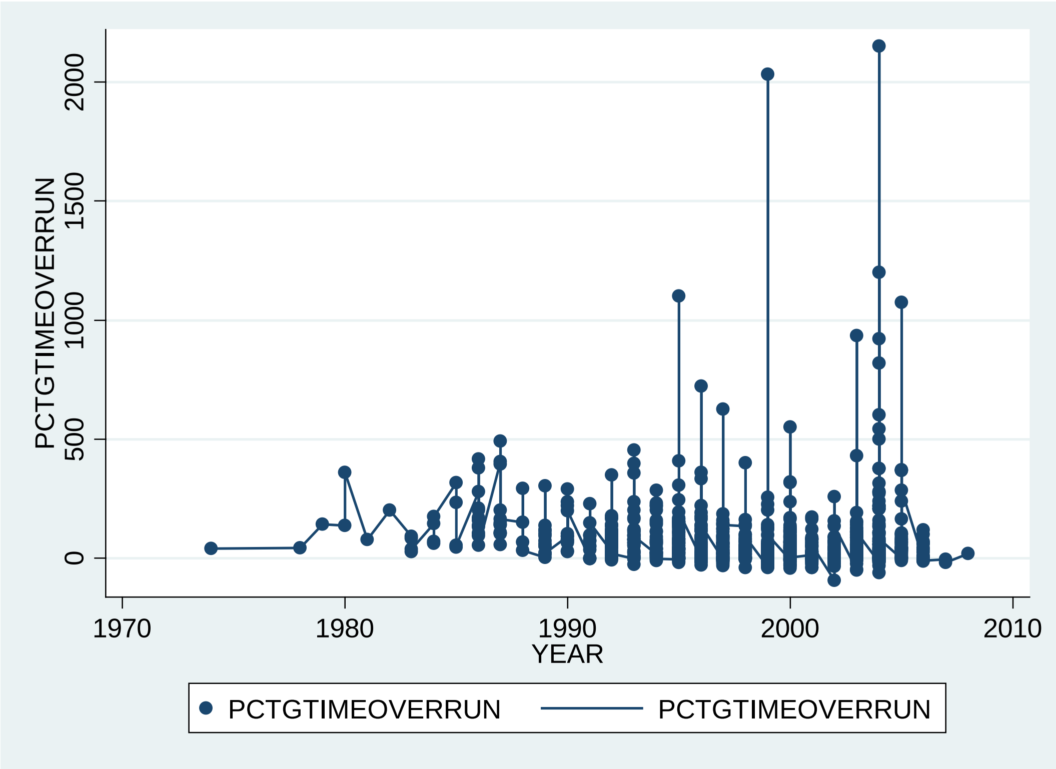
		% Cost Overrun			% Time Overrun			
Sector	Number Of Projects	Mean	Std. Dev.	% of projects with positive Cost overrun	Mean	Std. Dev.	% of projects with positive Time overrun	Projects with cost but not time overrun
Atomic Energy	12	15.05	113.12	25.00	301.02	570.48	91.67	8.33
Civil Aviation	47	-2.27	40.52	42.55	68.52	58.15	91.49	0.00
Coal	95	-19.90	73.85	22.11	31.05	69.28	61.05	3.16
Fertilizers	16	-12.57	28.92	25.00	26.53	41.80	62.50	12.50
Finance	1	132.91	0	100.00	302.78	0	100.00	0.00
Health and family Welfare	2	302.30	92.96	100.00	268.04	208.63	100.00	0.00
I & B	7	14.00	62.97	42.86	206.98	140.57	100.00	0.00
Mines	5	-33.16	20.65	0.00	42.44	36.23	80.00	0.00
Petrochemicals	3	-12.22	25.92	33.33	74.43	3.05	100.00	0.00
Petroleum	123	-16.10	28.96	20.33	37.57	49.60	79.67	2.44
Power	107	51.94	272.50	46.73	33.57	55.15	60.75	5.61
Railways	122	94.84	178.86	82.79	118.08	141.71	98.36	0.00
Road Transport and Highways	157	15.84	62.46	54.14	50.21	56.86	85.35	6.37
Shipping and Ports	61	-1.35	84.35	31.15	118.64	276.79	95.08	1.64
Steel	43	-15.88	47.78	18.60	49.91	60.67	81.40	4.65
Telecommunica tion	69	-32.09	57.59	15.94	238.24	259.34	91.30	0.00
Urban Development	24	12.31	50.27	41.67	66.44	44.58	100.00	0.00
Total	894	15.17	132.27	40.72	79.25	153.51	82.33	3.13

Source: Calculations based on MOSPI data.

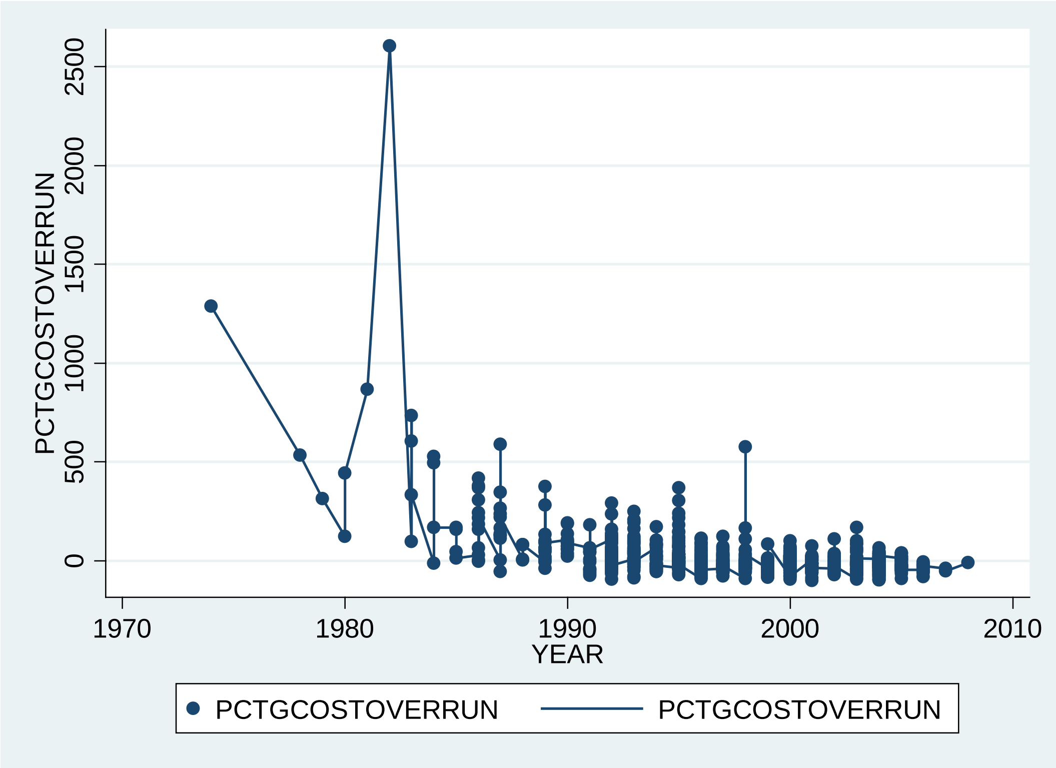
The quarterly reports are a rich source of information. But, unfortunately, no single report or any other official document provides all the information needed to determine the time and the cost overruns, and the implementation phase. The information on the other relevant aspects such as the location and the nature of project work is even harder to obtain. In order to collect the required information, each project had to be tracked at various stages, such as the project development, construction and completion stages. That meant that for each project we had to wade through several reports and other publications. Still, the required information could be obtained for only 894 projects; for the remaining 141 projects, information on one or the other aspect was missing. These missing projects were started in seventies and early eighties. Nonetheless, it is the largest dataset on completed projects for any study on the subject by far. For each of 894 projects, we have collected and compiled data on the aspects mentioned in Table 1. Sector-wise summary statistics are provided in Table 2.

