Human Factors affecting

Strategy and risk

in Complex projects – A system dynamics approach

A Thesis Submitted for the partial fulfilment of the requirements for the degree

in

Ph. D. Programme (Part-Time) in Management

Of

The ICFAI University, Jharkhand

Ranchi

By

Sarojkant Singh

Under the Supervision of

Research Supervisor

Dr.Mridanish Jha

Associate Professor

Strategic Management, Marketing Management & HRD

Approved by _____

Chairperson of Supervisory Committee

_____

_____

_____

Program Authorized

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Acknowledgement

I would like to thank foremost the university for giving me a chance to pursue research in an area which culminated in composing this original work to add to body of knowledge of project management. The university has given consistent guidance through a structured program to enable a working professional like me to understand academic research and contribute to the field. My sincere regards to my guides Dr. Hariharan and Dr. Mridanish Jha for showing me the path, constant encouragement and a bird's eye view to approach research. I must express my gratitude to Dr. Mridanish Jha to hand hold me after my guide Dr. Hariharan retired. The agility of Dr. Jha was so high that he could understand my needs quickly and guide me so that I could complete my thesis. My wholehearted obeisance to Vice Chancellor Dr. Raman Jha for inspiring me to work towards knowledge in society and to serve the nation. I also thank ex-Vice Chancellor Dr. Rao for his exceptional energy, encouragement, guidance and special regards to Dr. Satyendra Kishore, for teaching his out of box thinking approach, strategic guidance and policy thinking methodology. I would like to thank Dr. Bhagawati Barik, for his constant efforts to conduct classes and coordinate the program. Thanks to Dr. Rumna Bhattacharya, for her never ending encouragement and guidance for research and course coordination. Dr. Pallavi Kumari for support in publishing accomplishments and teaching research ethics. Dr. Rajkumar for his analytical approach and teaching fundamentals of statistics without which data analysis was not possible.

I would like to thank my fellow peers Prem, Zubir, Arnab, Joydeep, Dibyendu, Dhrub, Manisha, Simi, Silva, Subhadeep, Subhendu, Rajeev, Rajesh, Ravikant, Snehasish, Prabhat, Anjan, Pradeep, Rishi, Ritu, Subhanan, to be with me in thick and thin during this journey. Special thanks to my peer come senior Mr. Raja Ghosh, for encouraging me and helping me publish my first article jointly. Finally my heartfelt reverence to my guru, my parents, my sisters, my wife Aditi and my 1 year old son Ishaan for supporting me and bearing my behaviour and sometimes neglect, while I was deep into research.

ABSTRACT

The present thesis is an effort to present a seminal work in the domain of project management and specifically project strategy. No unified theory of project management has been satisfactorily been formulated and that of project strategy is yet underdeveloped. The research attempts to bridge this gap in research. It presents the definitions of strategy in various domains like war, business and brings forward a multi-dimensional convergence to these definitions. Through an extensive literature review we bring forth this research gap. A holistic view is required to define a complex subject and hence we adopt a system dynamics view of this subject. Our focus is on human factors and through literature review we collect human factor constructs which impact large complex projects. Data collected from 263 participants is normalized and factor analysis, principal component analysis and confirmatory analysis is performed. Our findings show 7 factors which impact project strategy in large complex projects. The factors thus discovered are categorized into the stakeholder view of project strategy. A system dynamics model is constructed to analyse how human factors impact the project strategy and risk in large complex projects. The results help in analysing and decision making for managers and academics. The thesis also builds on a theory of project strategy through the extensive literature studied and professional experience of the author in large complex projects which is presented in the appendices. Various scenarios and specific situations have been presented to show how the theory is able to help in decision making in complex projects.

Keywords: project strategy, human factors, system dynamics, dynamic complexity, complex adaptive systems

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1 INTRODUCTION

1.1 Background

As the nature of projects is evolving, due to influence of various factors complexity is being introduce. Projects by their very nature of interrelated parts are complex in nature and this complexity only increases with project size and scale. The PMBoK indicates project management domains as - Scope management, cost management, time management, quality management, risk management, stakeholder management, communications, HR management, Resource management. The uncertainties due to the COVID-19 pandemic have given another dimension to the complexity in projects. (Dean Rickles, 2007) explains the various types of systems and (John, 2017) illustrates how they become chaotic and early warning system can help recover them. The COVID-19 outbreak has made the project management community rethink the importance of crisis management and no more can the risk management be restricted to handling risks of project schedule, cost etc. and catastrophes separately. While crisis management will be a norm in the coming days & slowly get integrated in project management, automation and digital transformation will influence how projects are executed. This will bring emphasis on human factors and human–machine interactions. As the human factors gain importance in this sector, the crucial elements of trust amongst human relations and trust on technology will become an important and crucial area. In this context it is needless to say that research on human factors in projects is call of the day. What is more important is to understand the contribution of the human factors to complexity or in a larger sense VUCA factor in a project. Human factors have been studied in ergonomics, safety, reliability, human-machine interactions as well as psychological factors of team dynamics and leadership in projects. Various researchers have studied, the role of project manager, competency of team members, motivation etc. as critical success factors in a project. Furthermore, researchers have also studied criticality of schedule, cost and quality for project performance and therefore its

success. Project finance plays a key role in success of a project and depends on the ability of the project leader and the project team to attract and manage the finance. Human factors research will be critical from this perspective of connecting the impact of such factors on project profitability and finances in the coming days. Despite these studies, the field of **project strategy** is relatively nascent. In fact we may say there is a lack of understanding about project strategy. This research aims at addressing the problem and attempts at proving an integrated view of project strategy which has human factors at its core.

Keeping the above in mind this thesis aims to compare the system driven factors and human factors driven factors. In this research we shall approach complexity generated due to feedback i.e dynamic complexity. System Dynamics approach has been used in various applications including project risk management. In this thesis we address the apply this method to bring forth a tool to use for the practitioners of project management.

1.1.1 Strategy

Much has been written about "Strategy" by various authors in various contexts. The word "strategy" therefore gets misplaced in context or tends to be loosely used. The agony of the erudite and knowledgeable student worsens when the term sometimes abused by eminent leaders, and likely role models! Our research attempts to increase awareness of what the term stands for and its correct usage.

The Indian subcontinent somehow find equivalent English words for Sanskrit words. However my attempt failed to find one for "Strategy". The closest term that we may find is the Sanskrit word "Niti", which means "Policy". The reason for not finding the right Sanskrit equivalent lies in the fact that birth and evolution of the word is quite recent compared to the origins of Sanskrit. The first work in the area of business strategy was done by Michael E Porter in 1985 with is ground breaking article on competitive advantage(Porter, 1985).

1.1.2 Strategy- Use and misuse

Though Porter introduced the word, Richard Rumelt in his book Good Strategy and Bad Strategy explains “what strategy is Not” (Rumelt, 2012). The author explains how the word got widely used and exponentially used across after the year 2000 and also adding to confusion about it’s meaning. Rumelt highlights how the word has become fashionable to be used in business, education and government. The confusion increases when terms like “marketing strategy”, “digital strategy” etc. get used. To confuse further, people equate strategy to success or ambition. The author emphasizes how the two words “strategy” and “strategic” get loosely used by high officials and then these trickle down the pyramid and gets misused everywhere. Rumelt also clarifies that strategy is neither a standalone goal nor an ambition. Also assuming strategy as the big picture and overall direction is a mistake. He explains how many executives thus confuse strategy with goal setting.

The story of 6 blind men is a good anecdote in this explanation. Each of the 6 blind men touch the tail, trunk, legs, ears, tusks and the body respectively and come out with a completely different description of the elephant. Similarly when using the word “strategy” some misuse it for goal setting, some for the big picture , some with success and some with standalone goal. Rumelt describes Strategy “as a coherent set of analyses, actions, policies and concepts as a response to high stake challenges” (Rumelt, 2012) introduces to the core of strategy , the hard nut or what he calls the kernel consisting of : First a diagnosis, Second a guiding policy and Third a coherent set of actions to carry out the policy. Missing any part of the kernel leads us to the blind man and elephant situation.

Rumelt further describes bad strategy as consisting of “fluff” or out of proportion blown concepts and floating ideas, failure to accept the challenge and mistaking goals for strategy.

(Dutta, 2024) in his thesis discusses models for project strategy and project management and how these ensure value creation and cost optimization.

(ADAGBA, 2022) introduces strategic project management and to apply the framework concludes that projects should be flexible, dynamic and adaptable to strategy changes due to external factors. The author introduces the numeric

model which has payback period, IRR, DCF, NPV , ARR etc as parameters and the non-numeric which has special purpose, necessity for operation, competitive advantage, product line and cost-benefit analysis as parameter.

With this in mind and our foundations we look at the works done in strategy.

1.1.3 Project Strategy

There is a fundamental difference when we talk about strategy for business and project strategy. Financial statements use the words “ongoing concern” for businesses. The words signify a long term view i.e over many years even decades. On other hands projects are *temporal* and with a definitive start and finish. This reference of time on strategy makes project strategy *similar to military strategy*. However, while war destroys projects aim to construct and develop! This makes projects aimed at construction *quite different from military strategy* and *more akin to business strategy*. Therefore, project strategy is the “missing link” between the two. On one hand project strategy has the temporal nature with traits of military strategy & on the other hand constructive aspects of business strategy. (Shenhar et al., 2007) in his work “Project Strategy- a missing link” traces the origin from Sun Tzu’s Art of war to Porter’s work and then elaborates how in competitive and non-competitive contexts competitive advantage may be understood in context of projects. He explains the creation of “value” in both contexts. The author then guides the meaning with (Mintzberg, 1987) Five P’s principle. He explains the 1st P – perspective as “why” we do the project. The 2nd P – “what” Position that will be achieved after project is completed. The 3rd P- Plan on “how” the position will position will be achieved. The other 2 “ploy” and “pattern” are not so much stressed by the author. (Sarojkant Singh, 2022)What is critical is that we see the connection between Rumelt’s kernel, Raj Srivastav’s CSV matrix, Porter’s 5 forces and Mintzberg’s 5 Ps in context of projects.

(Martinsuo, 2023) discusses these two views and how this falls into the gambit of project business. The author explains that strategy of the organization impacts project strategy. They define strategy of organization and what this covers as achievement of mid-term goals, position, resource, capability, selection of

projects and the goal. They also inform that project strategies are influenced by stakeholder and these can be a powerful way to change organization strategy..Though this research by Shenhar connected the concept of project strategy to that of business strategy, its (Artto et al., 2008) work which hits out at the core difference and uniqueness of project strategy. But before we reveal that, it's important to understand how, in projects the similar theme was discussed as highlighted by Rumelt by informing the pitfalls of misplacing goal setting with strategy. Most research before Shenhar were focused on project success parameters. Shenhar further has coauthored (Patanakul et al., 2012), How project strategy is used in project management, where the authors extend the concept beyond achievement of project goals i.e. remaining within budget, within cost and within time. (Poli & Shenhar, 2003) Project Strategy- The key to project success, article is critical as it links corporate strategy to project strategy. (Hjelmbrekke et al., 2015) illustrate how bureaucratic structures and hierarchy inhibit and ultimately fail projects. There is a distinct connect with corporate strategy here.

Now we are ready to discuss (Artto et al., 2008)- " What is Project Strategy" . This work provides is a groundbreaking direction for understanding project strategy. The author highlights two dimensions on which project strategy depends and its success or failure is affected. Firstly, Degree of Independence and second number of stakeholders. On this basis he categorizes four categories of project strategies viz Innovative Leader, Obedient Servant, Strong Leader and Flexible Moderator. The article cites that these two dimensions determines how the strategies will be formulated and how they will be implemented. The innovative leader strategy has high independence and one stakeholder. The Strong leader has few stakeholders but high independence. The obedient servant has low independence and many stakeholders. Finally the Flexible moderator has high independence but many stakeholders. This article captures how positioning and external environment of project that includes the corporate which runs the project determines the kernel of strategy.

1.1.4 Towards a Theory of Project Strategy:

Mintzberg's parameters of strategy goal, plan, ploy and direction when reflected with Rumelt's kernel of strategy we find an interesting definition of strategy which can lead us towards developing a theory of strategy. Perspective would be an outcome of Diagnosis (kernel), Plan and Ploy would be part of guiding principle (kernel). Actionable steps (kernel) would lead to the pattern. Position is an outcome of this process and the seed of which is there in diagnosis. We thus see that there are certain emergent principles or *emergence* when we form the kernel. Risk and uncertainty will be factored in the guiding principle and the expected outcome shall be an emergent principle of this kernel.

The business complexity will also impact the project complexity and therefore it is as Sun Tzu mentions heaven and earth while the general formulates his strategy. It is important therefore to reflect on what Artto calls the *project strategy* as a position gained by observing the two dimensions of Degree of Independence of Project and No. of stake holders.

