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Decluttering Cost Estimation and Addressing Cost Overruns in Construction Projects - an Estimator's Perspective

Shubham Bajaj; IIT Madras, India
Ashwin Mahalingam; IIT Madras, India

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- An Estimator's Perspective

ABSTRACT:

Research papers on cost estimation and cost overruns in construction projects are plenty. However, most of them take empirical and statistical approaches. While these studies give explanations for cost and time overruns, they do not delve deep into routine challenges in estimation and behavioral biases of the estimators. In this paper, the problems of cost overruns have been studied from a new angle - the estimator's perspective. The study was conducted in India and the data is restricted to this context.

A qualitative analysis of cost estimation methods is done and reasons for cost and time overruns are studied. Seasoned estimators are personally interviewed and their approaches to cost estimation in real projects have been critically examined. We find that different stakeholders like clients, consultants, and contractors (small, medium and large) have different approaches to cost estimation resulting in varying estimates. The estimation process is compared among different stakeholders over 16 parameters.

From our study, we find that most cost overruns are genuine and there is very little evidence of any optimism bias and almost no evidence of strategic misrepresentation as suggested by the Flyvbjerg *(Flyvbjerg et. al., 2002)*. The uncertainty of the market, the complexity of the process and the inability of different stakeholders to come together seem to be the reasons for estimations to go wrong. Moreover, estimators have their own biases, approximations and time pressures that also play a role in costs being underestimated. Another interesting observation is that the initial estimate done by a consultant and the actual estimate done by a contractor for a project is very different. Currently, the cost overrun figures published are generally by taking initial estimates as the base. To get a more accurate idea of the cost overruns, the base should be the contractor's bid price and not the initial estimate. Finally, we suggest that the Alliance Model is the way to go forward for medium to large infrastructure projects. We also foresee a need for AI-based platforms which will help estimators make better assumptions and in turn will improve estimates.

KEYWORDS: Cost Estimation, Overruns, Estimator's perspective, Alliance model

INTRODUCTION:

Construction industry plays a pivotal role in the growth of the economy. It contributes both directly and indirectly to the economic output due to its strong linkages to several other sectors of the economy *(Mallick and Mahalik, 2008)*. It employs a large number of both skilled and unskilled labor. However, this sector suffers from excessive volatility and cycles of boom and bust. Adding to that is the complex nature of industry involving very diverse stakeholders.

The basics of cost estimation have not changed much in the last few decades. Even now, most of the stakeholders use first principle methods better known as the Quantity Rate Analysis method. In this method, the entire project is divided into small discrete work items and a unit rate is established for each item. The unit rate is then multiplied by the required quantity to find the cost for the work item. All costs are added to obtain the estimated total construction cost *(Shabniya and Dilruba, 2017)*. Most consultants and contractors still use traditional spreadsheets showing their revised rates for any type of work. Indirect costs are also calculated in the same way by using work breakdown structures. Clearly, the science of estimation has the same alphabets from a long time ago and hence the results should be the same. Research shows that there is hardly any reduction in cost overruns in the last 70 years *(Flyvbjerg et. al, 2002)*.

Accurate estimation of time and cost is crucial for the success of construction projects. Initial estimates are very useful in the decision-making process for the construction of capital projects. However, early estimates are typically plagued by limited scope definition and thus the high potential for scope change, and are often prepared under stiff time constraints *(Trost, et. al. 2006)*. Clearly, initial estimates are flawed and lead to cost and time overruns.

Cost overrun is a chronic problem across most projects. Increasing complexity and involvement of a multitude of stakeholders with varied stakes make it nearly impossible for modern construction projects to avoid cost overruns *(Doloi, 2010)*. Costs are underestimated 9 out of 10 times in large projects *(Flyvjberg et. al., 2003)*. Hence, the problem is more evident in large and complex projects. For example, in India, according to Ministry of Statistics and Program Implementation (MoSPI), infrastructure projects in central government sector costing INR 150 crore (USD 22 Million) and above are currently experiencing cumulative cost overruns of 20.1 percent of their planned cost *(Flash Report July 2018, MoSPI)*. It is also important to note that time and cost overruns are not mutually exclusive but are actually very closely interconnected phenomena.