As is evident from Table 2, there are wide-ranging variations across sectors in terms of average delays, cost overruns, and standard deviations. Within each sector also there are large variations with respect to the magnitude of time and cost overruns. Similar is the case with respect to the types of activities covered by projects. Again, projects are quite diverse across as well as within sectors. Yet, projects in road, railways and urban-development sectors are more homogeneous; most are construction projects. Majority of projects in civil aviation, shipping and ports, and power sectors also involve construction and the related activities. In contrast, in sectors like telecom and atomic energy, a large number of projects are for purchase and/or installation of equipments. There are some construction projects too. Similarly, project type in petroleum, petrochemicals and mining, etc., is very heterogeneous. For analytical convenience, projects have been clubbed in the following five somewhat homogeneous categories: First category is of road, railways and urban-development projects; Second, civil aviation, shipping and ports, and power projects; Third, telecom and atomic energy; Fourth, petroleum and petrochemicals; Fifth, all other projects. The rational behind this categorization is provided in Section 4.

GRAPH 1: Patterns of percentage time overruns over the years



GRAPH 2: Patterns of percentage cost overruns over the years



Time Pattern of Delays and Cost Overruns: To repeat, the project cost and the project time vary significantly from project to project, across sectors as well as within each sector. Therefore, for comparisons to be meaningful it is important to consider delays and cost overruns in percentage rather than in absolute terms. Using the above definitions, percentage time and cost overruns have been calculated for each project. Graph 1 depicts the trend of percentage time overruns. The percentage time overrun for a project is plotted against the year in which the project started. Similarly, Graph 2 shows the movements of percentage cost overruns over the years. Together these graphs show that since 1980s the official delivery system has improved somewhat. The magnitudes of cost overruns seem to have come down over the years. However, the decline in delays is less obvious. Moreover, cost overruns are still too frequent and unacceptably large. According to the latest MOSPI report, as on March 31, 2009, more than one-third of the ongoing projects are experiencing cost overruns. Collectively, cost overruns for these projects are huge at Rs 73791.51 crore; which is 54.75 percent of their original cost and 13.45 percent of the cost of all projects. From another perspective, the cost overruns in the ongoing projects are larger than the three consecutive fiscal packages announced during 2008-09! Similarly, delays are too frequent and at times intolerably long. Out of 925 ongoing projects, 445 have already experienced delays.

3. The Literature and the Indian Scenario

The literature on delays and cost overruns is fairly large. In a series of interesting empirical studies covering twenty countries across the five continents, Flyvbjerg, Holm and Buhl (2002, 2003, and 2004) have shown that infrastructure projects often suffer from cost overruns.[6] Merewitz (1973), Kain (1990), Pickrell (1990), Skamris and Flyvbjerg (1997), among others, have also come out with similar findings. In addition, there are numerous case studies depicting the extent and gravity of delays and cost overruns.[7] However, these empirical works do not explain why delays and cost overruns occur.

But, the theoretical literature on the subject offers several explanations. For example, Morris and Hough (1987), Arvan and Leite (1990), Gaspar and Leite (1989) and Ganuza (2007) attribute delays and cost overruns to imperfect information and technical constraints. According to these studies, due to imperfect estimation techniques and the lack of data, the estimated and the actual project costs turn out to be different. That is, delays and cost overruns are claimed to be a manifestation of 'honest' mistakes on the part of government officials. Another strand of the literature attributes cost escalations to political factors, i.e., to 'lying' by politicians. See, for example, Wachs, 1989; Kain, 1990; Pickrell, 1990; Morris, 1990; Flyvbjerg, Holm and Buhl, 2002; and Flyvbjerg, Holm and Buhl, 2004, among others. According to these works, politicians understate costs and exaggerate benefits in order to make projects saleable.

However, if time and cost overruns are only due to the imperfect estimation techniques, then one would expect the estimation errors to be 'small' compared to project cost, and unbiased with zero mean. Since, due to technological constraints, underestimation of cost should be as likely as overestimation. As a result, in each sector negative cost overruns should be as frequent as positive cost overruns. Moreover, as more and more projects get implemented, the officials should be able to learn from the past mistakes and avoid them in future. On top of it, the estimation technology also advances with the passage of time. That is, over the years, the institutional capacity of government departments to plan and develop projects improves, as policy-makers move up learning curve. Therefore, the frequency as well as the magnitude of delays and cost overruns should come down over the years.

As Graphs 1 and 2 show, over the years there has been some decline in the magnitudes of estimation errors only with respect to project cost. That is, some learning seems to have taken place over the years. To that extent, cost overruns in India seem to have been caused by the technological constraints. Nonetheless, for most sectors the errors for cost estimates are anything but unbiased with zero mean. Moreover, there is no indication of any significant decline in the frequency of delays. Table 2 shows that barring a few sectors average delays are nowhere close to zero. For most sectors, estimation errors for project time have remained biased with large positive mean. Similarly, errors in cost estimates are large and biased. Altogether, at least 82 percent of the projects under study have suffered from either delays or cost overruns. As we discussed earlier, the current situation is no better. Therefore, at least, in the case of India, the imperfect information and technological constraints cannot fully explain the observed delays and cost overruns. Similarly, the theory of 'lying' by politicians does not seem to hold the key. In principle, cost overruns do not necessarily imply time overruns; once a project has been approved by the people or their representatives, more funds can be commissioned to ensure timely completion. After all, politicians would want to take credit for faster completion of projects. Even otherwise,

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[6] The authors have studied 258 mega infrastructure projects from 20 countries including developed as well as developing countries. They have shown that *ninety* percent of large transport projects suffer from cost overruns.

[7] For example, Suez canal was constructed at costs three times of the estimated cost. The cost overrun for Panama Canal was in the range of 70-200 percent. Similarly, for the Concorde supersonic airplane project, the actual costs were 12 times the projected costs (Flyvbjerg *et al*, 2002). For more case studies see Pickrell, 1990; Skamris and Flyvbjerg, 1997; Kain, 1990; among others.

in India projects are planned by bureaucrats who need not please people, and politicians are not known to effectively control bureaucracy. To sum up, the existing theoretical literature cannot explain the features of delays and cost overruns observed in India. Moreover, it has focused only on the development phase and has totally ignored the relevant factors arising in the implementation phase. See Figure 1. As the following section shows, even for the first phase the literature has ignored some crucial underlying causes.

In contrast, several India-focused studies have made limited but interesting contributions. Morris (1990 and 2003), Dalvi (1997), Thomas (2000), Sriraman (2003), Thomsen (2006), Jonston and Santillo (2007), and Raghuram, Bastian and Sundaram (2009), among others, are notable works. According to these studies, delays in land acquisition, shifting of utilities, environmental and inter-ministerial clearances, shortage of funds, litigations over land acquisition and contractual disputes are the major causes behind time and cost overruns in India. [8] However, these studies too have some serious limitations. Very few of these are empirical works. Though there are some empirical works, but they have become somewhat dated by now. Moreover, rather than studying the completed projects, they have used data for the then ongoing projects (See, for example, Morris, 1990; and 2003). Therefore, these studies are based on the estimates, rather than the actual figures for the time and the cost overruns. For infrastructure projects, the estimated and the actual figures for delays and cost overruns are invariably different; in some cases considerably so. As our results will demonstrate, these studies have ignored several crucial underlying causes behind delays and cost overruns.