Our argument against Artto's theory is that this is a static view like porter's position in defining business strategy. We therefore extend it to a dynamic view in our thesis. We however, keep in mind that this should keep the generalization of a theory and hence, we observe the basic elements of the kernel again. We will elaborate this in our literature review how the field of physics and psychology gives us to clue to find the *basic constituent* of strategy. We may call it the atom of strategy. We call *decision task.* The kernel consists of Diagnosis, Guiding principle and Actionable steps. The goal or position is the emergent principle. The decision task is the constituent which shall form the diagnosis. We will reflect more on diagnosis in our literature review section. However, it is sufficient to understand for our present purpose that the decision task will be used in the process of diagnosis and then the guiding principles will be formulated leading to actionable steps which again have decision task as their basic constituents. In other words we may say that decision tasks form diagnosis, guiding principles and actionable steps when put in different configurations. As per Mintzberg's 5 P's , Perspective, Plan, Ploy are constituted by decision tasks as the basic units and Pattern and Position are the emergent principles of this. We must also note that the formulated strategy and

implemented strategy have a very different characteristics. Just as the idea of a product in one's mind and actual product in the physical world or we may think of it as the image of a drawing in one's mind and when the drawing is drawn on paper in the real world. The thought, will and action enables the concept in mind to get created in the physical world. The strength or intensity of one's thought is therefore important. The clarity of thought in one's mind, which is dependent on the mind-stuff and the *will* determines when and how similar to the thought is the creation in the physical world. The *decision task* thus has these properties of intensity and clarity embedded in mind. The decision task originates in the psychological space or mind space in the mind-stuff and our hypothesis is that it has static and dynamic properties, making it similar to a *tensor*.

(Tysiak, 2014) discusses and compares PERT and Monte Carlo simulations. This is relevant to our following theoretical development of strategy. PERT uses beta-distributions with density given as:

Equation 1: Beta Distribution: Source (Glenn, 1992)

$$f_b(x|a,b,p,q) = \frac{(x-a)^{p-1}(b-x)^{q-1}}{B(a,b,p,q)}, \qquad (1)$$

with B being the beta-function

$$B(a,b,p,q) = \frac{\Gamma(p)\Gamma(q)}{\Gamma(p+q)}(b-a)^{p+q-1}, \qquad (2)$$

and Γ being the well-known gamma-function:

$$\Gamma(x) = \int_0^\infty t^{x-1} e^{-t}\, dt, \qquad (3)$$

The author then explains that on one hand where PERT simplifies this into a triangular distribution and applies, Monte Carlo, takes advantage of advances in computer simulations and uses randomization to have more accurate estimates of risk. As with change of project the critical path varies, it is important to capture these changes to analyze risk which Monte Carlo does better than PERT. This analysis helps us intuitively to model risk into a distribution function and we will extend this to strategy.

We emphasize here that novelty of this thesis is in addition to the knowledge in the theory of project strategy which has not been discussed elsewhere. Strategy originates in the mind of the general in the war field, however, the general usually has a counsel to vet and iron out his thoughts. Hence, it is not one mind but a confluence of minds and hence our hypothesis is that project strategy is as a function decision task, stakeholder power and time i.e $f(task_d, S_{hp}, t)$. Taking a systems view we will try to prove that Strategy is a emergence of integration of this function i.e Strategy = $\int f(task_d, S_h, t)\, dt$, we consider decision $task_d$ and Stakeholder S_h as a function of time. Here, the decision task is an mental activity with purpose. The strength or intensity of the activity or inherent will in the decision task will determine the nature of emergence. We propose the following equation for the $task_d$:

$N_0 e^{\lambda t}$

Where λ is the emergent/growth co-efficient. If we consider $task_d$ as a function of time and increase and decrease shareholder power also as a function of time, we can write Strategy as :

$Task_d$/ time * Shareholder Power or S_{hp} /time = $(task_d * S_{hp}) / t^2$

Thus for a single person Strategy = $\int (task_d / t^2)\, dt = \int (N_0 e^{\lambda t} / t^2)\, dt$

If I is intensity of the decision task, we can write : Power of decision task is $\iint I\, e^{\lambda t}\, dt\, dw$

1.1.5 Stakeholder Power

The term stakeholder has relatively recent origins in the 1960s. The word was first coined in Stanford Research Institute. In 1971 Hein Kross published (Schwab & Kroos, 1971) a booklet where they argue that for long term sustainability, not just shareholders but all stakeholders must be served by an enterprise. In 1983 Ian Mitroff published Stakeholder and organizational mind. This subject and Stakeholder theory has not intersected Project Management Theory yet. Our thesis attempts to extend the theory of K. Artto (Artto et al., 2008) on autonomy and number of stakeholders to the stakeholder theory. (Ronald K. Mitchell, 1997) work is critical in this parlance. In their article

Mitchell et.al trace the background of stakeholder theory, its connection with Corporate Social Responsibility and how broad a view one should take on stakeholder and stake in a firm. Then the authors classify stakeholder using 3 criteria: Power, Legitimacy and Urgency. They classify stakeholders into 7 buckets viz: Dominant Stakeholder, Discretionary Stakeholder, Demanding Stakeholder, Dominant Stakeholder, Dangerous Stakeholder, Dependent Stakeholder and Definitive stakeholders. The others are termed as non-stakeholders. In project management literature or project strategy research this is the first attempt to bring in autonomy and power of stakeholders together through a system dynamics framework.

1.1.6 System Dynamics

System Dynamics tries to understand the nonlinear behavior of complex systems dynamically. It uses causal loops, stocks, flows. System dynamics was coined by MIT Professor Jay Forrester.

We briefly explain a system dynamics model. A system dynamics model uses stock and flow diagrams and causal loops.

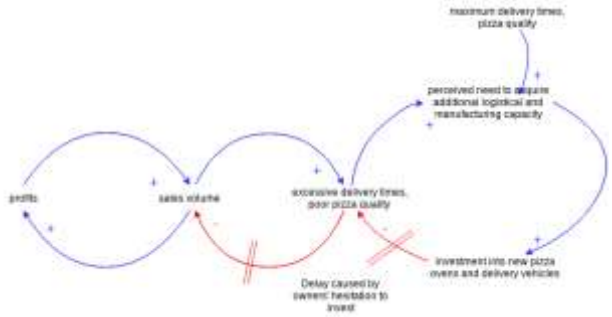


Figure 1Source: https://warren2lynch.medium.com/system-thing-with-casual-loop-diagram-learn-by-examples-61dabdc4cdd

Casual loops (CLD): A causal loop diagram (CLD) is a visualization (fig1) of different variables in a system and their interrelation. It consists of a node & edge for eg in the diagram see profits & sales volume. Here, profit and sales volumes are nodes and the edge links them. The +ve sign indicates that increase in profit will lead to increase in sales.

1.1.7 Stock and flow diagram:

Stock variables are measured at a point in time. For example: the number of Covid-19 cases in Dec-2020. Number for errors made in inspections in Mar-2021.

Flow variables are measured over a time interval. For example: Increase in competency of project team between Jan-2021 and May-2021 or Attrition of employees in FY 2020.

The power of the causal loop and stock and flow enable to capture the dynamic nature of human factors and thus their impact on project risk management. (Hussein et al., 2019) presents the following model. They explain how human rely on automated system for speed and accuracy (SAC) through this model. It shows nodes like Accuracy, human speed, tendency of verifications and flow variables like perceived recommended accuracy, trust accuracy etc. to conclude how the human trust plays a role in human reliance on automation.

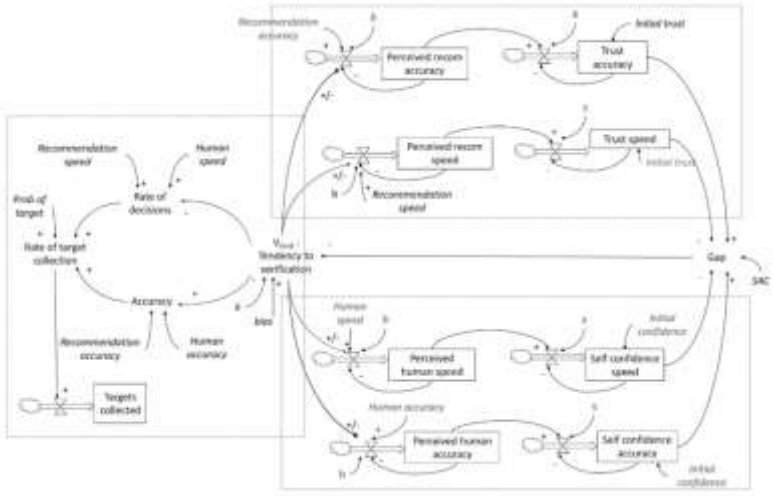


Figure 2: Causal Diagram: (Hussein et al., 2019)

1.2 Motivation of study

Project management has become extremely crucial and research on various aspects of this domain has been conducted. Having worked in this field for past 20 years in India and abroad, I find that various institutions carry out research in project management still a theory of project management is not fully developed. The origins of project management has been in practice and that may be a reason why a theory has not been developed yet. My research shall try to add to the formation of a theory in project management and to do that we shall dwell to the heart of the subject.

The spirit of project management lies in time. Most contracts state the line "time is essence of the contract". Our theory shall be developed in the same spirit. The consideration of time has a central aspect to understanding what we call "strategy" in association with projects or what is being called "project strategy". We shall differentiate project strategy from business strategy highlighting what the factor of time has on these two types of strategy. However, we shall consider strategy and risk in a project and not specifically coin a new term project strategy. We believe, the very core of strategy still remains even when applied to projects. It must be mentioned here that research on strategy in project is minimal and a major motivation to our research. Strategy and risk are inseparable aspects. A strategy cannot be developed without considering the risks associated with it. Our motivation to research this aspect with a holistic view and therefore design a questionnaire which captures this aspect of projects.

The third and most crucial aspect of large scale complex projects are stakeholders. This amplifies the human factor aspect and even brings it to center stage. We reflect the theories built for stakeholders and map them to projects. This is a novel work by itself. Though human factors play an important part and this is acknowledged, a gap in research and knowledge remains and there is a need to develop a well structured approach to handle such human factors and associate these to system driven factors. Our research motivation is fuelled by this need.

Complexity is studied by various scholars in physics, statistics, computer science and social sciences. However, its application in project management and strategy in projects has been limited. Adopting a system dynamics approach we attempt to provide a method to handle the complexity and incorporate human factors into this. Our research shall explain the diverse types of complexity and with the system dynamics models capture the dynamic complexities in projects.

1.3 Relevance of the research

This research is very crucial as human factors a becoming critical to project strategies. The research will try to bridge the gap between academic research

and practice in industry. This research aims to develop a system dynamics method for complex projects to enable managers take timely decisions.

In complex projects, from a high level view point, the contract formation is done. Subsequently, a L1 level schedule is prepared. As the project progresses, various changes take place in the project and change management becomes a major aspect. With such changes, many uncertainties arise and conflicting interests of stakeholders come into play. In systems theory research, catastrophic theory and chaos theory such small events that catapult the large eventuality has been researched, but no such research in project management of complex projects has been done. Through a system dynamics approach a holistic framework can be made to capture such occurrence and thus guiding the project managers to take timely actions. This will also address the gap in literature to address such human factors.

In the age of AI where systems are gaining prevalence and how humans interact with them is critical, this research shall guide how human factors should impact this implementations of systems. The proportion of impact of human factors and of projects will be crucial to projects in the future world and this research will add to this body of knowledge. Further our research brings forth an integral view of project strategy for the first time thereby building on the theory of project management.

1.4 Objectives and Scope

The scope of research will be to elaborate various aspects , theories and models used in project management, strategy, risk and human factors. Through an extensive cross-functional literature survey the research gap will be studied and the critical parameters will be ascertained to be studied. The research will limit itself to the study of the human factors and human factors risks which are crucial for a project strategy.

Our research aims to contribute to the development of theory of project strategy and we shall conduct our research in the large scale complex projects sectors in India from core sectors like steel, cement, ports and infrastructure.

Industry segments : Coal Handling, Steel Plant, Cement, Power, ports and infrastructure

The Objectives of the research will be:

1. To find the critical human factors in a complex project
2. To ascertain the impact of these factors on project strategy for various scenarios like schedule crashing, claims settling and dispute resolution
3. To develop a system dynamics model to observe the variables which impact project strategy.

1.5 Organization of the study and thesis outline

The scope of research will be to elaborate various aspects , theories and models used in project management, strategy, risk and human factors. Through an extensive cross-functional literature survey the research gap will be studied and the critical parameters will be ascertained to be studied. The research will limit itself to the study of the human factors and human factors risks which are crucial for a project strategy. Various project strategies and risks in a project

Our thesis after this introductory chapter is spread to 5 chapters. In chapter 2 : Literature Review , we review of literature pertaining to project strategy. The basic idea is to study the work done in large scale projects and how complexity has been addressed in these research works and how project strategy has been applied. Then based on that we intend to identify the research gap, conceptualize the domain of this work and identify the research variables.

After establishing the gap and finding the research variables, we move to chapter 3 where we presents the philosophy behind the research, the design and the methodology adopted to carry it out. In this chapter we also discuss about the process of instrument development, scales and samples selected for pilot survey, main survey and expert interview.