A lot of literature exists on the reasons and solutions of the cost overruns which is reviewed in some detail in the next section. Cost estimation in construction projects is not pure science - at least not yet - and hence the statistical approaches taken by most researchers have their limitations. What this study attempt is to declutter the cost estimation process by an ethnographic study from the perspective of seasoned estimators.

LITERATURE REVIEW:

The literature offers 12 major methods of cost estimation in construction projects which can be classified mainly as traditional and non - traditional methods. The main traditional method used for cost estimation is the Quantity Rate Analysis. Non-traditional methods are either statistical or artificial intelligence based. Some of the examples are Regression Analysis, Reference class forecasting, case-based reasoning, neural networks, fuzzy inference, and Monte Carlo simulations *(Shabniya. and Dilruba, 2017).* Any cost estimation method efficacy can be analyzed on three parameters accuracy, usability and easiness to understand *(Barakchi et. al. 2017).* Both, the traditional and the non - traditional methods have not been successful in addressing cost overruns in the construction industry.

A plethora of research work exists that analyze cost overruns. Many factors are responsible for these cost overruns such as underestimation of costs to make the projects more viable, the addition of scope during later stages of project planning and even during construction, changed conditions, etc. One of the most important contributing factors to the magnitude of cost overrun in large transportation projects are project delays *(Ali Touran et. al., 2006).*

Subramani et al (2014) identified the major causes of cost overruns to be slow decision making - poor schedule management, increase in material, machine prices, poor contract management, poor design, delay in providing design, rework due to wrong work, problems in land acquisition, wrong estimation and estimation method, long period between design and time of bidding. Some of the approaches suggested in the literature look at the behavioral and cognitive biases of the estimators to explain cost overruns. Estimators, when faced with a decision, do not always immediately know the right choice, but rather perform an informal reasoning process, sometimes referred to as preference construction *(Shealy et. al., 2015).* These shortcuts are very common in the estimation process and lead to cognitive biases.

There is an ongoing debate in the research community on the real reasons for cost overruns. Researchers such as Bent Flyvbjerg explain cost overruns on the basis of the Optimism Bias and Strategic Misrepresentation *(Flyvjberg et. al., 2002).* Flyvjberg and his associates indicate persistent bias in infrastructure project appraisals, where costs are systematically underestimated and demand systematically overestimated *(Flyvbjerg et al., 2002, 2004, 2005; Flyvbjerg, 2008, 2009).*

Other experts led by Peter Love refute these claims. Love argues that the major reason for cost overruns is the inability to predict numerous uncertainties in infrastructure projects (*Love et. al., 2018*). Research on leadership and governance of construction projects by *Gil and Lundrigan (2012),* perhaps offers a more holistic assessment of cost growth that aligns closely with the views of Love, et al (2018) above. That projects evolve, is essentially, the core of their defense.

Very often, construction projects change considerably in scope and design between conception, to inception and completion, often due to a client's proposed changes or technically imposed changes. For *Love (2018) and Gil et al (2012)*, project overruns are not really a case of projects not going according to plan (budget), but the other way round – plans not going according to the project.

Olawlae and Sun (2010), suggest 90 mitigating measures are established to address potential problems caused by the top inhibiting factors. The measures can be broadly classified as preventive, predictive, corrective and organizational measures.

We foresee the Alliance model as one of the organizational measures which can address cost overruns. Project Alliancing is a relational contracting mechanism widely employed to handle complex projects. Alliancing requires all project participants to work as one integrated team by tying their commercial objectives to the actual outcome of the project (mutual gain and pain). It covers the whole process of the project starting from the design stage, in some cases starting from the development stage, until completion by making use of all participants' inputs during each stage. *(Salamah 2017)*. Such approaches that facilitate knowledge transfer between participants are likely to yield accurate cost estimates.