4. Delays and Cost Overruns in India: *Possible Causes and Proxies*

As has been mentioned before, during the development phase, the project sponsoring department prepares the estimates of project works as well as of the time and the cost (funds) needed to complete project works. These estimates are approved by the appropriate authority in the department. In addition, a project generally requires approval from several other departments.[9] In the beginning of the next, that is, the construction or the implementation phase a contract is signed between the sponsoring department and a contractor.[10] Depending on the context, the contract can be for construction or for procurement of equipments or both. During this second phase, timely completion of the project often requires active cooperation from the sponsoring authority, the contractor(s) and several other departments. Therefore, whether a project can be delivered in time and on cost depends on how well the activities and efforts of the departments involved and the individuals concerned are coordinated. The activities and efforts of the parties involved are governed by two different modes of governance. The activities of the contractors are governed by market contracts signed between the sponsoring department and the contractor. As will be shown in the following, the nature of the contract and subsequently its enforcement have profound implications for delays and cost overruns. On the other hand, efforts of the officials involved in project planning and implementation are governed

[8] Besides, there are several interesting studies with a focus on the operation-and-maintenance phase of infrastructure projects. For a comprehensive account of various challenges faced by urban-development projects see Kundu (2001 and 2003), also see Banerjee-Guha (2009). Goyal (2008) provides an enlightening discussion on the problems faced by railways and civil aviation sectors. These works show that privatization itself has not delivered the expected results in urban-development and civil aviation sectors. For a discussion on power sector see Nagaraj (2006).

[9] For example, a typical civil aviation project needs clearances from the ministries of civil aviation, finance, environment and forest, and the Airport Authority of India.

[10] Generally, the contractor is selected through competitive bidding.

by the organizational structure of the government departments. Government organizations are hierarchical in nature. Hierarchy based organizations are inherently weak in inducing the desired efforts from individuals concerned. The problem is acuter for government organizations. Therefore, both contractual and organizational modes of governance are subject to failures. In the following, I discuss what kind of contractual and organizational failures are major causes of delays and cost overruns in India. For the ease of exposition, it is helpful to divide the set of possible causes in the following subgroups.

***Technical and Natural Factors*:** The estimation of project time and cost for infrastructure projects is a characteristically complex exercise. Though the estimation techniques have become better and sophisticated in recent times, they are still imperfect. As work on a project starts, its future unfolds and the authorities along with the contractor become better informed about the specific technological and material requirements of the project works. For example, during construction phase of a road project, an unexpectedly poor quality of soil may necessitate changes in the engineering, the design and the quality of bitumen required, from what were initially planned. Such changes may require extra time as well as funds. In some cases the actual circumstances, in contrast, may turn out to be favourable and the parties may find that they had made excessive provisions of funds and time. Similarly, flood or any other event of *force majeure* may cause delay as well as destroy the project assets. Alternatively, the natural conditions may turn out to be rather conducive, saving construction time and costs. Therefore, due to imperfect estimation and natural factors the actual project time and cost will generally be different from their expected values.

However, one would expect the effects of the technical and natural factors to be random without any bias. Also, due to the above-discussed learning-by-doing among officials, both the delays and the cost overrun would be expected to come down over the years. Therefore, if the decline in the delays and cost overruns over the years turns out to be statistically significant, we can attribute some of the delays and cost overruns to the technical and natural constraints. To confirm whether this is the case, for each project we have calculated the *TIMELAPSE*. It is the time that has lapsed since May 1974 to the date of approval of the project. The *first* project in our dataset was approved in May 1974. *Ceteris paribus,* the longer is TIMELAPSE for a project the lower should be time and cost overruns. However, as they move up the learning curve, learning among officials and its efficacy in reducing delays and cost overruns will come down. By the same account, the effects of policy interventions are expected to decline over time. Therefore, starting from mid-seventies, percentage delays and cost overruns are expected to have come down over time, but at a ‘decreasing rate’. Formally, the variable TIMELAPSE is expected to have a quadratic relation with time and cost overruns.

***The Contractual Failures*:** As discussed before, the construction phase of an infrastructure project starts with signing of a construction/procurement contract. In terms of Figure 1, the contract is signed between the authority (employer) and the contractor at date t=1. It specifies the works that are to be performed, or the good that is to be delivered by the contractor. The degree of precision in this initial contract has direct implications for cost overruns. Suppose the initial contract is *contingency-complete* in that it fully specifies all the works that are to be carried out in each possible contingency that may arise during the construction phase. Under such a contract, cost overruns can be avoided altogether. Since every contingency has been completely planned for, no additional (un-specified) work is ever required. Now, if the initial cost is determined for each contingency, there will be no cost overruns. Moreover, the contract price can be fixed or can be contingency specific. In either case, the parties' obligations have already been spelt out fully. No 'additional' payment is required to be made by the either party. In fact, delays on the part of contractor can also be avoided with the help of suitable penalty clauses. Therefore, in principle, *complete-contingent-contracts* can ensure that project is completed in time and within (contingency-specific) budget.

In reality, the initial contract cannot be complete. Parties cannot predict every possible scenario that may unfold during the construction phase. As a result, the initial contract cannot completely specify every relevant aspect of the project works; different states of nature during construction require different modifications in the project works. For example, on a railways project depending on the local conditions, it may become necessary to have more of manned-crossings or railway-over-bridges than were initially intended. The bounded rationality of the parties along with imperfect forecasting techniques makes it impossible to specify every contingency and the relevant tasks to the last details. As a result, the initial contract leaves out several project works. This is especially true of infrastructure projects, which are inherently complex and have long building phase. Formally speaking, the initial contracts for infrastructure projects are intrinsically 'incomplete'. Once the contractor starts the work at the project site and the future unfolds, the need for additional works arises invariably. Additional works require more funds and hence cause cost overruns. In some cases, extra time is also needed. So, some of the cost overruns are caused by what we have called the contractual incompleteness.

Construction projects are typically more complex and therefore more difficult to plan and execute than is the case with non-construction projects, say, those involving purchase of equipments. So, the degree of incompleteness of the initial contracts is expected to be higher for construction projects. As clarified in Section 2, most projects in Road, Railways and Urban-development sectors are construction projects. Majority of projects in Civil Aviation, Shipping and Ports, and Power sectors too involve construction and are complex even otherwise. Each project in these latter sectors is generally unique in terms of its requirements. So, learning from previous projects is limited. If our claim about the causal relation between the contractual incompleteness and the cost overruns is correct, the cost overruns experienced by projects in the above sectors should be significantly larger than by other sector projects. The next section shows that this indeed is the case.

The contractual incompleteness is expected to increase with the project size. Since, compared to smaller ones, bigger projects involve more works. Besides, big projects are generally more complex than the smaller ones. It is plausible to argue that the contractual incompleteness increases with the project size. Therefore, the resulting cost overruns are also expected to grow with the project size. The initially expected project cost (*INITIALCOST*) is a good measure of project size, its complexity, and hence of the contractual incompleteness.[11] So, cost overruns are also expected to swell with the INITIALCOST, at least in absolute terms. But, what can we say about the percentage cost overruns across projects? For a given degree of contractual incompleteness, percentage cost overruns need not increase with the project size.[12]

[11] Please note the initially expected project cost, rather than the actual cost, is a better indicator of the size and incompleteness of the contract. Due to cost overrun, the final cost can be large even for small projects. The same argument applies to the implementation phase.