After this in Chapter 4 –Data Analysis and Interpretation, we provide details the analysis of data and interpretation of results of the survey. This chapter also elaborates on the model development in system dynamics and establish how

insights on complexity can be derived from such a model. The literature review and content analysis helped in identifying human factors in large scale projects.

Finally in Chapter 5–Results, Discussion and Conclusion, we detail out the summary of the findings from the survey. It also highlights the limitation

of the present study and how the study has contributed to the existing body of knowledge from the theoretical, practical and social perspective. Lastly the chapter also contains recommendations for further research.

1.6 Summary

The chapter outlined the basic idea of this research study is to study the human factors impacting large scale complex projects and what is meant by project strategy. The study further endeavoured to investigate the relationship of the criticality of risk with the complexity and strategy in projects. The chapter started with an introduction giving the background and the theoretical basis of this study followed by the motivation for this study. The chapter also provided an overview of the other 4 chapters in the thesis.

CHAPTER 2

REVIEW OF LITERATURE

2 REVIEW OF LITERATURE

2.1 Introduction

This chapter will present the literature reviewed for the research topic. Four broad arears are covered. First we research work in project management and how project strategy and risk appears in this domain. The chapter then moves on to human factors research. In this area we elaborate how human factors have been traditionally perceived in project management literature and in general. We then move on to works in project complexity. Project by their very nature are consist of various domains and which make them complex in structure. We expand on what we mean by complexity and how this is reflected on our research through and extensive literature review of work done in this field. Finally we move on to work in the field of system dynamics and projects.

After we have elaborated each domain we move forward to work done in the overlap of these domains. The same is illustrated in the following venn diagram.

Figure 3: Domains of Literature Review

In the introduction section we have given an introduction to project strategy, which is also an outcome of this literature review. We shall also elaborate how this definition and line of thought was developed from the literature survey.

In this we shall also illustrate the various concepts and models used in literature.

2.2 Literature Reviewed

2.2.1 Project management

Figure 4: Domains- Project Strategy

Project management has origins in the army and first literature are from applications in US and Russian defence research application. Then **PMBoK:** Project Management Body of Knowledge provided a guide on project management. However, (Koskela Lauri, 2002) argue that there is a lack of theoretical development of project management. Through a review of literature they show that some authors have advocated that there is nothing to report on project management theory implying that either there is no theory or theory is not significant for the field. The author however argues that both views are wrong and a theory of project management is needed. The author goes on to base theoretical foundation from related theories of Transformation flow theory, Value generation theory, Management as planning , management as organizing, classical communication theory of language, thermostat model and scientific experimentation method. **Theory of production:** explains the principles based on which a business decides how it will use the inputs of raw material, labour, capital etc. to produce what mix of products it wishes to sell. Cobb-Douglas formulated the first production function in 1927. **Theory of Value:** is used in a diverse sense in philosophy. It is used with a broader meaning in moral philosophy, social and political philosophy, where it is deemed to cover some "evaluative" aspect. In a narrow sense, "value theory" is used for normative ethical and of concern to consequentialists primarily concerned with classifying things as good or bad. In economics this connotes **Intrinsic theory of value, Subjective theory of value.**

2.2.1.1 Project, strategy & Risk related literature

(Raydugin, 2017) provides a pre-bid stage risk assessment technique. (CIOCA, 2011) elaborates qualitative methods of risks management in an aviation project. (GALWAY, 2004) illustrates quantitative methods for project risk assessment. (MJ Thaheem, 2012) reviews quantitative techniques used in risk management in construction projects.(Awojobi, 2015) provides a cost and

schedule risk planning for hydroelectric project.(Jarman & Dreher, 2018) illustrates Strategic Misalignment for divergent interests and suggests structured risk based solutions to handle them.(Nersesian, 2017) risk simulation for a solar project is illustrated.(De Meyer et al., 2002) describes management strategies to handle uncertainity.(Aven & Krohn, 2014) presents a new integrated perspective, to capture, understand, assess and manage the uncertainty in a practical operational setting. (Shenhar et al., 2007) proposes a project strategy framework.(Williams, 2016) show how success factors combine in complex interactions. By a case study method of a company working on two major construction programs the research describes factors contributing to project performance by mapping and analyzing paths from root causes to success criteria.(Artto et al., 2008) introduces four types of strategies for a project along the two factors of number of strong project stakeholder organizations & project's independence: , flexible mediator, strong leader, obedient servant, independent innovator. It contributes to development of new and context-specific project management bodies of knowledge in the future.

2.2.1.2 Risk

ISO 31000 : *Risk management* –describes principles, provides a framework and method for risk management. Exploitation of probabilities of occurrence and impact of opportunities or threats will increase value in projects and proper identification, managing risk and treatment of risk.

(Yuri, 2017)Introduces classes of fallacies inside standards of Project Risk Management (PRM) and practices to displace fallacies, gaps in PRM assessment. The author introduces 32 risk objects, best practices in PRM and ways to adopt correct methods, the psychological and organizational bias (Hidden Agenda - Principal -Agent Theory, "Anchoring" , Conscious and Unconscious bias) which can effect decisions by project managers in Risk Assessment. (Swin, 2017) Uses fuzzy logic to assess risk factors like: expert diversification, risk culture, process mining, human biases reasons, and personal factors (Hallowman, 2017) illustrates concept of system risks in complex projects, project specific and systemic risks and how to handle them. The human factors constituting these two types of systemic risks and state of team

development including business leadership bias in estimates. Team development and IPA is critical and correlated to cost and schedule performance. Project Dicotomy of order and disorder is explained. (Corpoley, 2017) suggests shortcomings of prevalent risk management approaches and favors an Integrated schedule and cost risk management. (Agarwal, Monte Carlo Risk Analysis, 2017) introduces Monte Carlo simulations for risk management (Malik, 2017) elaborates how MCS can aid assessing contingency estimates.(Nasirzadeh et al., 2013)provides a fuzzy logic approach to risk management. (Agarwal, Integration of Project Risk Management into Enterprise Risk Management, 2017) argues to integrate PRM to ERM. (Plumery, 2017) provides speedy and forensic based project performance drawbacks and presents a risk centric approach. (Michale, 2017) a case study explaining complex decision making (Townley, 2017) illustrates various models to risk management.(Kreydieh, 1996) explains through a case study the financing risks in BOT projects.(Kahneman & Tversky, 2012)prospect theory introduces the outside view and how it can remove biases.

2.2.1.3 Trade Credit :

Stackelberg Game has asymmetric roles of leader and follower. The “leader” moves first, and all the “followers” move after the leader. Named after Heinrich Freiherr von Stackelberg it evolved the first mover advantage in oligopoly market theory.**Nash equilibrium** is a theorem that states that a player can achieve the desired outcome by not deviating from their initial strategy. It is a concept from game theory where each player's strategy is optimal with respect to the decisions of other players. **Price discrimination Theory** comprises of practices to extract maximum price from heterogeneous consumers. Due to information asymmetry, only the monopolist knows the distribution and finds the optimal nonlinear tariff enabling the optimal markup for each purchase level and consumers do not have incentive to imitate the behaviour of others. **Bargaining Power Theory** was published in 1988 in a work Bargaining: Power, Tactics, and Outcomes by Samuel Bacharach and Edward Lawler. "Bargaining" is regarded as a process of managing and manipulating impressions and information. It has 4 assumptions viz. power is essence of

bargaining, bargaining is a process of tactical action, bargaining power is subjective.

2.2.1.4 Cash flow related literature

(DeVaney et al., 1996) investigates cash flow and credit use 3 months post women's financial information workshops. The findings suggest association between participation in the program and change in behavior and attitudes.(Shash & Qarra, 2018) elaborate the cashflow management practices in Saudi Arabia for complex projects.(Khosrowshahi & Kaka, 2007) go beyond the traditional forecasting methods to drive the project with the cashflow projections.(Oral & CenkAkkaya, 2015)explains how CaR can be used in different scenarios to ascertain cashflow risk in projects.(Larkin, 2013) shows that intangibles like brand perception reduce cashflow volatility and riskiness of business.(Baranga & Ps, 2013) provides a cashflow strategy to reduce risk by reducing international trade. (Zaher, Heba; Illescas, n.d.) illustrates how cash conversion cycle can provide better cashflow and moderating credit.

2.2.2 Human Factors:

Psychodynamic theory , Tripartite Theory of personality proposed by Sigmund Freud, interaction between nature and nurture explains, personality as a combination of id, ego and super ego. **Eysenck's Personality Theory** explains personality based on biological factors. **Risk personality types** framework by Geoff Trickey explains 8 risk personality types. **Moore's Law** states that the number of transistors double each year though cost has halved. Hence, every couple of years we pay less for them. **Fuzzy Logic** coined by Lotfi Zadeh of University of Berkley as a method of reasoning which mimics the human reasoning. The approach of FL imitates humans thinking which involves all intermediate possibilities between digital binary values. **General Theory of Trust** authored by Christiano and Falcone explains the concept of trust, based on cognitive,

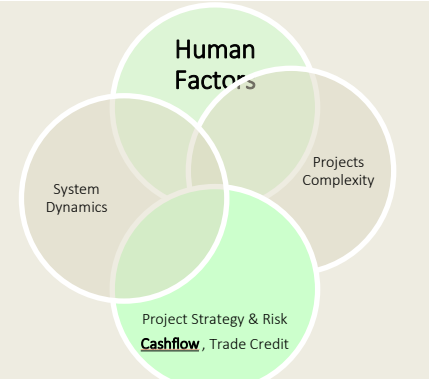


Figure 5: Domain: Human Factors

institutional, cultural, normative and technical factors. **Trust Model** uses public key cryptography and collection of rules that informs the computer application to check legitimacy of a digital certificate. **Social Cognitive Trust** theory studies the influence, behavior and behavioral choices on three main factors: behavioral factors, environment and individual personality. **Agency theory** explains issues in the relationship between owners and their agents or managers in business. The conflict of interests between agents and owners is the well known principal-agent problem. **Analytic hierarchy process (AHP)** is a framework for decision making, created in the 1970s by Thomas L. Saaty, of University of Pittsburgh. The aim of the analytic hierarchy process is to structure a problem relating it to overall goals and providing solution alternatives rather than 1 definitive solution.

2.2.2.1 Human Factor and Risk related literature

(Zwikael & Smyrk, 2015) that in turbulent environment ,trust of the project owner in the project manager is more effective , whereas in in a more stable project setting, more control by the project owner of the project management process is a superior management approach. Finally, management role of the project owner is discussed and a project governance model is introduced. (Organ & Stapleton, 2017)outlines a study to address human factors in systemic financial systems providing a view to relationship between human and tech, functionalist, interpretive, radical humanist and radical structuralist world view. (Kahneman 1934- author, n.d.; Kannengiesser & Gero, 2019) provide an explanation of the prospect theory and a framework to apply the same.(Kahneman & Lovallo, 1993) explains how human psychological bias from overconfidence errs decision making.(Flyvbjerg, 2006) highlights inaccuracy and forecast risk in Project managers, optimism bias and strategic misinterpretation.(Flyvbjerg, 2009) &(Flyvbjerg et al., 2009) illustrates how biases decisions and principal-agent theory plays in large infrastructure projects. An outside view de-biasing technique that has proven successful in overcoming both delusion and deception in private and public investment decisions is shown for illustrating the RCF method.(Flyvbjerg & Budzier, 2011) illustrates the risks in IT projects and the myths and dangers.

2.2.2.2 Human Factor and Cash flow related literature

(Moro visconti, 2019) relates intangibles, economic value and cash flow.(Uzma et al., 2010)explains how DCF method aids valuation of intangibles. (Damodaran, 2007) gives a primer of valuation approaches. (Baldi & Trigeorgis, 2020)informs how human career valuation is carried out.(Baldi & Trigeorgis, 2020) presents a real options approach to value intangible investments. (Pantzalis & Park, 2009) investigate whether and how well firms' stock market valuations reflect their employees' collective skills and effectiveness relative to that of their industry peers and competitors and conclude that reliance on human capital intangibles may proxy for risk not fully accounted for by conventional asset pricing models, or alternatively, that the market cannot correctly price human capital intangibles for small size firms.(Monika et al., 2013)elaborates various valuation models for intangibles and their accounting.(Kutcher et al., 2008) illustrates the increase in productivity by strategic human capital use which in turn increases market valuation.(Tkachenko et al., 2018) elaborates on the DCF method to value intangibles.(Fulmer & Ployhart, 2013) provides a multidisciplinary review of existing literature that has been concerned with financial value associated with human capital resources. (Wilson & Stenson, 2008)concludes on attributes of information that give rise to its value as an asset.(Özer & Çam, 2016)illustrates how a firms can become competitive in long term by valuing human capital and relevant planning.(Roy & Shijin, 2018) models a 6 factor asset pricing with human capital factored in.(Ross, 1978)gives the basics of CAPM model.