Clearly, the research fraternity is divided on reasons of cost overruns. *Dominic et. al. (2014)* put this in a very interesting way they suggest that estimates reliability and accuracy depends on two separate but often confused phenomena underestimation and cost overruns. Underestimation includes optimism bias and strategic misrepresentation while overrun includes scope changes, genuine uncertainties and ground conditions.

With this understanding of cost estimation and cost overruns, we hope to fill up the research gap between the statistical understanding of cost overruns and qualitative insights from practitioners. The aim of this research is threefold; first to declutter the cost estimation process and compare and contrast it among different stakeholders. Second, to approach cost overruns from the estimator's perspective and fill up the research gap between the statistical understanding of cost overruns and qualitative insights from practitioners. Third, to think of better models and technological innovations which enable estimators to come up with better and more accurate cost estimates in construction projects. The study is restricted to the Indian context, where the data was collected, as explained in the next section.

RESEARCH METHODOLOGY:

We have used first-hand techniques such as personal interviews (primarily) and questionnaires (supplementary) to get information from estimators who estimate costs in construction projects. To get more clarity and authenticity, we made sure that the minimum experience of the professionals involved in the study must be greater than 10 years. We have used semi-structured

interviews so that we can elaborate and highlight some of the research questions and hypothesis that we had after going through the literature.

Step 1: Semi-Structured interviews with seasoned estimators

Six different players were identified in the construction sector: Client (both public and private), Small contractor, Medium Contractor, Large Contractor, Consultants, and Infrastructure project managers. The interviewees involved people from 12 different organizations across these 6 segments. In the first step, each of these stakeholders was interviewed personally and they were asked to explain their approach of estimating project costs in detail. Our research intuition was that there exist a routine process and some strategic considerations that go into preparing a budget estimate. Hence each and every detail of the routine procedure as told by practitioners was carefully noted and clarified. The assumptions and biases of the estimators were noted and confirmed by asking them supplementary questions. Some of these questions were:

- How much time do they get to prepare the budget estimate?
- How many people from the organization are involved?
- What all risks have they considered in their risk matrix?
- How do they quantify risks that they foresee?
- How many times do they visit the site before beginning to estimate?
- What is the basis of their assumptions?
- How are they bringing their past experience, past data into use?

The interviews were recorded and transcribed. The details of the interviews are as follows (most interviews were taken in parts and only details of one interview per organization is given):

Table: Details of Interviews conducted for this study

Sr N o	Roles	Experience in Cost Estimation (years)	Represents Stakeholder	Project Types	Duration of Interview
1	Chief Estimator	20	Public Sector Client	College Buildings	2 hrs
2	Head of Estimation	25	Small Contractor	Projects < INR 100 crore, mostly Industrial buildings	3 hrs
3	Head of Estimation	28	Medium Contractor	Projects from INR 50 crore to INR 500 crore	3 hrs
4	Senior Executive	30	Large Contractor	Large projects	1.5 hrs

| 5	Senior Executive	30	Large Contractor	Large projects mainly roads	1.5 hrs
6	Senior Executive	15	Consultants (1)	Buildings	2 hrs
7	Head of Estimation	15	Cost Consultants	Commercial Space	2 hrs
8	Senior Executive	30	Chennai Metro (Public Client)	Metro Rail	2 hrs
9	Ex- CEO	35	Private Infrastructure Developer	Infrastructure Projects on PPPs	3 hrs
10	Senior Manager	15	Large Contractor	Commercial Buildings Expert	1.5 hrs
11	Director	18	Consultants	Medium sized projects	3 hrs
12	Manager	10	Contractor	Metro	2 hrs
13	Estimator	10	Contractor	Ports and Harbours	1 hr
14	Senior Executive	20	Private Client	Commercial Infrastructure Projects like IT Park	2 hrs