[12] To take an example, suppose a project is worth Rs 100 crore. But, the initial contract misses out on say ten percent of relevant work. As a result, there are cost overruns of Rs 10 crore. Take another same-sector project that is worth Rs 200 crore. This bigger project may show higher cost overruns of Rs 20 crore. But, percentage cost overrun for both projects is the same; 10 percent. Of course, as complexity of a project increases, it

However, if project planning is poor, cost overruns can increase with project size not only in absolute but also in percentage terms. To see why, first of all note that the initial contract can be made more or less incomplete by the parties involved. If project planning is bad and apathetic, estimates of project time and cost will be vague and so will be the initial contract. As a result, many un-contracted for works will become necessary later on, leading to high cost overruns. In contrast, a meticulous planning in terms of technical and material requirements of the project can enable the parties to stipulate most of work details in the initial contract itself. This, in turn, means less frequent and lower cost overruns. The problem, however, is that careful planning is a tedious work. Planning of big and complex projects requires all the more of painstaking and drawn out efforts. If there is no accountability, the officials will have no incentives to put in the desired efforts at the planning and contracting stages. Certainly, quality of efforts put in will not increase in sync with the project size and its complexity. Since, bigger projects entail not only more works but also more complex ones; the initial contracts for bigger projects will become more incomplete. This, in turn, means a larger proportion of additional, uncontracted for, works will have to be undertaken during the construction phase. To sum up, if project planning is sloppy, the greater is the project size and its complexity, the higher will be the proportion of project works that gets left out of the initial contract. So, if project planning is defective, the greater is the project size the larger will be the cost overruns.

Project planning processes in India are infamous for their ad-hoc and shoddy approach. Detailed project reports (DPRs) as well as feasibility reports are sloppy and vague, prepared only for the sake of formality.[13] This problem is further exacerbated by the use of *unit-price EPC* contracts. Under these contracts neither the officials nor the contractors find it worth haggling over work details.[14] On this count also, contractual incompleteness increases with project size.

If the above arguments regarding the deficient project planning in India are the consequent contractual are correct, *the percentage* cost overruns should increase with the project size. Therefore, we have another testable hypothesis: the greater is the initial costs, the larger is the percentage cost overrun, and *vice-versa.* The next section shows that this claim too is valid.

Yet another aspect of infrastructure projects suggests itself as a proxy for the size. It is the implementation phase or IMPLPHASE for short; the duration in which the project is initially planned to be completed. Intuitively, the implementation phase will increase with the project size. If so, the initial project cost and the implementation phase should be highly correlated. It is instructive to note that in our dataset these two variables are not correlated at all; correlation coefficient is just 0.067! There can be at least two reasons for this lack of correlation. May be it is yet another manifestation of poor project planning in India. But, it could well be due to the large heterogeneity in terms of the project types. Many projects in our dataset are for purchase/procurement of machines and equipments. For such projects, there is no reason for IMPLPHASE to increase in proportion to the project cost (i.e., with

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becomes more difficult to provide every minute detail in the initial contract. For an accessible account of incomplete contracts see Hart (1995).

[13] See Lok Sabha (2006) and LEA (2008).

[14] Under unit-price EPC contracts, the contractor gets paid based on the quantities of inputs used. Therefore, he does not have to worry too much about details of material requirements.

the cost of the equipments). To that extent the IMPLPHASE perhaps is not a very good indicator of the (money) size of the project. So, the weak correlation is not surprising.

Plausibly any increase in complexity of the project as well as the number of construction works should entail an increase in the IMPLPHASE for the project. That is, the IMPLPHASE appears to be a very good indicator of the complexity and the quantum of project works. Therefore, it is a good proxy for the incompleteness of the initial contract. Also, note than the above arguments regarding the implications of poor project planning are more pertinent for complex, say, construction related projects than for simple procurement projects which involve purchase of standard machines and equipments. It is worth emphasising that the proxy INITIALCOST does not make this crucial distinction. Besides, uncertainties related to the appropriateness of initially planned works naturally increase with time. Therefore, due to poor planning an undue increase in IMPLPHASE can cause excessive cost overruns by necessitating many more changes during the construction phase. If the above arguments are correct, the *percentage* cost overruns should increase with the IMPLPHASE, on account of the contractual failures caused by the poor project planning. To sum up, between the INITIALCOST and the IMPLPHASE, the latter appears to be a better and direct indicator of contractual incompleteness as well as of the contractual failures. So, we have one more testable prediction: *ceteris paribus,* the longer is longer IMPLPHASE, the higher are the cost overruns, in absolute as well as percentage terms.

But, what is the nature of relationship between INITIALCOST and IMPLPHASE, on one hand, and delays, on the other hand? The above discussion suggests that an increase in IMPLPHASE may lead to longer delays. However, *ceteris paribus,* projects with longer IMPLPHASE have already got more time to complete project works than projects with shorter duration. On top of it, longer IMPLPHASE projects have greater flexibility for accommodating additional works. Therefore, they should show relatively small percentage of time overruns. For instance, between the two same-type and same-cost projects, the one with longer IMPLPHASE should show lower time overrun. Therefore, *ceteris paribus,* we expect the *percentage* time overrun to come down as implementation phase increases. Similarly, it seems plausible to expect the absolute time overrun to increase with initial cost, but, *ceteris paribus,* there is no reason to expect time overrun to increase in percentage terms.

Organizational or Institutional Failures**:** As argued above, execution of infrastructure projects requires active cooperation of several departments within as well as among various ministries. Government departments are hierarchical organizations. A large body of literature shows that there is a conflict between the individual and the organizational objectives at every stage of hierarchy. As a result, hierarchical organizations are inherently weak in inducing the desired efforts from the people involved.[15] This is especially true of government organizations. Therefore, infrastructure projects have to face the consequences of organizational failures within the sponsoring ministry itself. On top of it, these projects need joint efforts of several other organizations. In India, different departments are responsible for different project activities. For example, project implementation, shifting of power lines, water lines, sewer lines, cutting of trees, environmental clearances and other such activities are performed by different departments. Executions of these activities are highly dependent on joint and timely efforts of the departments involved. However, interdependence of efforts means that it is easy for departments to shirk and pass the blame

[15] Bolton and Dewatripont (2005).

on others. So, in addition to intra-organizational failures, infrastructure projects in India are vulnerable to inter-organization failures. Several reports, including the official ones, corroborate our claims.[16] But, how can we measure the implications of these failures?

As mentioned earlier, most projects in road, railways and urban-development are construction projects. Projects in these sectors generally require environmental clearance from the central as well as the state agencies. Moreover, compared to those in the other sectors, these projects require much more active cooperation of several departments for land/property acquisition, shifting of power lines, water lines, sewer lines, approval of under or over-passes, etc. Laxity on the part of just one department or dereliction of duty by a few officials can hold-up the entire project. So, these projects are highly vulnerable to delays caused by all kinds of organizational failures. The same is the case with projects in civil aviation, shipping and ports, and power sectors, though to a lesser extent. Majority of projects these sectors too involve construction or setting of network points. In several cases, ecologically sensitive land has to be acquired. This means more regulations and increased vulnerability to inter-organizational failures.[17]

However, if organizational failures mentioned here is a major underlying cause for delays, then compared to other sectors, projects in road, railways, urban-development, civil aviation, shipping and ports, and power sectors should exhibit longer time overruns. To test this hypothesis, we introduce dummy variables called *DRRU* for road, railways and urban-development projects, and *DCSPP* for projects in civil aviation, shipping and ports, and power sectors. In view of our arguments dummy variables *DRRU* and *DCSPP* can serve as proxies of organization failures. As argued earlier, road, railways and urban-development sectors are more homogeneous and initial contracts for projects in these sectors are more incomplete than is the case with projects in civil aviation, shipping and ports, and power sectors. That is why separate dummies have been used.