2.2.3 Complexity:

Chaos theory focuses on the study of dynamical systems where apparent random states of disorder and irregularities are secretly governed by underlying patterns and predictable laws which are highly sensitive to initial conditions. In 1960 Edward Lorenz, a professor in MIT discovered chaos which later was synonymous with the 'butterfly effect,' an extreme sensitivity to initial conditions and also lead to discovery of Lorentz attractors, a set of equations called Lorentz equations. A metaphor to explain it was flapping of a

butterfly's wings over the Amazon influenced the weather in Bejing. This phenomenon led to the birth of *deterministic chaos*.

General Unified theory of strategic performance and management (GUT) builds on generic principles of firm's performance based on accumulation and depletion of resources over time and it's interaction between rivals and other exogenous factors. The theory is proposed by Kim Warren of strategy dynamics. **Stacey Matrix** developed by Ralph Douglas Stacey helps to understand the factors constituting complexity. R D Stacey identified five areas: near agreement & near certainty, away from agreement but near certainty, near agreement but away from certainty, zone of complexity, away from agreement & away from certainty.**U Theory** is a change management method by Otto Scharmer presents 7 steps to change.**Prospect theory** developed by Daniel Kahneman and Amos Tversky in 1979 postulates that individuals make decisions based on perceived gains rather than perceived losses assuming that losses and gains are valued differently by individuals.

Figure 6: Source: The Systems

Reference class forecasting or **comparison class forecasting** developed by Daniel Kahneman and Amos Tversky assumes that by observing past situations and their outcomes we can predict the future.

2.2.3.1 Human Factor, Complexity and Cash flow related literature

(Ferrer et al., 2020) studies intangibles and their risk on cashflows and how they contribute to complexity.(Iazzolino & Migliano, 2015) gives a framework to model intangibles into valuation.

2.2.3.2 Human Factor and Risk and Complexity

(Nachbagauer & Schirl-Boeck, 2018) conclude that based on resilience research and Human Factors research, ideal types for managing the most unexpected events in projects. While humans are possible sources of error, they are at the same time the most valuable resource to manage the unexpected successfully.(Andreas G.M. Nachbagauer, 2018) develop a useful framework

combining the social dimension comprises the project manager, the project team and the project-oriented organization and the time-related dimension.(Marshall & Ceylan, 2019) illustrate how to obtain risk intelligence.(Giezen, 2012) studies a metro project in Rotterdam and lessons on how to reduce complexity.

2.2.3.3 Project, Risk and complexity related literature

(Thamhain, 2013) suggests specific work environment to control complexity and risks.(Sumit Roy (ICFAIJharkhand), 2019) provides a framework for risk management including human factors and factors like pace of project, structural complexity, dynamics of project, Uncertainty of project, socio-political influence, and Critical risks. (Dale F. Cooper, 2005)deals with risk management in large complex projects. To managing risk better, project teams need to obtain better project outcomes.

2.2.3.4 System Dynamics related literature Research Gap

(Torres, 2019) provides a systematic literature review of 498 articles and find that 4 major areas are studies viz model validity, modelling of dynamical problems and understanding and improving decision making in system dynamics.(Tang & Vijay, 2001) provides a history of system dynamics and possible prospects in future.(Sisodia et al., 2016)provides a system dynamics model for solar power policy on countrywide level.(Ahmad et al., 2015) illustrates solar policy making by feed in tariff in Malaysia and scenarios till 2050.(Vafa-Arani et al., 2014) guides policy makers for reduction of air pollution by taking 2 sub-systems i.e. urban transportation and air polluting industries.(Yu & Wei, 2012) shows how genetic algorithm and system dynamics can be used jointly to assist policy making.(Ghaffarzadegan & Rahmandad, 2020) shows how uncertainty can be captured through system dynamics modelling by to understand the state of the COVID-19 pandemic. It shows that the state relies on infection and

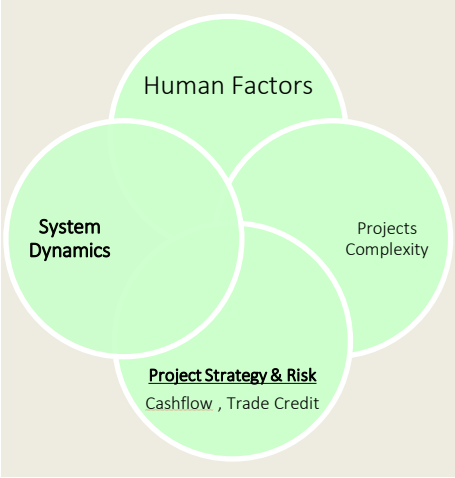


Figure 7: Domain: system dynamics

mortality data and how to the put-break rate. (Lyneis & Ford, 2007) review literature and past works on project management and system dynamics & synthesize the policy messages for project policy making the authors show that system dynamics can improve project management and develop a theory in project management which is lacking. (Tan et al., 2010) show how system dynamics better predicts cash flow.(Sterman, 1961) explains put the foundation of system dynamics in business. (Forrester, 1993) illustrates development in system dynamics space.(Warren, 1999) provides the basics of system dynamics for business strategy. (Warren, 2018) provides a tutorial for analysts.

2.2.3.5 System Dynamics and Projects related literature

(Rodrigues & Bowers, 1996) compares system dynamics against traditional approaches of project management.(Huang, 2008)illustrates how project management teaching can be enhanced with system dynamics methodology through an experimental study. (Kasperek, 2016) shows how design and engineering can be improved through system dynamics. (Williams et al., 2003) show how to use system dynamics for litigation on claims for project management.

2.2.3.6 System Dynamics, Complexity, Risk, Strategy and Projects related literature

(Lyneis et al., 2001) shows how **system dynamics** can be used for developmental projects which bring in high risk and uncertainty through complex project in defence. (Chapman, 2017) shows how stocks and flows, the basics of system dynamics, can manage complexity and avoid gaps and omissions in project risk management.(Warren, 2005) gives a system dynamics perspective as a powerful logic that offers substantial improvements in dealing with issues in strategic management, both for one-off challenges & continuous enterprise strategy.(Raydugin, 2020) gives a detailed process of using non-linear dynamics, system dynamics and Monte Carlo simulations for complex projects.

2.2.3.7 System Dynamics and Human Factors related literature

(Caulfield & Maj, 2001) explain benefits of SD to prove the Fred Brook's Law to capture the complexity of human interactions.(Hussein et al., 2019) human trust model under speed and accuracy.

2.3 Research Gap

We find in the above studies that though project management success and critical factors have been studied, human factors specific research is very little. Our research has therefore tried to focus on these factors and their impact. We attempt to filter the factors from these studies and evaluate their impact on an area which is virgin. This is the area of "project strategy".

Based on the synthesis of above literature review we have the following variables/constructs for human factors:

Table 1:Literature Survey Constructs

SN	Author	Description	Country	Sample Size	Approach/ Type of model
Errors due to humans					
1.	(Oropesa, 2020)	Human error and project success relation and causes of errors	Columbia	14 projects 2 companies	Rasmussen Model, correlational-explanatory
2	(Daniel W. M. Chan 1, 2022)	Main causes of human error	Iran	17 experts	Delphi method
3	(Rose, 2012)	Human factors and safety culture.	UK	300	Case study and survey
4	(EWEJE, 2010)	Human factors and project failure, decision making	France	107	Factor analysis
5	(Dekker, 2010)	Systems thinking v/s Newtonian ethic	Sweden	-	philosophical
6	(Ajith1, 2022)	A framework for Human error assessment	India		HEART method
7	(Samarth Ramprasad. K, 2019)	Human reliability in construction projects	India	1029	Survey

Communication					
1	(Turki Alsudiri, 2012)	Factors affecting misalignment between project management and business strategy	UK	4	Case study
2	(Digitemie², 2024)	Strategic project management framework	Nigeria		Review
3	(Rehan, 2024)	Project success factors	Australia	109	EFA, Regression
4	(Wawak, 2024)	Team management and project quality	Poland	510	Survey
5	(Haridharan*, 2017)	Success factors in projects in construction	India		Literature review SPSS
6	(Alias, 2014)	Critical Factors	Malaysia		Conceptual
7	(Prabhakar, 2008)	Project success	India		Review paper
Flexibility of Project Manager					
1	(Cheng M. I., 2005)	Qualities of a project manager	UK	60	Focus Group from 2 construction companies.2 Way ANOVA
2	(Sunindijo, 2015)	Skill components of project managers	Australia	107	Factor analysis
3	(Webb, 2014)	Project based International Joint Ventures to develop a framework	UK		Interview & Case study
4	(Shenhar, 2015)	A research based approach to project management	USA		Theoretical
Decisive Client					
1	(Neringa GUDIENĖ, 2014)	Critical Success Factors	Lithunia	27	Analytical Hierarchical process
2	(Johnson Matu*, 2021)	Clients support on contractor's performance	Kenya	62	Stratified sampling , Regression
3	(K.C. Iyer, 2004)	What factors impact cost performance	India	300	Factor Analysis

Trust between client and contractor					
1	(Astha, 2006)	Client-contractor relation DMRC metro project	India		Interview
2	(Pengpeng Xu, 2014)	Policy making and EPC for projects in buildings	China	8	Focus group, Analytical Network Process
3	(Weiping Jiang, 2017)	Trust and project success investigation	China	366	Exploratory Factor analysis, SEM
4	(Shahnawaz Khan, 2011)	Contracts and trust in projects	Pakistan		Literature Review
5	(Bakker, 2010)	Project success and trust from owner's perspective	Netherland		Q-methodology
6	(Manu, 2015)	Trust between contractor and sub-contractor	UK		Case study and interviews
Client's experience					
1	(Akintoye, 2002)	Conceptual framework with client's attributes	UK		Literature review
2	(Shakya, 2019)	Assessment of risk factors	Nepal		Literature review
3	(Altarawneh, 2018)	Critical success factors on critical delays	Abu Dhabi	323	PLS-SEM
4	(Shakir Iqbal, 2024)	Causes of project failure and cost overun	Pakistan	104	Questionnaire and interview
5	(Koushki, 2005)	Causes of delay in construction	Kuwait	450	Questionnaire survey and frequency analysis
Support of senior management					
1	(Iqbal, 2015)	Project success factors	Pakistan	125	PLS-SEM
2	(Ahmed R. H., 2021)	Senior management support on project performance	Pakistan	310	Correlation, Regression
3	(Thamhain, 2004)	Project environment and performance	Global	2240	Content Analysis, Kendall's Tau rank-order correlation
4	(Moza, 2024)	Critical success factors and project success	India	213	ANOVA

5	(Alias, 2014)	Critical Factors	Malaysia		Conceptual
Contract Handling by Project Manager					
1	(KEBEBE, 2022)	Factors influencing over run in projects	Ethiopia	70	Regression
2	(Shibani, 2015)	Project manager role in construction projects	India	20	Statistical
3	(Jha, 2013)	Determinants of project success	India	300	ANOVA
4	(Sanchaniya, 2024)	Framework for Project management in construction	India	78	Principal Component Analysis
Effective feedback					
1	(Schrapers, 2018)	An examinations of methods in construction project management	Scotland	9	Interview
2	(Pinto, 1988)	Critical Success factor for effective project management	US		Conceptual
3	(Albert P. C. Chan, 2001)	Design and Build project success factors;	-	53	Multivariate analysis
4	(Chan, 2004)	Factors affecting the success of a construction project.	-		Conceptual
5	(Alias, 2014)	Critical Factors	Malaysia		Conceptual
Reputation of project manager					
1	(Singh L. &., 2024)	Traits and skills of PM to complete projects	India		Literature review
2	(Oh, 1999)	Case study on project management	US		Case study
3	(Sankaran, 2020)	Project manager's influence on strategies	Australia		Case study
4	(Barnett, 2006)	Corporate reputation	Australia		Theoretical
5	(Olawale, 2020)	Key drivers of reputation	UK	134	Mixed method research

6	(Karlsen, 2020)	Project manager's role in public change project	Australia	-	Case study and interview
Charisma of Project Manager					
1	(Blaskovics, 2016)	Project manger's attitude and leadership style	Hungary		Conceptual
2	(Ahmed R. &., 2014)	Project Manager's leadership competencies to Project success	USA		Conceptual
3	(Zhao, 2021)	Impact of Transformational leadership on project success	China		Empirical, Meta analysis
4	(Shah, 2018)	Impact of charismatic leadership on Construction project performance	Nepal	154	Empirical, Factor Analysis
5	(Keegan, 2004)	Transformational leadership in project based environment	Netherlands	115	Empirical
Leadership of project manager					
1	(Prabhakar G. P., 2005)	Transformational leadership in projects	Global 28 countries	107	Empirical, Regression
2	(Chacko, 2023)	Critical Project success factors	Singapore	-	Empirical
3	(Rustam, 2024)	Dominant factors of Project manager competence in projects in Construction industry	India	-	Literature review
4	(Turki Alsudiri, 2012)	Aligning project management to business strategy	Saudi Arabia		Conceptual
Organized Project Team					
1	(Han, 2019)	Stakeholder Management for Project success	Vietnam	163	Empirical, Factor Analysis
2	(Sudhakar, 2016)	Project success	India		Literature survey
3	(V. Sanvido, 1992)	Critical success factor	USA		Empirical
Stress					