Step 2: Synthesizing the Estimation Process

In the second step, different approaches are compared among themselves and contrasted with each other. Senior managers in these firms were approached to give insights into the strategic

considerations used for preparing estimates and understanding the final decision making. Construction is a very competitive industry and hence strategic decisions which decide the profit margins and risk contingency are the real determinants of the tender bid price. The second round of interviews was also conducted to clarify the remaining lacunas in understanding the process. The basis for approximations and guess estimates are critically analyzed and an attempt was made to understand the origin of biases of the estimators. Hypothetical scenarios were given to estimators to find out if there exists optimism bias or strategic misrepresentation in the construction industry. Overall 36 hours of personal interviews were conducted and these were further supplemented by circulating questionnaires.

Step 3: Data Analysis and Recommendations

Data collected from interviews was analyzed through qualitative comparative analysis. An extensive matrix was developed comprising of 8 key stakeholders in the construction industry on X-axis and 16 different parameters relating to estimation and outcomes on the Y-axis. The stakeholders involved were divided into 3 main categories: Client, Consultant and Contractor as shown in figure below:
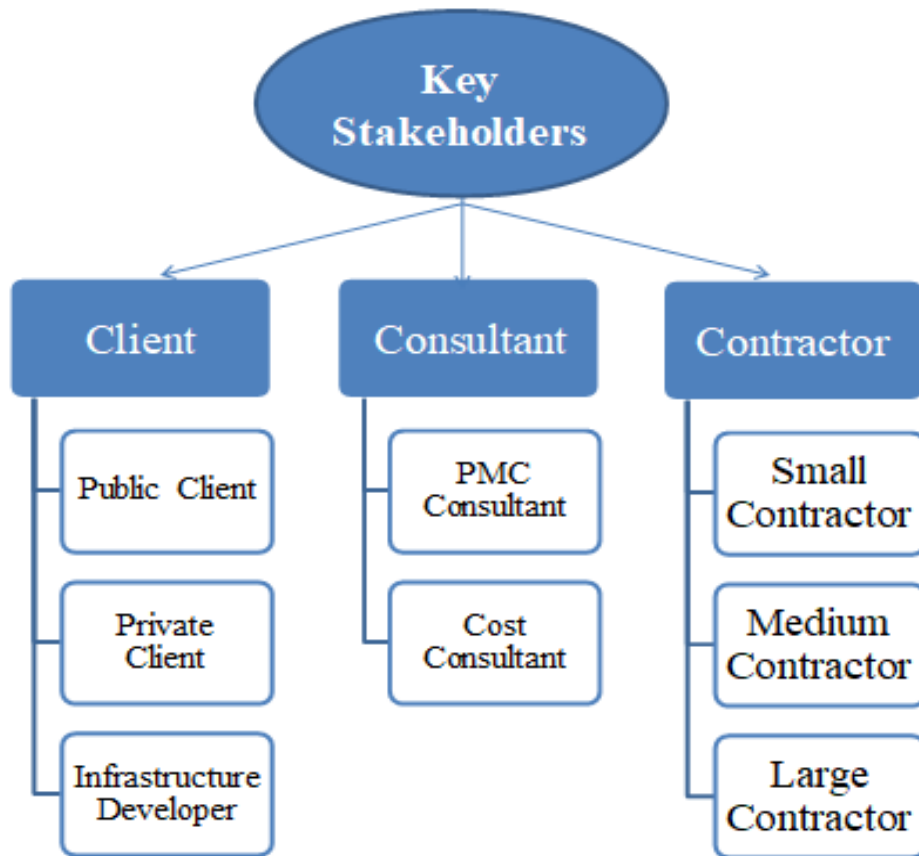
The parameters selected were divided into four categories: Routine process, Strategic considerations, Risk estimation and Relation to overruns as presented in figure below:
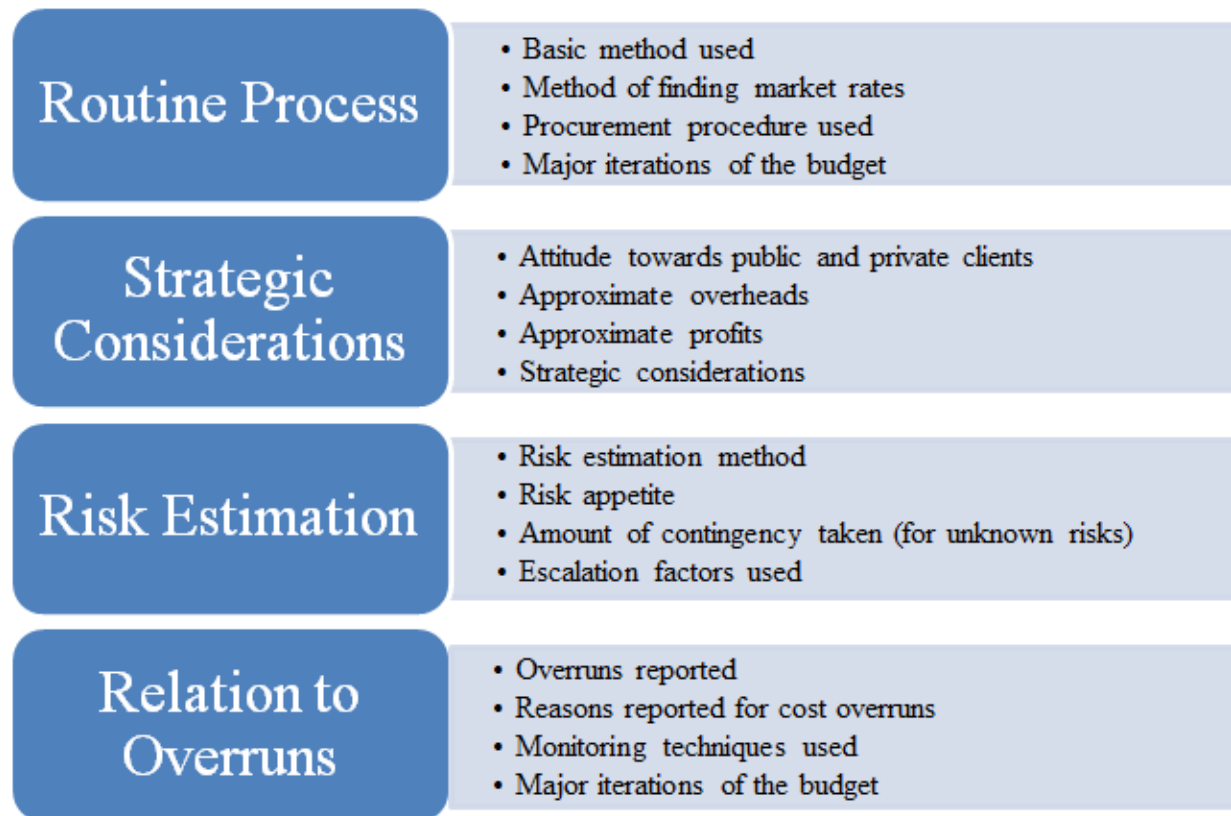
This analysis allowed us to distinguish between the estimation methodologies of key stakeholders. It also gave an understanding of how the estimation process is related to underestimation of costs or cost overruns.

Further research was done by delving into behavioral economics and alliance contracting to find solutions to problems suggested by estimators. Through a feedback loop, feedback was taken from our informants on suggested solutions and their inputs were assimilated in final recommendations presented in this study.