In the following, I will show that delays regardless of their source are a major and statistically significant cause of cost overruns. This implies that the organizational failures also cause cost overruns through delays. They may have a direct effect too. Every department involved in project planning and implementation can suggest changes in project works, and hence can contribute to cost escalations.

Similarly, if a project spans across more than one state, it has to deal with the concerned departments in each state. Therefore, projects spanning across multiple states seem more susceptible to inter-organizational failures. To test this hypothesis, we introduce another dummy variable called *DSTATES*.

To sum up, if organizational failures are a significant cause of delays and cost overruns, then multistate, road, railways and urban-development, civil aviation, shipping and ports, and power sector projects should exhibit relatively long delays and high cost overruns.

One may be tempted to apply the above arguments regarding delays and cost overruns to some other sectors too; like telecom and atomic energy, petroleum and petrochemicals, mines, etc. Unfortunately, as discussed in Section 2, project types in these and other sectors are too heterogeneous to be amenable to valid statistical inferences. Moreover, several projects in these sectors involve purchase of machinery and equipments. Such projects

[16] See Lok Sabha (2006), LEA (2008) and quarterly reports of MOSPI.
[17] For a case study of Dhamra Port expansion project see Jonston and Santillo (2007).

don't have to suffer from the above organizational failures. Still, it will be interesting to study some of these sectors. So, we will use dummies DTA for telecom and atomic energy projects, and DPP for petroleum and petrochemical sector projects, respectively.

Time Overruns: Logically, any delay in implementation in itself should cause cost overrun for the project. This should happen simply on account of inflation itself. In most cases, initial cost estimates are arrived at using the current input prices. If there are delays, inputs will become more expensive and, in turn, will cause an increase in the project cost. Moreover, certain overhead costs have to be met as long as the project remains incomplete. Delays should increase these costs also. Also, a long delay may cause depreciation of project assets, necessitating expenses on repairs or replacements. This means that in addition to the above factors, time overrun on account of any other factor is also an underlying cause for cost overruns.

***Economic Factors*:** Each project is located in some state(s). Several departments of the state government concerned play rather crucial role in project implementation. After all, activities like land-acquisition, shifting of utilities, etc., are performed by the state government concerned. Moreover, economic and geographical features of the state may affect the project time and costs. For example, if a state has better transport, power and telecommunication infrastructure in place, it will be easy to execute projects in the state. Generally, richer states are said to be in possession of superior infrastructure. In contrast, due to law and order as well as difficult terrain, project implementation is likely to be difficult in the North-Eastern states and Jammu and Kashmir. To check statistical validity of these conjectures, states have been clubbed in four categories. Five richest states, in terms of per-capita income, are grouped together.[18] These are Haryana, Punjab, Delhi, Gujarat and Maharashtra. We have used dummy DMRICH for these states. In the next category, we have four southern states: Andhra Pradesh, Karnataka, Kerala and Tamil Nadu. These states have well above average per-capita GSDP and are considered to be better governed. For these the dummy used is DRICH. In the third category we have the North-Eastern states and Jammu and Kashmir with dummy DNE.

5. A Simultaneous Equation Model and its Results

The arguments in the previous section show that several factors cause delays and at the same time cost overruns. Such scenario warrants use of a simultaneous-equation model in which the time and the cost overruns are endogenous variables, jointly dependent on the explanatory variables introduced in the previous section. But, the relationship between the time overrun and the cost overrun for a project needs to be discussed further. As argued in Section 4, any delay in implementation in itself will cause cost overrun for the project. This means that 'time overrun', among others, is an explanatory variable for 'cost overrun.' In contrast, cost overrun *per-se* does not imply time overrun. Suppose, there is an increase in project cost due to inflation. There is no reason why such a cost overrun *per-say* should lead to a delay in the implementation.[19] Therefore, between the time overrun and the cost overrun, the causation seems to run from the former to the latter, not the other way round.

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[18] The ranking has been arrived at by taking average of constant price per-capita SGNP for three years from 2004-05 to 2006-07 we have used EPW for this purpose. Shetty (2003) has shown that during 1980s and 90s the ranking of states in terms of per-capita income did not change much.

[19] Cost escalation can cause delays, one may argue, if there are not enough funds available for the project. However, examination of MOSPI reports by the author shows that in most cases the actual expenditures have been less than the project outlays. Therefore, delays cannot be attributed to the shortage of funds. Moreover, lack of funds seems to be serious issue only for railways projects. See quarterly MOSPI reports.

Moreover, time overrun also manifests the underlying effect of several factors not considered above. For example, delays on the part of the contractor, etc. These factors also cause cost overrun through time overrun. So, for our purpose the relevant model is the following *simultaneous-equation model*.

$$PCTIMEOVERRUN_t = \alpha_0 + \alpha_1 TIMELAPSE_t + \alpha_2 TIMELAPSE^2{}_t + \alpha_3 INTIALCOST_t + \alpha_4 IMPLPHASE_t + \alpha_5 DRRU_t + \alpha_6 DCSPP_t + \alpha_7 DTA_t + \alpha_8 DPP_t + \alpha_9 DSTATES_t + \alpha_{10} DMRICH_t + \alpha_{11} DRICH_t + \alpha_{12} DNE_t + \varepsilon_{1t} \quad \textbf{(1)}$$

$$PCCOSTOVERRUN_t = \beta_0 + \beta_1 TIMELAPSE_t + \beta_2 TIMELAPSE^2{}_t + \beta_3 INTIALCOST_t + \beta_4 IMPLPPHASE + \beta_5 DRRU_t + \beta_6 DCSPP_t + \beta_7 DTA_t + \beta_8 DPP_t + \beta_9 DSTATES_t + \beta_{10} DMRICH_t + \beta_{11} DRICH_t + \beta_{12} DNE_t + \beta_{13} PCTIMETOVERRUN + \varepsilon_{2t} \quad \textbf{(2)}$$

Remember, the dependent variables are *percentage* cost overrun (PCCOSTOVERRUN) and *percentage* time overrun (PCTIMEOVERRUN). The explanatory variables along with their expected signs and the relevant causes have been discussed in Section 4. Data sources have already been provided in Section 2. The following Tables 3 and 4 provide the relevant statistics about the variables and the dummies used.

Table 3: Summary Statistics for variables.

Variables	Mean	Std. Dev.
PCGECOSTOVRRN	-3.65769	45.97005
PCGETIMEOVRRN	51.72642	60.49127
TIMELAPSE	40.46667	50.65964
$TIMELAPSE^2$	4200.459	4470.295
INITIALCOST	219.7263	344.3501
IMPLPHASE	42.20408	20.67688

Table 4:

Dummy	Number of projects
DRRU	261
DCSPP	181
DTA	31
DPP	104
DSTATES	62
DMRICH	191
DRICH	195
DNE	24
Total	894

The two error terms in equations (1) and (2) were tested for any correlation between the two. The null hypothesis that the two errors are correlated was strongly rejected, i.e., $\text{cov}(\varepsilon_{1t}, \varepsilon_{2t}) = 0$. This means the model specified in (1) and (2) is actually a *fully recursive simultaneous-equation model*. Therefore, we can apply OLS estimation technique to each equation individually to get consistent estimates (see Green, 2008; Ch 13).