1	(Wang, 2020)	Workplace stress and project success	Pakistan	453	Empirical
2	(Sampaio, 2021)	Stress as a factor in emotional intelligence	Global	131	Confirmatory factor analysis
3	(Mei-yung Leung, 2011)	Performance of construction project managers		108	SEM
4	(Morris, 2010)	System dynamics model for stress			SD Model
Engagement by Project Manager					
1	(Saadé, 2015)	Factors of Project manager success	Canada	66	Exploratory Factor analysis
2	(Montenegro, 2021)	Project manager's emotional intelligence on Project success	Serbia	110	Confirmatory factor analysis and SEM
3	(Beringer, Jonas, & Kock, 2013)	Stakeholder behaviour and engagement intensity of project manager	Germany	426	Regression
4	(Prabhakar, 2008)	Project success	India		Review paper
Anchor Bias					
1	(Lorko M. , 2020)	Anchoring effect in project schedules	Australia	93	Regression
2	(Romanazzi, 2024)	Behavioural biases in Project evaluation and cost	Venice	-	Case Study, Regression
3	(Lorko M. S., 2021)	Improving Project Scedules	Australia	139	Experimental
4	(Flyvbjerg, 2009)	Human bias in projects	USA		Case Study
5	(Cadorin, 2015)	Portfolio selection and biases	Sweden	8	Expert Interview
6	(Shang, 2017)	Risk management	Global		Conceptual
Risk Personality					
1	(Murray-Webster, 2021)	Making Risky decision in projects	USA		Conceptual

2	(Hillson, 2019)	Capturing upside of risk in projects	USA		Conceptual
3	(Trickey, (2017))	Risk Personality	-		Conceptual
Self Awareness					
1	(Creasy, 2013)	Personality trait of project managers impacting project succes	USA		Conceptual
2	(Thomas, 2018)	Project manager's emotional intelligence and Project success	USA	104	Empirical, ANOVA
3	(Zhang, 2013)	Improving performance Emotional Intelligence	China	112	Empirical
Persuasiveness					
1	(Simango, 2022)	Critical success factors	South Africa	33	Empirical
2	(Turner, 2006)	Leadership style and type of project	USA		Conceptual
3	(Hauksson, 2015)	Persuasiveness as a trait of influence	Finland		Theoretical
4	(Rivard, 1999)	Project Manager's Influence tactics and authority	Canada	139	Confirmatory Factor Analysis
5	(Keane, 2022)	Social cognitive perspective	-		Theoretical
6	(Jansen, 2021)	Influence in project management	South Africa	99	Factor Analysis, Regression
Technical expertise of project manager					
1	(Rwelamila, 2010, September)	Technical expertise of project manager	South Africa	50	Reliability Analysis
2	(Ma, 2014, November)	Skills of construction project manager	Australia	57	Interview and descriptive statistics
3	(Gillard, 2009)	Soft and technical skills of project manager	USA		Theoretical
Assertive Project Manager					

1	(Solga, 2014)	Interpersonal skills of project manager in successful project management	Germany		Conceptual
2	(Gruden, 2018)	Behavioural competencies on	Slovenia	70	Multivariate Analysis
Aggressiveness of project manager					
1	(Martens, 2018)	Impact of entrepreneurial Orientation (Risk taking, aggressiveness, proactiveness, autonomy) on project success	Brazil	100	SEM
2	(Ullah, 2020)	Impact of Entrepreneurial Orientation on Project Success: Mediating Role of Technological Orientation and Moderating Role of Top Management Support.	Pakistan	258	SEM
Adaptability of Project Manager1					
1	(Gewanlal, 2015)	Project Manager Attributes for project success	South Africa	163	Descriptive statistics
2	(Cheng M. I., 2005)	Project manager's skills	UK		ANOVA, Principal Factor extraction

We shall establish how strategy and risk are closely associated, in fact we may say inseparable and base our study in this research gap. In other words, we are for the first time studying the impact of human factors on project strategy. We can claim that because an attempt to define of project strategy with human factors has been done only in a few works of Artto. We bring forth for the first time the integration of the concept of strategy in business by Rumelt and that of Mintzberg with that of Artto. We take this further by putting it in the stakeholder theory model conceptualization. The novelty of this research lies in the fact is that it's not just a patchwork of 3 theories put together but a holistic attempt to bring forth the impact of human factors on this integrated understanding of project strategy through a system dynamics model. Thereby paving the way for a theory of project management.

The research not only reduces the vacuum in human factors in project management is also our research bring for a definition of what human factors mean in respect of project strategy. Our research methodology section shall elaborate more on this. However, since we are discussing the research gap, it is pertinent to mention that the factors are chosen from existing literature and categorized in buckets to add to the body of knowledge of project management.

2.4 Conceptual Framework

First we do a literature survey and identify possible human factors. This figure below depicts the model.

Figure 8: Stages of literature survey

In the 1st stage we define project strategy as this is the variable on which we will study the impact of human factors. This is the first time a holistic definition of project strategy has been done. Further, human factors were either studied from the point of error in process and its reduction or as human resource parameters of team building, leadership etc. This is for the first time that we are studying both the impact of system based and human resource based human factors together in a holistic way.

Stage 1 : Identify Human Factors

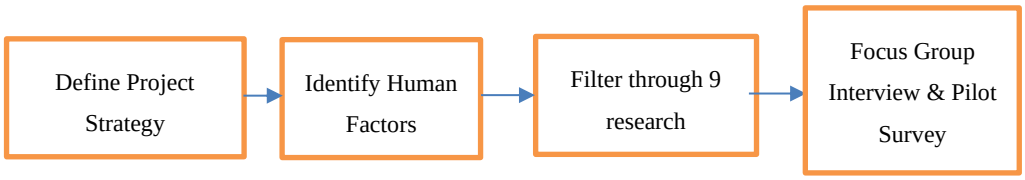


Figure 9: Stage 1

Stage 2 : Identify impacting human factors and quantum of impact

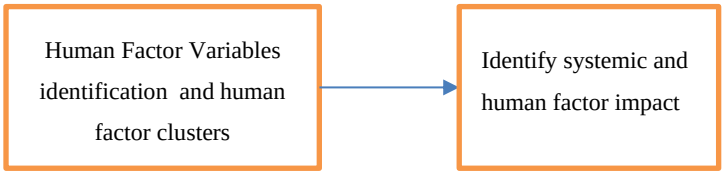


Figure 10: Stage 2

Stage 3: Validation

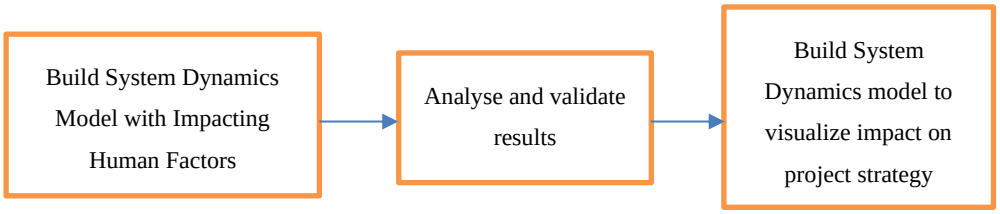


Figure 11: Stage 3

In Stage 1 after project strategy's holistic definition we move towards identifying the human factors by researching 9 databases with keywords derived by an extensive literature deep dive and finally filtering our 23 human factors. We then prepare a questionnaire and pre-test this with selected 5 people. After that the questionnaire is revised and a focus group interview is conducted. In this interview of the 23 human factors top 16 are evaluated and the observations of experts on the less important human factors as per literature survey but felt as critical by experts in focus interview is noted.

The conceptual model is thus developed for the questionnaire. The questionnaire is so designed that the critical factors as informed by experts is captured. Also the experts inform the major division of variables into System based and human factor based variables and those which have a mixed nature.

The experts are also shown the questionnaire and after their suggestion the final questionnaire is designed. A pilot survey is done on this finalized questionnaire

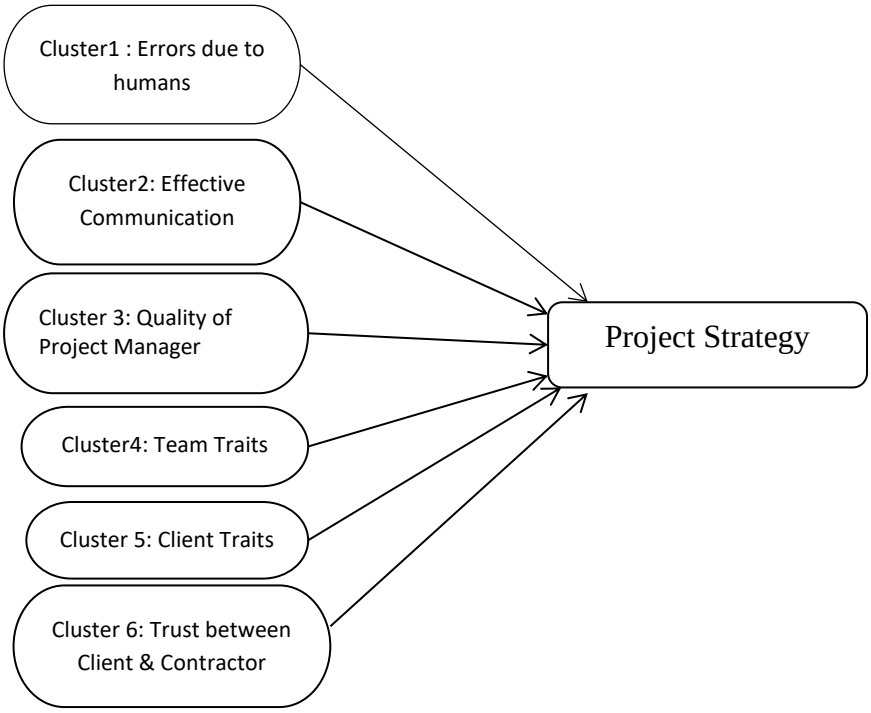


Figure 12: Conceptual Model

After the pilot survey, we enter Stage 2 i.e the main survey is done to ascertain and prioritize the human factors.

After the main survey through Structural equation modelling we find the possible human factor variables.

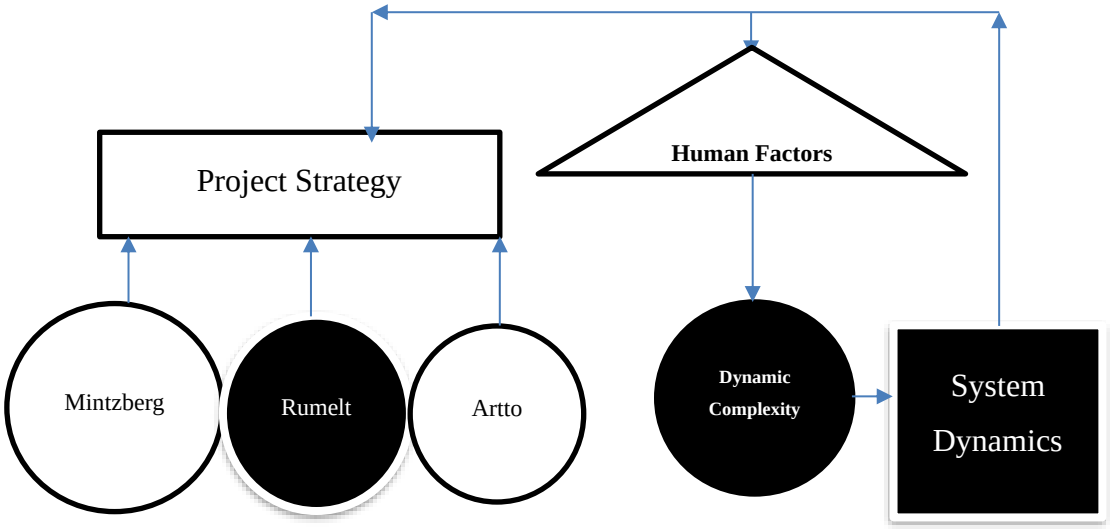
In this context we must mention that the definition of project strategy derived from the definitions of Mintzberg and Rumelt combined. These two definitions give a structure to project strategy however, the dynamic aspect is not established. In Rumelt's definition the kernel does contain actionable steps and in Mintzberg though manoeuvre is mentioned, it is only theoretical. Our research takes it forward by analysing this dynamic nature through a system

dynamics model. Not only does such a model study this dynamics but also drills down into dynamic complexity.

However, before doing that in stage 3, we analyze the results by categorizing the human factors into system based and human based factors.