ANALYSIS OF RESEARCH AND OBSERVATIONS:

Difference between estimation methodology of Consultants and Contractors:

Construction projects have three main stakeholders - the client, the consultant, and the contractor. Generally, consultants prepare the initial estimate as per the requirements of the clients and conduct bidding. Contractors prepare separate estimate which they use to place their bid. Consultants tend to use reference class forecasting where they use similar projects and items to estimate costs for new projects. The director of a leading consulting firm that we interviewed explains:

"Consultants use three things: Experience from past projects especially similar projects in the same location, Quotations from Contractors and for some items first principle methods. First principle method gives higher costs than the contractors actually bears and hence is avoided by the consultants."

This is very inaccurate as the consultants we interviewed revealed that their estimates are wrong by as much as 20% (without any major change in the scope of the project). On the other hand, contractors prepare their estimate by Quantity Rate Analysis. Contractors have reported a much lesser deviation from the actual cost reporting a figure of 5% cost overrun over their bid estimate (without any major change in scope of the project). Contractors also have a better overall estimation methodology. They have better linkages with subcontractors and vendors and are really aware of the ongoing and upcoming market conditions. Another reason for the difference in the estimate of consultants and contractors is the contractor's ability to foresee risks and take them into account. Ex CEO of a leading Infrastructure developer firm commented on this:

"Initial Detailed Project Report is prepared by a consultant. Consultant's ability to conceive the project is limited by time and expertise. They can estimate only on the basis on given requirements and market conditions which are obviously subject to change during the long development phase of the project."

Consultants generally do not do any risk analysis and this makes their estimate inaccurate. Contractors with their enormous on-site experience, market awareness and incentive to bid correctly estimate more accurately than the consultants.

Difference between estimation methodology of Small, Medium and Large Contractor:
We also find differences between estimation methodology of small, medium and large contractors. Though all contractors use the Quantity Rate Analysis method; the detailing varies for each. Small contractors have a more simplistic and deterministic approach while medium and large contractors have a mix of statistical and deterministic approaches. They use different scenarios to come up with their estimate. For large contractors whether to bid or not to bid is also decided by the market expectations. A senior executive of India's leading contractor firm that we interviewed comments:

"In business, both top line (total volume of Business) and bottom line (margins from each project) has to grow simultaneously. Everything is determined by the expectations of the market and shareholders. Shareholders expect the company to take on more and more projects. Therefore many times such projects are selected which may not be very viable for the company."

We have also found that small contractors have a single pre-bid and post-bid budget whereas both medium and large contractors have different pre-bid and post-bid budgets. The post bid

budget is prepared by the estimation team in confluence with the on-site team responsible to implement the project. Head of estimation in a contracting firm explains:

"Once the bid is won, Accepted Cost Estimate (ACE) is prepared with the help of Project manager who is going to implement the project on the ground."

Thus there is more responsibility to finish projects on time and under budget. The major difference is found in the methodology to estimate risks. Small contractors just assume a contingency factor based on past experience or intuition. Whereas medium contractors break down risks into the different phases of the project. For each phase a checklist of risks is made mentioning different activities and kind of risks associated with them. Estimators assign values to each of these activities based on their experience and risk appetite of the organization. This risk factor depends a lot on how much contractor is interested in winning the bid. Large contractors use a much more sophisticated and well-architected risk estimation framework. A seasoned estimator in Large contracting firm explains:

"Large organisations have specialized people for managing risk called risk managers. Although the probability that they estimate is subjective. Generally they prepare a risk chart and give different weightages to different risks like who is Joint Partner, Client, contractual conditions, commercial conditions"

It is also important to note that small and medium contractors are very risk averse and not optimistic as Flyvbjerg *(Flyvbjerg, 2002)* suggests. However, we find some optimism bias when it comes to large contractors and infrastructure projects.