The dataset has been treated for outliers and influential observations which resulted into dropping of 159 observations.[20] For the remaining 735 projects also the two error terms were found uncorrelated with each other. The regression results for these projects are presented in Tables 5. A close look at the dropped 159 outliers shows that some of these projects have very long positive time overruns and simultaneously huge but negative cost overrun. For instance, there are 40 odd projects with time overrun of 20 percent or more

[20] In order to identify outliers, Studentized residuals were predicted and observations having absolute value greater than 2 were dropped. To identify influential points STATA's in built command for calculating leverage of each observation, DFITS, DFBETA,WELSCH DISTANCE and COVRATIO were used. (See Belsley, *et al*, 1980)

and *negative* cost overruns of at least 70 percent. This means that if, for example, the initially estimated cost was Rs 100 crore, the actual cost turned out to be less than Rs 30 crore, even though the project has suffered from delays! No convincing explanation can be provided to rationalize saving at this scale, that too by government officials. Similarly, there are many projects with large negative time overrun and simultaneously with *huge and positive* cost overrun. Indeed, for many projects in the dataset the time and the cost overruns figures appear to be rather incredible. I can think of only two possible explanations for these implausible observations. Most probably these are instances of reporting/typing errors. Alternatively, it could be that during the implementation phase the changes made in the scope of project were so large that the final project and the initial one are incomparable.[21] In either case, such projects are potentially hazardous.

TABLE 5: Regression Results*.

Variables	PCGETIMEOVRRN (%Time Overrun)	p-value	PCGECOSTOVRRN (%Cost Overrun)	p-value
PCGETIMEOVRRN			0.1804 [0.0309]	0.000
TIMELAPSE	-0.7649 [0.0638]	0.000	-0.3615 [0.0604]	0.000
$TIMELAPSE^2$	0.0031 [0.0006]	0.000	0.0032 [0.0005]	0.000
INITIALCOST	-0.0077 [0.0050]	0.124	0.0053 [0.0032]	0.096
IMPLPHASE	-1.3328 [0.1717]	0.000	0.4635 [0.1237]	0.000
DRRU	40.8908 [5.3214]	0.000	42.2939 [4.4655]	0.000
DCSPP	18.9439 [5.2645]	0.000	24.3207 [3.9731]	0.000
DTA	108.8696 [17.8039]	0.000	-10.3845 [6.9493]	0.136
DPP	-8.2850 [6.2304]	0.184	16.0656 [4.0655]	0.000
DSTATES	-11.9754 [5.3651]	0.026	3.8990 [4.4822]	0.385
DMRICH	-3.6562 [4.7470]	0.441	-1.3504 [3.5835]	0.706
DRICH	-5.8881 [4.1581]	0.157	-5.9202 [3.2931]	0.073
DNE	-5.0787 [8.7995]	0.564	3.1613 [7.5694]	0.676
CONSTANT	108.4437 [10.1106]	0.000	-53.7083 [6.5581]	0.000
Observations	735		735	
R-squared	0.3710	0.000	0.3928	0.000

* White's heteroscedastic consistent estimates. Robust standard errors in parentheses.

Guided by this concern and to check robustness of our claims and results, regressions were run for various somewhat 'cleaner' subsets of the entire dataset. Table A1 in the Appendix provides the BLUE estimates for the subset reached at by dropping all the projects with

[21] For example, initially a 200 km road was to be built but finally it was decided to bring down the length to just 40 km. Clearly, a road project of 200 km is not comparable to the one covering just 40 Km.

time overruns of 40% and more, such as 50% etc., and at the same time with cost overrun of -40% and less, such as -45%, etc.[22] Besides, estimates were checked with various thresholds of less than as well as greater than the 40% limits. The results are very similar to those in Table A1.[23] Only the significance level for INITIALCOST shows small variations. This outcome is not surprising since most of the problematic projects are outliers and get dropped anyway. Moreover, results for the entire dataset of 894 projects are reported in Table A2 in the Appendix. Since, the entire set has many outliers Quantile regression is used for this set. Compared to OLS, the Quantile regression is less vulnerable to the effects of outliers. Results in Table A1 and Table A2 are very similar to those reported in Table 5, with respect to the major hypotheses presented in Section 4. Also, the coefficients of the variables are robust to the presence or absence of the dummies. Therefore, we can afford to be confident about the findings.

Most of our hypotheses have turned out to be correct. For all regressions, the trend variable TIMELAPSE has negative coefficient and is extremely significant at 1% for time as well as cost overrun equations. Besides, in both the equations, the coefficient of $TIMELAPSE^2$ is positive and significant at 1%. These results imply that the downward trends for percentage time and cost overruns are statistically significant. Moreover, as predicted, the TIMELAPSE variable has a U-shape effect on delays and cost overruns. The coefficient of INTIALCOST in equation (2) is positive and significant at 10%. Though, the significance level is somewhat sensitive to the presence/absence of outliers and the 'implausible' figures discussed above. But, the variable continues to have explanatory power. However, the coefficient of IMPLPHASE in equation (2) is positive and exceedingly significant at 1%. This means as implementation phase increases, cost overruns soar up not only in absolute terms but also in percentage terms. As predicted in Section 4, IMPLPHASE is a better proxy for contractual failures. These results also confirm our claim that poor project planning and the resulting contractual failures are statistically significant causes behind cost overruns observed in India. For equation (1), as expected, the coefficient of IMPLPHASE is negative and highly significant at 1%. The coefficient of INTIALCOST is negative but insignificant. Therefore, as explained in Section 4, the main effect of the sloppy planning and contractual failures is to increase cost overruns; they do not matter that much for time overruns.[24]

As predicted, time overrun is one of the important factors behind cost overruns; the coefficient of PCTGTIMEOVERRUN is positive and extremely significant at 1% in all the regression run. This corroborates our assertion that regardless of the underlying reason, delays in implementation are a major cause of cost overruns.

The results also confirm our claim that organizational failures are a significant cause behind delays and cost escalations. Indeed, in every regression, the proxies for organizational failures – DRRU and DCSPP – have come out to be positive and extremely significant for delays as well as cost overruns. That is, *ceteris paribus* the road, railways,

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[22] While any threshold is arbitrary, figures showing -40%, -45%, etc. of cost overruns or time overruns are rather implausible. Therefore, it appears safe to exclude such projects on account of the reasons provided in the previous paragraph.

[23] After dropping of the observations with time overruns of -40% and less, and cost overrun -40% and less, the remaining observations were treated for outlier as explained above. The same procedure was followed with the other threshold limits.

[24] However, note that in equation (1) the dependant variable is *percentage* time overrun rather than the absolute value of the time overrun. Time overruns in absolute terms should increase with the project size.

urban-development projects have experienced relatively high percentage of time and cost overruns. The same is the case with civil aviation, shipping and ports, and power sector projects. Significance level of the dummy DSTATE is not robust to regression techniques and across various datasets used. As expected, dummies DTA and DPP have not shown any consistency regarding the delays. Compared to the residual category, Petroleum and petrochemical sector projects have experienced higher cost overruns. However, given the level of heterogeneity of in these sectors, one should not read too much in these results. Indeed, as Table A1 shows, telecom and atomic energy projects are either outliers or have unreasonable figures.

As far as the relative performance of the States is concerned, there are no significant variations across regions. Yet, the southern states seem to have performed better than the rest. Projects in these states have experienced a bit smaller cost overruns. The performance of north-eastern states and Jammu and Kashmir is not significantly and consistently worse than the other regions.

Before concluding, let me make an observation. As Table 2 shows, most projects suffering from cost overrun have experienced delays. In contrast, there are a number of projects with delays but no cost overruns. In view of our arguments on time overruns versus cost overruns, these figures are somewhat puzzling. It appears that these paradoxical figures are a result of somewhat different procedures used to calculate time and cost overruns. In terms of Figure 1, initial estimates of time and cost are made at time t=0, however the contract is awarded at t=1. Generally there are delays between t=0 and t=1. As a result, input prices at t=1 are significantly higher than at t=0. It appears that only cost estimates get revised upward at t=1, not the time estimates, and these revised cost figures are reported in official files. This indeed has been found to be the case with road projects. Moreover, since cost escalations necessitate additional funds, so cost figures get revised to avoid audit objections; time, in contrast, appears to be a free good in government departments.