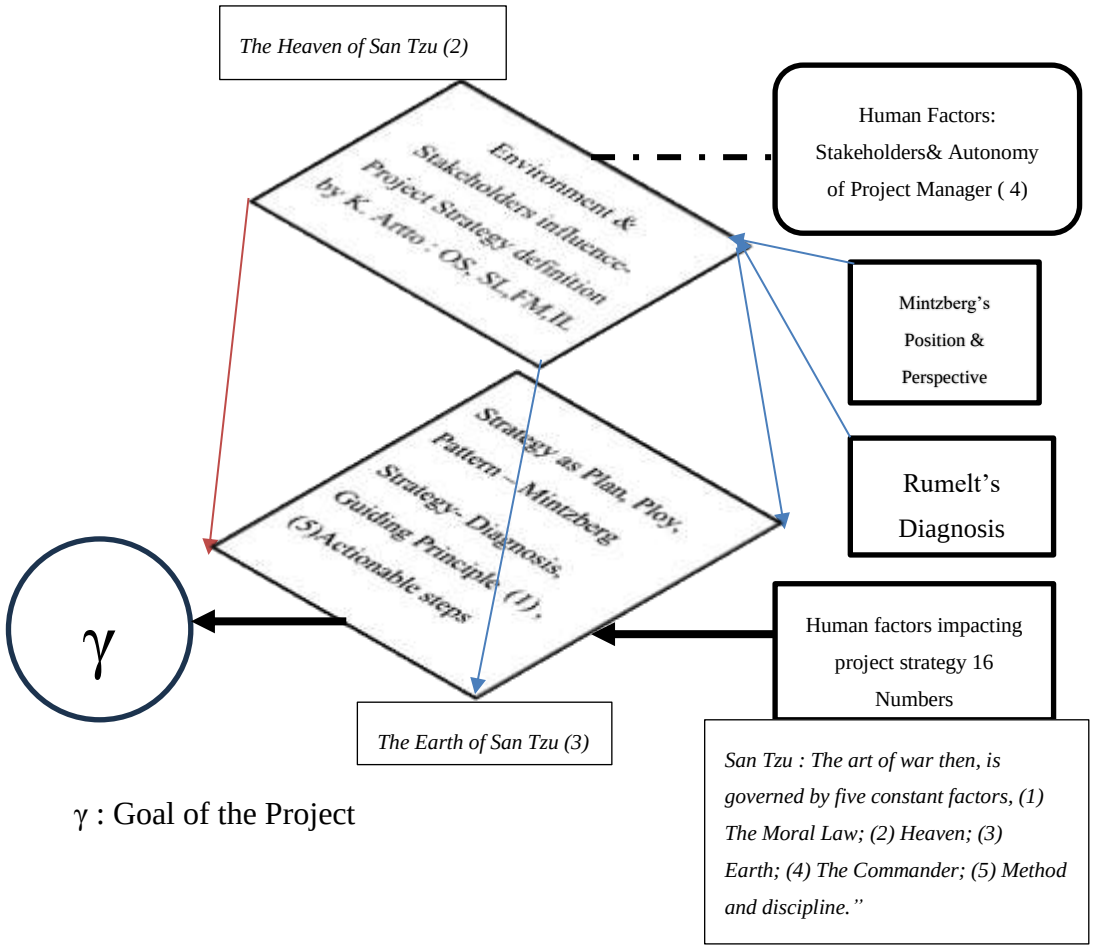
In stage 3 we develop the system dynamics model and validate the results obtained from the structural equation modelling.

After doing that we move towards the third dimension of project strategy definition i.e proposed by Artto and has a stakeholder view. However, Arttos definition is like establishing a position and categorization. A strong semblance is there with Porter's definition of business strategy where a position is taken by a business. We give this static viewpoint a dynamic dimension through a system dynamics model.



Though conceptually very different from the Rumelt or Mintzberg definition, the system dynamics model enables us to test the same variables we validated in the stage 2 and then a system dynamics model in stage 3.Thus with the help of system dynamics we not only for the first time bring forth a human factor

based impacted analysis on project strategy, but also give project strategy a holistic definition. The research gap is thus bridged through an integrated approach.



γ : Goal of the Project

Figure 13 : Conceptual Model for Project Strategy

2.5 Summary

This chapter presents the review of the available literatures in the area of project strategy & risk and human factors impacting the same. The available literatures suggested several definitions of project strategy and human factor variables. Content analysis was carried out to ascertain and identify human factor variables

occurrence in different studies. Further a definition of project strategy is arrived at from the literature. This definition is actually conceptually very different. To bring a holistic definition a system dynamics approach is adopted. Based on this literature survey the research gap was identified for the present study. The chapter, thereafter concluded with the conceptual framework of the proposed study. This chapter presents the review of the available literatures in the area of project management, human factors, risk, strategy and complexity. The chapter, thereafter concluded with the conceptual framework of the proposed study.

CHAPTER 3

RESEARCH METHODOLOGY

3 RESEARCH METHODOLOGY

3.1 Introduction

This chapter deals with philosophy, approaches, design and methodology to address a research problem. Sanders et.al proposed the research onion to establish the research process. In this there are the methods or tools and methodology or framework. In this chapter we will establish both the framework and the methods.

However, before that it is important to inform the approach to research. In other words we may say the belief system, premises and approach to research is research philosophy. Pragmatism, Positism, Interpretism and Relism are the major classifications in scientific studies.

Before we elaborate our approach we would also like to illustrate the approach in ancient Indian thought. The importance of this is very crucial specifically to this research as megaprojects are impacted with global geopolitics and ideology and hence any research without addressing that shall be incomplete. In India the British Empire had a great impact infact prior to that the Mughal dynasty shaped our thought structure. However, this was also the time a lot of ancient texts got destroyed. However, the ancient method of mentor disciple knowledge transfer was not a written but verbal transmission and hence this was preserved. During the British rule however, there was an attempt to impose western thought structure as superior to our traditions. As this was happening, the west was also impacted with the colonial power dominance. Soon the communists rose in the far east in Soviet union. They had a very materialistic approach to knowledge and world affairs. The west was growing capitalist thought dominance but still not atheistic in nature. Soon America became a world leader and capitalism overtook communism after fall of the Soviet Union. Most of knowledge acquisition was impacted by a bipolar world race between Russia and America during the Cold War and industrial revolution. After this came the rise of China a more competitive ruthless communist-capitalist regime. However, this is all history and now we are at the beginning of the collapse of capitalism. Hence the

prominence of knowledge acquisition of the methods preached by the dominant materialistic thought leaders of west is wanning. Our attempt to provide this background is establish the basis or answer to why the scientific world preferred a positivist, interpretivist, realist or pragmatist standpoint. Definitely the field of research is critical in this context. For example in problems of social science the interpretivist standpoint provides advantages. However, despite this the base of our belief plays a great role on what route we choose.

(Kapil Kumar Bhattacharyya, 2014) provides the approach in Samkhya Tattva Kaumudi. He informs that there is a 5 siddhi or powers which are a way of knowledge acquisition, though modern scientists may not approve that. Considering our in access to this portion we limit ourselves to the lower method more acceptable to modern thought.

The 5 stages of acquisition are *Taram, Sutaram, Tartaram, Ramyakah, Sadamuditam.* In the taram stage two research activities are mentioned: *pratakshya and sabda.* Pratakshya is the witnessing with your eyes about the truth. This may be similar to finding the problem and research gap. *Sabda* is the sound or verbal testimony of illuminated minds.

The second stage or *sutaram* we have two research activities *anumana and arthapatti.* The first *anumana* is getting a first estimate and this may be by review of earlier works or a qualified guru. The second *arthapatti* is the knowledge that provides a supposition to a known fact to resolve the inexplicability. For example if a person says he never sleeps at night and still remains fit, we may presuppose he sleeps in the day to resolve this inexplicable portion. Similar to hypothesis formulation.

The third stage is *taratam* i.e reasoning behind the supposition , this is like our hypothesis testing.

The fourth stage or *ramyakah* is establishing authority of the valid knowledge thus found. This is similar to our data analysis and results.

The fifth stage is *Sadamuditam*, giving away generously of the thus found knowledge. In our case the thesis compilation, publication and teaching.

Thus we see that the stages of research are very similar to what we carry our in our modern method.

Having observed the above stages and activities it is worthwhile to reflect of the knowledge acquisition method of Patanjali illustrated in his yogasutras. During this phd research the publication on Agile epistemology was highly influenced by this work.

Patanjali mentions 3 ways of knowledge acquisition *pratyakha (*perception) i.e going to the airport and seeing the aeroplane with your eyes, *aumana* (inference) i.e. conclude from logic that such an aeroplane can fly in the sky with drag and lift forces and *aptavacana* (testimony /authority of a seer or reliable source). We will utilize the 1st two methods in our research.

However, we shall also elaborate how this limitation of research is addressed by the sage. Patanjali's yogasutras is a technology of the mind. It provided the process of attaining knowledge. First, it illustrates that our mind is the tool to acquire knowledge. In our research we use tools of research method analogous to the mind. The fit tool to acquire knowledge in research we have decided is a questionnaire and then a system dynamics model. However, as per the sage knowledge can be acquired by a *purified mind.* The purified mind has no restrictions or fluctuations i.e *vrittis* as informed by the sage. The commentary by Swami Vivekananda gives an analogy of a lake, which is quite and that on which we drop a pebble. The pebble sets ripples on the lake. While the quite like bottom can be seen through, the ripples restrict the vision to the bottom. Similarly, truth is restricted by the fluctuations on mind stuff. The sage then goes on to give an 8 limb method to restrict these fluctuations. We shall not elaborate that, but in our research we will create a framework which shall enable us reach our solution. This will be our research framework.

However, the 8 limb framework is only the means to the end. The sage informs that after the steadiness in framework is attained, there is concentration. A technology of knowledge acquisition is thus expounded in the 3rd part or *vibhuti pada,* in this the three stages of *dharana, dhyana and Samadhi* are explained. After Samadhi comes the powers of the mind and something called *samyama.* Though this is beyond our gambit of research the reason we are elaborating this

is to reflect on the methodology we shall adopt for this research. Furthermore, this research unlike a pure academic research has experience from a 20+ years practical experience in project management field. The research is an attempt to build up on body of knowledge in project management and its theory. In fact in a recent publication we have attempted at paving way to "Project management as Technology" in the lines of " Management as technology" and in this above process of knowledge acquisition is critical and an area of future research. Any technology is nothing but the "science of application of scientific knowledge" For example, French scientist Sadi Carnot in 1824 proposed the ideal Carnot Cycle. In 1876 Nicolaus Otto built a coal-gas- air mix fuel for a stationery engine. It was the 1st four stroke working engine using spark plugs. While Carnot conceptualized the conversion of energy in gaseous medium to thermal work, Otto cycle used this scientific knowledge to build the technology of car engines. Hence we can say Carnot gave the science and Otto brought in the technology. In the similar analogy we can say projects are run without a project management theory. So a science behind this application exits. We may argue that the application of the scientific knowledge may be happening without knowing the science or possible being done incorrectly! Once we unveil the science we will know the right usage of this knowledge. In Management as technology the Stanford, Harvard & MIT scholars, the working paper argues that in the labour and capital factors of the production function proposed by Cobb Douglas, the intangible capital of Management may be introduced. They tested it in many firms and concluded that Management practices impact this function's output just as labour or capital. Hence Management is like a technology which runs a company's business like an engine runs the car!

Our research is on Project Management and unlike a business which is complex, we can deduce that project management is the technology which is like the engine of the project. However, we will develop shall develop this line of thought further. The authors in the working paper mention management practices, but do not dig further. We would say this includes the business strategy as the core of this engine called management which is like a technology running the business engine i.e like the Otto cycle behind the 4 -stroke engine.

Lot of counter arguments may come with culture of company, tools and processes etc. It's a complex problem to pin-point what exactly is the business strategy. However, the nature of projects make it simpler. Projects have a definite beginning and an end. This very temporal nature makes them easier to analyze and gives Project Strategy a dimension we have touched upon before. Our research and our research framework will be directed towards this aspect of establishing Project Management as a technology behind the project. Further more, unlike a business we can establish the Project Strategy is the science behind this technology!

To establish this science first we have to identify the variables and ask the right research questions.

3.2 Research Questions

This is our stage of *sabdam* to find the right thread or *sutram.*

Our research questions are:

1. What is project strategy?
2. What are the human factors which affect the project strategy and risk?
3. Do human factors impact project strategy more than systemic factors?
4. How can we study the impact of dynamic complexity on project strategy?

3.3 Statement of the problem

As mentioned in our research philosophy we have been building on the project strategy definition. We have two types of definitions in literature. First type is that by Mintzberg which provides the 5 P's of strategy and Rumelt's which provides the kernel of strategy as diagnosis, guideline and actionable steps. This line of thought brings out goals of project as an outcome or we may say as an emergent principle of the process. In this type in the strategy we have both human factor and systemic factor. However, the core question remains on the decision making process, is it human factor driven or system driven. We have presented that the strategy formation is a mental space phenomenon and whether it fruitful or not is dependent on the decision task potency.

The second type is the stakeholder based view by Artto. This as mentioned is a static view of project strategy. Our formulation of the theory is a function of the decision task and stakeholder influence. This integrates the two views of project strategy. To affect this holistic definition, we approach the first research question in two stages.

However, before we touch these two concepts of project strategy our problem is to first know what remains at the core of it : Human Factors or Systemic Factors. But even before that our first problem statement is to find what are these human factors.