Optimism bias and Strategic misrepresentation:
Construction is a competitive industry and hence contractors are by nature aggressive in their bid estimates. This is found across all levels; whether small, medium or large projects. Bidding psychology plays a key role in deciding the final cost estimate. We find that small and medium contractors cannot afford to be optimistic or aggressive with their bidding. Only in very few instances will a small contractor bid optimistically if they are very confident of the client's reputation as a generous paymaster. However, when it comes to large contractors, they are much more optimistic. Large contractors are large corporations whose shares are publicly traded and hence many of their choices are dictated by the market. They cannot afford to be seen as losing bids and hence they are more optimistic. A senior executive at India's one of the largest construction companies commented during one of our interviews:

"You are always optimistic, Winning project is more important. Optimistic but conscious call is taken to select break-in project, but have confidence in operational efficiency to turn it around later".

In many cases, especially in large projects, the cost is only one of the dimensions. Overall, the offer should be more attractive as compared to other competitors. Moreover, if calculated with accuracy, there shouldn't be a difference between the cost of different competitors. A senior executive of India's leading contractor firm that we interviewed comments:

"The only difference will be how much optimistic I am, what is the profit margin I put over my bid. To win the bid I have to consciously under-assess the risks or my method of risk estimation should be different".

However, we did not find any evidence of major strategic misrepresentation. This is possible in cases when the government is the client and the project may be strategically misrepresented to serve some vested interests.

Longtime players cannot afford to lose their reputation by misrepresenting and lying. Hence there is a very little complaint of sugar coating projects among estimators.

Public and Private Projects:

There is also a lot of difference between how contractors estimate and place their bid for private projects and government (public) projects. In private projects, impacts of risks are much lesser compared to government projects. Contractors and clients can always negotiate and settle their disputes amicably. The scope for negotiations in later stages is nonexistent in government projects. Estimator at one of India's leading contractor firm puts it like this:

"Govt. officers can drag the project because no personal stake involved, However for private player time wasted is revenue lost. With government there is a very slim chance of negotiating later; hence have to be more careful. In government projects, only L1 is taken into account, whereas private can award to other than L1 also private player tends to keep higher contingency for govt projects"

Hence, contractors admittedly load more risk in their bids in government projects. This can be as much as 5% of the project cost. We feel that more research is required to compare the cost overruns and cost estimation methodology in public and private projects.

Trust Deficit:

In developing economies like India, the construction industry faces a lot of social and cultural barriers. Many of these cultural practices either are the result of the trust deficit or leads to a trust deficit. One example of this is this is the refusal to commit to the budget by clients. Clients are not sure of their requirements and also of their budget - this makes projects more haphazard. In our interactions with consultants, they find this trust deficit as a source of cost overruns as the expectations of clients are never met. Director of a leading construction consultancy firm puts it like this:

"Firstly there is a social and cultural dimension as businesses in India do not like to commit. Secondly, as the project is long term clients are not sure of their budget or cash flows. They make haphazard decisions without much understanding. Third, there is some amount of trust deficit for the initial period of time and it forces the client to keep their budget secret."

Clients just express their basic requirements and site location. This creates a lot of redundancy for the consultants as they have to go to and fro to find what the client actually wants and what is their budget. This trust deficit in all steps of construction especially during planning stages of the projects needs to be addressed to make better and reliable cost and time estimates.

Are cost overruns overestimated?

Finally, we observe that the way currently overruns are estimated and reported is flawed. What we take as the base cost for reporting cost overruns are initial estimates just after the Detailed Project Report. We have taken two anecdotal evidence to put forward this point.

Anecdote 1: Flash reports of Ministry of Statistics and Programme Implementation (MOSPI). These flash reports review the progress of infrastructure projects in India on a monthly basis. The report from July 2018 reports:

"Total original cost of implementation of 1361 projects when sanctioned, was of the order of Rs. 678,634.82 crore but this was subsequently revised to Rs. 2,016,360.99 crore implying a cost overrun of 20.1%. The expenditure incurred on these projects until July 2018 is Rs. 768,186.93 crore, which is 38.1% of the anticipated cost of the projects."