6. Conclusions and Policy Implications

The following findings have emerged from the econometric analysis of the MOSPI data: *First*, since 1980s the delays and the cost overruns have declined. Cost overruns have systematically declined not only in absolute terms but also as a percentage of project cost. Similar is the case with delays. However, the effect is U-shaped. *Second*, regardless of their source, delays are one of the crucial causes behind the cost overruns. *Third*, bigger projects have experienced much higher cost overruns compared to smaller ones. *Fourth*, percentage cost overruns also escalate with length of the implementation phase; *ceteris paribus*, the longer is the implementation phase, the higher are cost overruns in absolute as well as percentage terms. *Fifth*, compared to other sectors, projects from road, railways, urban-development sectors, as well as those from civil aviation, shipping and ports, and power sectors have experienced much longer delays and significantly higher cost overruns. *Sixth*, compared to other states, projects located in southern states, Andhra, Karnataka, Kerala and Tamil Nadu, have experienced somewhat shorter delays and lower cost overruns. Performance of rich states is not significantly better than that of the poorer states.

The first five findings are statistically significant and robust to regression techniques as well as sample sizes. Each result is symptomatic of a set of underlying causes. Below we discuss each finding and its policy implications in view of the relevant underlying causes.

The first finding shows that during the last three decades some learning-by-doing has taken place among government officials involved in project planning and implementation. This along with the technological advances has enabled officials to improve estimates of project time and cost.[25] However, the finding also reveals that the effect of cost overrun reducing learning and innovations has declined over time. Some policy interventions are urgently called for.

The policy implication of the second result is immediate. Measures are immediately called for to avoid delays at each stage; from project approval, to awarding of contract, to its implementation. In what follows, while discussing the remaining findings, I will propose some of the steps that can help in the matter.

Coming to the third and the fourth findings, the analysis shows that due to imperfect techniques and contractual incompleteness some delays and cost overruns are inevitable. Besides, some of the cost overruns can be attributed to inflationary fluctuations. To that extent delays and cost overruns do not reflect wastage of resources. However, delays and cost overruns are too frequent and too large to be explained by the imperfect techniques, contractual incompleteness and the inflationary fluctuations. The third and the fourth findings in view of the pertinent discussion in Section 4 imply that the defective planning and contractual failures are largely responsible for cost overruns and consequently for wastage of public resources. Several measures can be helpful. For instance, to the extent possible, policy makers should avoid planning for large and big-cost projects. Similarly, planning of projects with long implementation phase is problematic. Such projects are vulnerable to future uncertainties, deterioration in project assets and the inflation. Wherever possible the project size as well as the implementation phase should be kept small. Projects that have to be inevitably large should be planned and implemented with utmost care.

However, the project planning process itself needs a radical overhaul. Rather than paying higher cost later on, it is worth investing resources to have more precise initial estimates of project time and cost. Moreover, wherever possible *fixed-price* rather than *unit-price* EPC contracts should be used. Under the commonly employed cash EPC contracts neither government officials nor the contractors have incentives to take the contracts seriously. As a result, contracts are vague at the time of signing and poorly managed afterwards, leading to delays and cost overruns.

The fifth finding is indicative of the organizational failures that have come to afflict the project implementation process. It shows that the organizational failures are a statistically significant cause of delays and cost overruns. In view of the arguments presented in Section 4, relatively long delays and high cost overruns experienced by the road, railways, urban-development, civil aviation, shipping and ports, and power projects are due to these failures. Some other results in the study also corroborate this finding. In fact, organizational failures frequently trigger yet another form of contractual failure. It is widely known that contract management during the construction phase is very important if delays are to be avoided. At present, construction contracts are generally awarded even before the required land for the project is acquired. Similarly, utilities are shifted during the construction phase. Invariably, several departments are involved in approving and the actual shifting of power, water and sewer lines and other the utilities. Government agencies rarely do what they are required to do, but can use cobweb of complicated rules and procedures to pass the blame

[25] This result supplements findings that performance of public sector as a whole has improved since mid 1980s (see Nagaraj, 2006).

for delays on each other. So much so that even if the delay is caused by the contractor it is almost impossible to punish him. Since contractor can easily prove a contributory negligence on the part of one or some other department. This explains why contracts are rarely terminated, even when contractors cause prolonged delays. Several measures can help on this front too. For example, if activities like land acquisition and shifting of utilities can be completed either before or within a pre-scheduled time after the award of contract, the contractors can be put on high powered incentives to deliver on time and quality.

Coming to the sixth finding, there is perception that due to superior infrastructure and better governance, the public delivery system is better in richer states. However, contrary to popular perception, this finding shows that the performance of richer states is not any better than the rest of the country. Though, the projects located in the Southern states have exhibited a bit lower cost overruns.

The above conclusions are relevant for the present official policies toward infrastructure. Policy makers seem to be keen to privatize the funding, management and ownership of infrastructure facilities. While an outright privatization has invited strong protests from several quarters, the PPPs have become politically acceptable channel of transferring management and ownership rights to private firms. The 11th five-year plan crucially depends on private sector participation in infrastructure. The problems of delays and cost overruns with the public delivery systems are being used to justify privatization of public goods and services. However, our results imply that a change in ownership in itself cannot mitigate all the problems with the supply and administration of infrastructure facilities. After all, even PPP projects have to be initially planned by government officials. PPP projects are equally vulnerable to some of the contractual and organizational failures discussed above. Projects for upgradation of Delhi and Mumbai airports, construction of Bangalore Metro Train and for Delhi-Gurgaon Expressway are some of the cases in point. These are all PPP projects and have experienced major delays and cost overruns. In contrast, the contractual and institutional approach adopted by the DMRC for the construction of Delhi Metro is worth emulating. Most of its projects have been completed on time and within budget. Interestingly, the DMRC has adopted some aspects of the approach suggested above.

I would like to conclude with a few remarks on the findings of this paper. The results and conclusions are relevant to all infrastructure projects, regardless of the sector and the project type. However, generality always comes at a cost. Apart from the issues discussed here, there are sector-specific issues also that impinge on delays and cost overruns. The present study has ignored such issues. For a better understanding of the causes behind delays and cost overruns, it will be useful to supplement this work with sector-specific analyses. Sector-specific studies may allow testing of additional hypotheses. For example, it may become feasible to evaluate the comparative performance of different types of contracts, say acquisition versus construction contracts, PPP versus Non-PPP contracts, etc. Besides, though the results seem robust enough, still it will be useful to explore the reasons behind the doubtful figures on delays and cost overruns (such as, reporting errors), and rectify them to the extent possible. I intend to take some of these next steps.