Thus, in the first stage we study the various human factors and filter out those studied extensively in literature and study their impact on the first view of project strategy. During this we add our experience in the field through expert views how tactical issues impact strategy and how they intermingle. This include project schedule crashing, trade credit availability, project cashflow and related risks. Unlike long term business plans, large and megaprojects span over 2-5 years which gives them a nature more akin to war. A war has battles in short term and series of battles determine the result of a war. A battle may be a few weeks to a month. The strategy is a battle is more akin to tactics and strategies of the war have a reciprocity with tactics, in fact in a battle strategy and tactics intermingle. Similarly in projects strategies are more intermingled to tactics than businesses which span for years. Our attempt therefore is to capture this aspect in our research and hence state the problem accordingly.

After this stage we evaluate what is the quantum of impact of human factors as compared to that of systemic factors. In this stage we also study the risks associated in projects and how human factors relates to such risks. We do not give preferential treatment to risks in projects as many literature do. The premise to this is that like goal of projects is an emergent principle, risk should be factored into project strategy i.e. the components in project strategy are such that risks are inherently handled.

We have till now stated how we shall approach the our problem of the two disparate views. To understand and observe the problem holistically, our statement of problem would look something like follows: " How do we observe

the impact of human factors on project strategy and also the dynamic complexity? ”

3.4 Scope and Objectives of study

The scope of research will be to elaborate various aspects , theories and models used in project management, strategy, risk and human factors. The objective is to carve out project strategy from the intermixed understanding in the present body of knowledge. Through an extensive cross-functional literature survey the research gap shall be unearthed and the critical parameters will be ascertained to be studied.

We can give an analogy to explain our objective. Mankind has always been in search of creating value. One of these was gold mining. In the past, men identified possible places where gold deposits may be present. Then they start exploration by digging the earth and finally extract gold by separating the ore from impurities. Research of knowledge is similarly identifying the places of knowledge, in our case the research gap and then like digging earth dig for knowledge and fill this gap like the purification process. The objective of gold mining was to find gold. Our objective is to find a definition for project strategy with human factor at it’s core.

Our objective in this research is to identify human factors which impact project strategy and study the dynamic complexity to give the definition of project strategy a holistic view.

The research will limit itself to the study of the human factors and human factors which are crucial for a project strategy. Various project strategies and risks in a project will be studied. But limit itself to aspect of project management strategy and risk. We may summarize the objective of the study as follows:

1. To find the critical human factors in a complex project e.g. a coal handling plant, steel plant etc.
2. To ascertain the impact of these factors on project strategy for various scenarios like schedule crashing, claims settling and dispute resolution
3. Study dynamic complexity impacting project strategy
4. To bring out the holistic definition of project strategy

3.4 Theories and models adopted for the study

We have till now elaborated the literature we have review and the research gap we have identified. However, to understand the objective of the study mentioned above, it is crucial to discuss the theories behind this study.

We have already mentioned that till date there is no one acceptable theory of project management, our research aims to build on the theory of project management. To do that let us discuss some of the crucial theories we shall be reflecting upon.

Chaos theory focuses on the study of dynamical systems where apparent random states of disorder and irregularities are secretly governed by underlying patterns and predictable laws which are highly sensitive to initial conditions. In 1960 Edward Lorenz, a professor in MIT discovered chaos which later was synonymous with the 'butterfly effect,' an extreme sensitivity to initial conditions and also lead to discovery of Lorentz attractors, a set of equations called Lorentz equations. A metaphor to explain it was flapping of a butterfly's wings over the Amazon influenced the weather in Bejing. This phenomenon led to the birth of *deterministic chaos*.

General Unified theory of strategic performance and management (GUT) builds on generic principles of firm's performance based on accumulation and depletion of resources over time and it's interaction between rivals and other exogenous factors. The theory is proposed by Kim Warren of strategy dynamics. Stacey Matrix developed by Ralph Douglas Stacey helps to understand the factors constituting complexity. R D Stacey identified five areas: near agreement & near certainty, away from agreement but near certainty, near agreement but away from certainty, zone of complexity, away from agreement & away from certainty.U Theory is a change management method by Otto Scharmer presents 7 steps to change.Prospect theory developed by Daniel Kahneman and Amos Tversky in 1979 postulates that individuals make

Figure 14:Source: The Systems Thinker

decisions based on perceived gains rather than perceived losses assuming that losses and gains are valued differently by individuals.

Psychodynamic theory , Tripartite Theory of personality proposed by Sigmund Freud, interaction between nature and nurture explains, personality as a combination of id, ego and super ego. Eysenck's Personality Theory explains personality based on biological factors. Risk personality types framework by Geoff Trickey explains 8 risk personality types. Moore's Law states that the number of transistors double each year though cost has halved. Hence, every couple of years we pay less for them. Fuzzy Logic coined by Lotfi Zadeh of University of Berkley as a method of reasoning which mimics the human reasoning. The approach of FL imitates humans thinking which involves all intermediate possibilities between digital binary values. General Theory of Trust authored by Christiano and Falcone explains the concept of trust, based on cognitive, institutional, cultural, normative and technical factors. Trust Model uses public key cryptography and collection of rules that informs the computer application to check legitimacy of a digital certificate. Social Cognitive Trust theory studies the influence, behavior and behavioral choices on three main factors: behavioral factors, environment and individual personality. Agency theory explains issues in the relationship between owners and their agents or managers in business. The conflict of interests between agents and owners is the well known principal-agent problem.

Theory of production: explains the principles based on which a business decides how it will use the inputs of raw material, labour, capital etc. to produce what mix of products it wishes to sell. Cobb-Douglas formulated the first production function in 1927. Theory of Value: is used in a diverse sense in philosophy. It is used with a broader meaning in moral philosophy, social and political philosophy, where it is deemed to cover some "evaluative" aspect. In a narrow sense, "value theory" is used for normative ethical and of concern to consequentialists primarily concerned with classifying things as good or bad.

Stackelberg Game has asymmetric roles of leader and follower. The "leader" moves first, and all the "followers" move after the leader. Named after Heinrich Freiherr von Stackelberg it evolved the first mover advantage in oligopoly

market theory.Nash equilibrium is a theorem that states that a player can achieve the desired outcome by not deviating from their initial strategy. It is a concept from game theory where each player's strategy is optimal with respect to the decisions of other players. Price discrimination Theory comprises of practices to extract maximum price from heterogeneous consumers. Due to information asymmetry, only the monopolist knows the distribution and finds the optimal nonlinear tariff enabling the optimal markup for each purchase level and consumers do not have incentive to imitate the behaviour of others. Bargaining Power Theory was published in 1988 in a work Bargaining: Power, Tactics, and Outcomes by Samuel Bacharach and Edward Lawler. "Bargaining" is regarded as a process of managing and manipulating impressions and information. It has 4 assumptions viz. power is essence of bargaining, bargaining is a process of tactical action, bargaining power is subjective.

3.5 Definition of constructs

Human factor variables are constructs used in the research. Though literature survey of 6 large databases we filtered 23 variables to study the impact of Human factors on strategy and risk in complex projects.

Strategy and risk is encapsulated in a single construct or dependent variable “Project Strategy”.

Before we proceed, we must define a variable and a construct. A construct in the context of social science research is nothing but a concept that social scientists use for their scientific purpose. Its an abstract idea inferred from observable phenomenon. Variables on the other hand are factors that can be measured. For example Intelligence is a construct and IQ score is a variable.

In this research all independent and dependent variables are constructs. There are some moderating variables which not constructs like age and gender.

The construct Project strategy consists of four sub-constructs or variables Goal, Plan, Ploy and Direction.

The independent variable constructs are listed below:

Stress	Anchor Bias

Self Awareness	Decisive Client
Assertive Project manager	Effective Feedback of project Team
Persuasiveness	Effective Communication
Technical Expertise Project manager	Support of senior management
Adaptability of Project Manager	Risk Personality
Aggressiveness of Project manager	Organized Project Team
Reputation of Project Manager	Experience of client
Engagement of Project Manager	Errors due to humans or Human Error
Flexibility of Project Manager	Contract Handling by Project Manager
Charisma of Project Manager	Trust Between Client and contractor
Leadership of project manager	

Possible human factors or constructs from literature survey: (PrakashPrabhakar, 2009)- Effective communication, engagement, flexibility and adaptability, preference for significant initiative and leadership, aggressiveness, confidence, persuasiveness, verbal fluency, ambition, activity, forcefulness, effectiveness as a communicator and integrator, broad scope of personal interests, poise, enthusiasm, imagination, spontaneity, able to balance technical solutions with time, cost, and human factors, well organized and disciplined, a generalist rather than a specialist, able and willing to devote most of his or her time to planning and controlling, able to identify problems, willing to make decisions, able to maintain a proper balance in use of time.

(Korsakiene et al., 2020) the study revealed that communication and trust affect other human-related factor. (Hussein et al., 2019) trust as a human factor in human and human machine interaction.(Borsci et al., 2019) human machine trust and human factors in healthcare. Trust towards system concept (TTS).(Thompson, 2018) stress as a human factor. (Morris et al., 2010) Stress as a human factor.(Kadefors, 2004) factors that influence development of trust and co-operation in client–contractor relationships in construction projects.(Strahorn et al., 2017) Human Variables-Relationship, trust , project management, relationship interaction and trust, initial intent of stakeholder, Attribution Variables- Trust worthiness, reliable behaviour, communication, competence, benevolence, integrity, honesty contextual variables- risk vulnerability and uncertainty, control mechanism, positive team environment, trust & project outcomes, trust and temporal nature of project. Trust failure-trust breakdown, trust repair, trustworthiness factor, social explanations,

apology or denial, competency or integrity trust violation, apology and internal and external attributes, reticence. (Tejpal et al., 2013)complex multi-dimensional construct of supply chain partner's relationship and (Tejpal et al., 2013) factor analysis.

(Sasu, 2018)Self awareness, (Love et al., 2009)innovator, (Costigan, R., Iiter, S., & Berman, n.d.)risk taking, assertiveness and motivation, (Moshood et al., 2020)emotional intelligence, educational background, safety, professional competency

(Alias et al., 2014)Human factors considered-Human-related factors involve client's experience, nature of client, size of client's organization, client's emphasis on low construction cost/ high quality of construction/ quick construction, and client's ability to brief including to make decision; to define roles; contribution to design; contribution and support from senior management ,Skilled designers, skilled project manager ,Troubleshooting, project team motivation, Commitment of all project participants ,Strong/detailed plan effort in design and construction ,Adequate communication channels ,Effective feedback, (Dul & Neumann, 2007)ergonomics in strategy and risk

(Francis et al., 2008)Project management and reputation of PM.(Zadeh et al., 2017)Cooperation and (Hsieh et al., 2020)goodwill, (Flyvbjerg et al., 2009)deception, (Flyvbjerg, 2006) inaccuracy and forecast risk in Pm, optimism bias and strategic misinterpretation

(Poster, 2013) Emotions, (Zwikael & Smyrk, 2015) control and trust.

3.6 Research Methodology Formulation

We take forward the concept of *sutaram* i.e building our hypothesis. The first stage of research *Taram* i.e literature survey was done and variables identified. Research gap found from this survey was *Pratyaksha* i.e gap in which we can add knowledge. The work of others was analogous to *Sabda.* As per Samkhya this stage has two parts *anumana* i.e measurable units or estimation and *arthapatti* i.e a supposition to explain the inexplicable fact.

For the first part we prepare the questionnaire to collect the data after identifying the variables. In the next we build our hypothesis. It is pertinent to mention here that like mind is the tool to reach to the wisdom by silencing the mind. In scientific research, filtering out noise is the route to unearth new knowledge.

Our null hypothesis are:

Prior studies have studied project success factors, some have segregated human factors and system driven factors. However, the quantum of impact of these two types of factor have not been studied before. This has lead to our first hypothesis.

H01: Human Factors have no significant impact on project strategy

Though human factors have been studied in literature their impact on project strategy i.e project goal, project plan, project ploy and project direction has not been studied before. This has lead us to propose the following hypothesis.

$H_0$2: While crashing the project schedule human factor risk has no significant impact

Schedule is one of the critical aspect of projects. Value of projects is derived from crashing the schedule and completing projects before schedule time. Due to crashing of schedule, the costs of overheads is reduced. In the above hypothesis we present whether project goal of creating value and project plan which includes schedule.

Managing contracts have been an art in project management. It involves both systems and human capabilities. Project strategy has a component of ploy or manoeuvre as per Mintzberg and Guideline as per Rumelt. Our following hypothesis tries to test this as well as Project plan.

$H_0$3: Contract Handling has no significant impact on project strategy

Since projects are complex systems, segregating into parts looses some of the knowledge, hence studying in scenarios gives a better understanding. A part of managing projects consists of handling disputes which has both ploy and direction in it. Diagnosis, Guideline and actionable steps all present in this scenario. This leads us to our fourth hypothesis.

$H_0$4: Human factors have no significance in ploy and direction in complex projects

To have a closer look at this we need to understand one we look at the leadership, reputation etc. of project manager to see if this cluster of constructs impact project strategy.