Clearly, they are taking sanctioned cost as the base cost which is just the initial cost prior to any estimation being done. We also confirmed this with the authors of the reports.

Anecdote 2: Tata Realty Infrastructure Limited (TRIL) developed a world-class information technology park called Ramanujan IT Park. The cost estimate of phase 2 of this building shows:

Table: Summary of Cost Estimates of Ramanujan IT Park

	First Estimate (By Consultant)	**Final Estimate (Bid Amount)**	**Actual Cost**	**Remarks**
Phase II	247 cr	380 cr ((version 6) almost 2 years before the project started)	353 cr	New scope added when bidding took place

From these two anecdotes, it is clear that estimates change a lot from the initial estimate before the project hits the floor. This is because all the dimensions of the project are unknown at the initial stages. As the new players come on they bring in new complexity and projects costs keep increasing. Hence, keeping the initial estimate as the base for reporting cost overruns is overestimating cost overruns. Similar observations were made by *Dominic and Smith (2014).* Much of the media hype on cost overruns, however, is often based on a comparison between the cost at inception and cost at completion, almost ignoring the mediating phases of project gestation and definition.

SUMMARY OF FINDINGS:

The research shows that there are different ways in which different stakeholders approach estimation. Consultants and clients rely more on references from previous projects, this method is called reference class forecasting. Whereas, contractors estimates are much more detailed and thought through and they follow Quantity Rate Analysis. We also find different methods of risk estimation and different detailing in which risks are foreseen. Consultants seem to ignore risk factors, whereas small contractor assumes some contingency based on intuition. Large contractors do have a much more sophisticated way of assessing risks. We also observe different approaches to government and private projects. Governments projects are generally more loaded keeping in the rigidity and unpredictable delays in government projects.

Researchers have already identified factors for cost overruns through statistical approaches. However, the research was not done on estimators' process and its impact on cost overruns. We have tried filling in this gap. We found that estimators are making assumptions that are not justified but purely based on their gut feeling especially while making risk estimates. There is some evidence of optimism bias especially when it comes to large contractors and infrastructure developers. But the same is not evident for small and medium players. Strategic misrepresentation has to be totally rejected because in long term contractors and clients cannot afford to sugar coat any project. Cultural barriers are also hindering the growth of the Indian construction industry. There is widespread trust deficit in the construction industry which is leading to inaccurate cost estimates as the necessary designs, drawings and details are not shared with the estimators at the right time. Also, this trust deficit is leading to a lot of redundancy. The research argues that the baseline used for calculating the cost overruns is the initial estimate prepared during the DPR which gives an inaccurate and overestimated value of cost overruns.

RECOMMENDATIONS AND DIRECTIONS FOR FUTURE WORK:

From our interactions with estimators, we came up with few ideas to improve the cost estimation process and reduce both underestimation and cost overruns (*Dominic et. al. (2014).* We also discussed these ideas with estimators and management to check if these suggestions can be implemented in the Indian scenario and their response was positive.

- First, the Australian Alliance model for Indian Construction scenario. This model will encourage more cooperation among stakeholders and encourage more confidence building. It will also ensure that due diligence is paid in the initial stages of project planning.
- Second, we recommend a technology up-gradation and use of Artificial Intelligence-based platform. It would have data of all past projects and all assumptions made would have to be necessarily approved by this engine.
- Third, we recommend standardization of BOQs in the construction industry so that a lot of redundancy and mistakes can be avoided. We hope to take a cost estimation from art to science.

Due to constraint of time we were unable to do extensive research on these recommendations especially on their implementation part. We encourage future research on some of these recommendations and researchers can implement these suggestions on pilot projects. Our research shows there is a gap between the consultant and contractor's estimate. Researchers can come up with ways to fill this gap and help different stakeholders to meet at some common ground. Research shows that current method of reporting overruns overestimates it. Researchers can come up with better and more accurate representations of cost overruns.

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