APPENDIX

Table A1: Regression results.*

Variables	PCGETIMEOVERRUN (% Time Overrun)	P - value	PCGECOSTOVRRN (% Cost Overrun)	P - value
PCGETIMEOVRRN			0.2429 [0.0369]	0.000
TIMELAPSE	-0.7328 [0.0633]	0.000	-0.3845 [0.0651]	0.000
$TIMELAPSE^2$	0.0028 [0.0006]	0.000	0.0035 [0.0006]	0.000
INITIALCOST	-0.0063 [0.0049]	0.193	0.0050 [0.0030]	0.094
IMPLPHASE	-1.2333 [0.1681]	0.000	0.5067 [0.1220]	0.000
DRRU	40.9296 [5.3430]	0.000	37.9870 [4.5982]	0.000
DCSPP	19.7656 [5.4361]	0.000	24.0051 [4.0508]	0.000
DTA	dropped		dropped	
DPP	-4.7462 [6.3433]	0.455	14.6585 [4.0358]	0.000
DSTATES	-11.8610 [5.3573]	0.027	1.7636 [4.4294]	0.691
DMRICH	-5.7687 [4.5601]	0.206	0.0901 [3.6606]	0.980
DRICH	-3.5852 [4.1605]	0.389	-5.4182 [3.4273]	0.114
DNE	-4.1623 [8.9883]	0.644	5.1536 [6.6445]	0.438
CONSTANT	101.7805 [10.0440]	0.000	-54.8966 [6.4634]	0.000
Observations	672		672	
R-squared	0.3207	0.000	0.4283	0.000

* White's heteroscedastic consistent estimates. Robust standard errors in parentheses.

TABLE A2: Regression Results – Quantile Regression (Standard errors in parentheses).

Variables	PCGETIMEOVRRN (%Time Overrun)	p-value	PCGECOSTOVRRN (%Cost Overrun)	p-value
PCGETIMEOVRRN			0.0257	0.000
			[0.0073]	
TIMELAPSE	-0.6558	0.000	-0.5347	0.000
	[0.0403]		[0.0211]	
$TIMELAPSE^2$	0.0029	0.000	0.0044	0.000
	[0.0005]		[0.0002]	
INITIALCOST	-0.0008	0.814	0.0023	0.165
	[0.0033]		[0.0017]	
IMPLPHASE	-0.9046	0.000	0.2473	0.000
	[0.0433]		[0.0226]	
DRRU	36.7614	0.000	42.1693	0.000
	[5.7493]		[2.9710]	
DCSPP	17.0066	0.008	19.9639	0.000
	[6.3534]		[3.2765]	
DTA	124.9216	0.000	-13.5074	0.005
	[8.9962]		[4.7953]	
DPP	-6.4807	0.384	14.0290	0.000
	[7.4378]		[3.8430]	
DSTATES	-7.7387	0.267	6.2275	0.084
	[6.9621]		[3.6050]	
DMRICH	2.3849	0.650	-3.9707	0.144
	[5.2572]		[2.7129]	
DRICH	-1.3095	0.801	-3.6842	0.171
	[5.1935]		[2.6890]	
DNE	4.3152	0.612	15.4589	0.000
	[8.4949]		[4.4202]	
CONSTANT	78.4338	0.000	-34.8407	0.000
	[5.9022]		[3.0972]	
Observations	894		894	
Pseudo R2	0.1595		0.1748	

TABLE 3A Summary Statistics: State-wise details of Delays and cost overruns in infrastructure projects during April1992-March 2009.

		% Cost Overruns*				% Time Overrun*			
States	Number of Projects	Mean	Std. Dev.	Min	Max	Mean	Std. Dev.	Min	Max
All India	5	22.94	78.70	-50.17	157.68	117.50	147.55	21.21	378.13
Andaman & Nicobar Islands	2	320.54	358.98	66.70	574.38	6.77	14.00	-3.13	16.67
Andhra Pradesh	91	-12.94	47.67	-99.73	143.39	62.93	104.02	-33.33	542.86
Arunachal Pradesh	3	153.22	200.31	-52.95	347.10	95.66	47.32	45.83	140.00
Assam	29	51.25	146.52	-49.62	588.95	69.70	62.87	-9.68	275.00
Bihar	31	32.49	92.74	-61.95	443.98	90.04	104.61	-4.76	359.57
Chhattisgarh	20	-19.51	30.24	-91.85	44.99	21.36	41.75	-93.33	100.00
Delhi	35	19.65	82.34	-98.40	279.46	183.40	250.58	0.00	1200.00
ER	2	30.70	47.70	-3.03	64.43	28.59	11.43	20.51	36.67
Goa	5	-6.74	61.09	-90.37	65.68	93.06	43.92	37.04	138.46
Gujarat	54	12.09	99.03	-93.37	534.37	58.69	74.68	-41.38	314.29
Haryana	12	32.72	115.73	-46.68	368.82	68.43	115.44	-19.67	366.67
Himachal Pradesh	4	105.18	181.27	-16.94	373.86	100.07	93.73	-6.67	217.65
Jammu & Kashmir	7	517.73	972.22	-60.86	2603.96	95.78	66.16	22.08	202.08
Jharkhand	20	-12.49	45.97	-64.84	136.75	176.91	441.10	-5.13	2033.33
Karnataka	34	5.93	60.22	-80.32	265.12	81.28	186.52	-10.96	1100.00
Kerala	15	13.42	68.99	-72.89	190.97	98.33	129.42	-11.90	500.00
Madhya Pradesh	43	-11.79	56.26	-99.32	207.83	29.62	75.61	-62.50	397.14
Maharashtra	125	-14.42	45.48	-91.93	238.82	100.05	241.86	-42.68	2150.00
Manipur	2	170.26	279.70	-27.52	368.03	274.45	199.57	133.33	415.56
Mizoram	1	-26.84	.	-26.84	-26.84	59.09	.	59.09	59.09
Multi City	4	11.09	88.20	-72.38	132.91	147.11	104.12	86.67	302.78
NR or North East States/region	10	-0.13	63.52	-67.51	166.82	67.53	86.24	-10.00	220.00
Nagaland	3	254.89	315.87	-9.07	604.85	109.32	55.71	70.83	173.21
Orissa	52	10.11	115.11	-74.90	735.33	61.54	69.46	-18.18	305.56
Punjab	10	33.44	84.47	-69.00	193.69	83.19	78.07	-14.29	232.91
Rajasthan	24	-1.55	50.72	-53.68	216.77	38.14	75.05	-13.64	356.52
SR	3	-22.39	4.41	-26.84	-18.03	12.27	24.95	-4.17	40.98
Sikkim	4	31.85	72.55	-32.14	136.16	31.51	34.10	-2.44	75.38
Tamil Nadu	61	-5.41	68.05	-93.86	331.09	98.73	163.71	-10.00	1075.00
Tripura	4	25.30	24.60	2.54	55.34	80.94	79.26	11.48	162.50
Uttar Pradesh	59	19.58	85.41	-78.69	377.24	51.90	55.35	-25.00	237.50
Uttaranchal	4	59.63	133.40	-64.82	178.91	151.73	158.86	-9.76	366.67
WR states/region	4	-23.02	36.78	-61.19	19.97	21.01	67.16	-25.00	120.83
West Bengal	53	32.93	104.15	-56.60	527.56	79.17	72.87	-27.78	405.26
Spans in more than one state	59	50.01	176.51	-61.83	1287.98	64.04	80.92	-100.00	408.70
Total	894	25.17	132.273	-99.73	2603.96	79.19	153.56	-100.00	2150.00

*. For all projects in a sector

Table 4A: Correlation Matrix

	PCGECOSTOVRRN	PCGETIMEOVRRN	TIMELAPSEMONTHS	TIMELAPSESQMONTHS	INITIALCOST	LENGTHIMP
PCGECOSTOVRRN	1					
PCGETIMEOVRRN	0.2561	1				
TIMELAPSEMONTHS	-0.3478	-0.1936	1			
TIMELAPSESQMONTHS	-0.154	-0.0639	0.7726	1		
INITIALCOST	-0.008	-0.1509	-0.0052	-0.0149	1	
LENGTHIMP	0.3566	-0.2072	-0.488	-0.3522	0.067	1

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