$H_0$5: Project Manager's qualities has no influence on project strategy.

While one part of project manager's qualities cluster of constructs impacting project strategy in a dispute gives us insight into ploy and direction, the impact on the same on trade credit shows the impact on project goal and ploy. This leads us to our next hypothesis.

$H_0$6: Project Manager's qualities has no influence on ploy and direction

After analyzing the impact of Project Manager's qualities we look at impact of a relationship construct "Trust" on project strategy. In the next hypothesis we formulate our intent to observe the impact of this on a financial aspect of trade credit. In this hypothesis we will be observing value creating i.e goal of a project.

$H_0$7: Trust between contractor and client has no impact on project strategy.

In the above hypothesis there are two sides, the client and the contractor. The contractor team is what we study next. We analyze the human factor cluster Team Traits. Project Team is an amalgamation of relationship, interaction, leadership and the link between client and contractor.

$H_0$8: Team traits have no significant influence on project strategy

In the next hypothesis we investigate the other side of the relationship i.e client side.

$H_0$9: Client traits have no influence on project strategy

After the relationship construct we investigate whether the most widely studied human factor variable and also the most prominent in literature, i.e human error (many a times used interchangeably with human factor), has any impact on project strategy.

$H_0$10: Error due to human no significant level of influence on project strategy

3.7 Research Design

In the above section we have elaborated on *sutaram's* research activity of *anupritti*. Now we explain the *anumana* or how we measure and estimate. This is what our present section is about. We may state that research methodology is setting up the broad framework while research design is more specific focused on answering the research questions.

In the research methodology we have set our that framework is critical to our systematic research study. In fact as we reflected on *patanjali's* 8 limb framework, we saw that this is the foundation of extracting knowledge.

In the research design stage we deep dive into the approach of how relevant information to answer the research questions shall be obtained.

As mentioned in the methodology while literature survey identifies the gap, we nor move deeper into how to fill this gap. We have already put our hypotheses and to validate these we need to now find the right research method. The first stage of this is to design a well structured questionnaire (for project managers and team members) and semi structured interviews with experts in this field (project managers with more than 30+ years of experience in participating organizations).

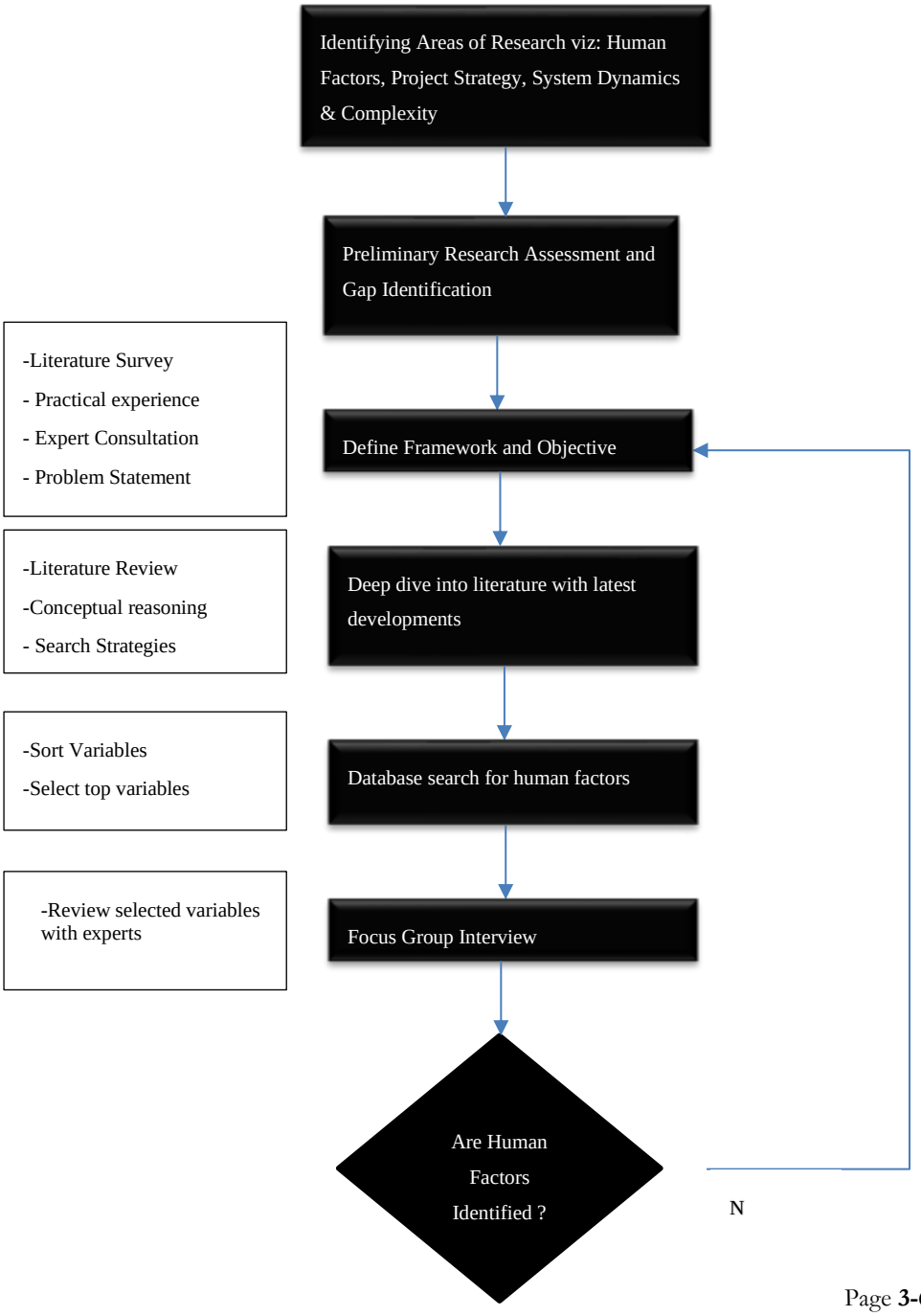
The second stage is that of the system dynamics modelling. In this stage we develop the model to see the impact of the human factors found relevant by our 1st stage research on the various project parts i.e schedule, cost and quality. In past studies, the impact of employee attritions, trade credit, rework etc. has been studied separately, the system dynamics model incorporates all these factors. In fact through the model we shall attempt to capture the dynamic complexity and their impact on project cashflow.

It is relevant to state here that our approach in the 1st and 2nd stage are connected but disparate. In the first stage project strategy is the dependent criteria while in the second stage it is broken into tactics and factors and we study the impact on project cashflows to study the impact of these factors. The combined provide a holistic view of strategic and tactical parts and how they intermingle.

The third stage is where we develop the system dynamics model of stakeholder impact on project strategy. This brings out the complete picture of the 1st and 2nd views of project strategy and provides the holistic view.

This is therefore a mixed type, descriptive design which uses data collection, expert interviews and modelling to bring out the essence of the research. Taking the example of gold mining, the right drilling machine is used to drill out the gold. But the gold is mixed with impurities so we purify it to get 99.99% gold. In our case, the drilling machine is the questionnaire and the modelling is the purifying process.

The Overall design flow is depicted below:



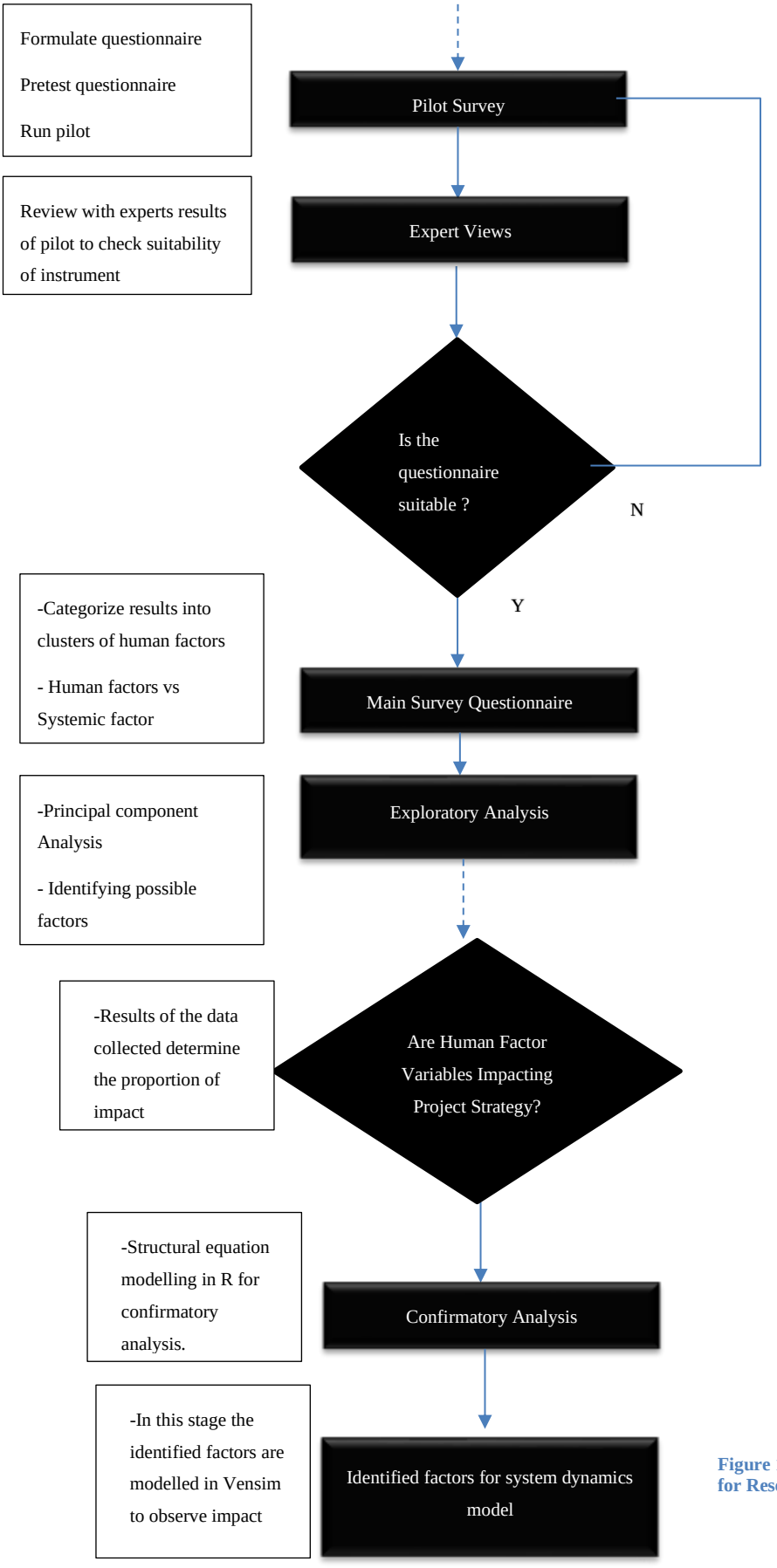


Figure 15 : Flow Chart for Research Process

3.8 Population

(Fraenkel FJ, 2002) refers population to the entire set of subjects or events having common characteristics in which the social scientist or researcher is interested. In our case it's the project managers and project team members.

We use secondary data from Govt. of India and PMI to ascertain this sample size. (Knowledge Hut, 2024) informs that as per PMI there are 47073 PMP holders in India. (PMI, 2024) Of these 55% are in IT sector. Since our audience is majorly the core sector where megaprojects and complex projects are being evaluated, we can assume that 21000+ are in core sector.

(MoSPI, 449th Flash report on projects greater than 150 Cr., 2023) reports around 1449 projects above 150 Crs. Of which 966 are reported as delayed. Hence they are spill over from other years. Which means projects within schedule are 138 projects. Of this 19 projects are not in core sectors, i.e. around 119 projects are worth our attention. A usual team size of these projects shall be in these projects shall be 15 to 20. Hence in 119 projects this shall vary from 2100- 2300 project management professionals. Delayed projects of these shall hold not more that 0-2 members and they usually see multiple project possibly 20-30 numbers by the same person. Hence, these projects will hold less than 50 people. So we may estimate the population is these projects to be 2350 project professionals.

(MOSPI, 2020) reports 1703 projects containing 467 mega projects and 1236 major projects above Rs. 150 Cr. Of these 303 were reported to be within schedule and 1400 delayed. Projects above Rs. 1000 Crs. Are Mega Projects. These have team sizes of 40-50. Of these 69 are reported to be on time. In such large projects the team size remains intact upto 5-7 years of delay and subsequently reduces to half and then further down. Hence we assume around 50% having full teams and 50% having 10-20 team size i.e around 3000 - 5000 project professionals in these projects.

(MoSPI, 79th flash report on Mega projects, 2015) reports 277 of which 58 are within schedule rest all delayed. Hence we can assume that 3000 project professionals are in these projects.

Hence the population of 5000 professionals between 2015 – 2023 may be assumed.

The Megaprojects have Project Directors and project managers of experience above 20 years. There will be 5-10 such profiles in each Mega Project while in Rs. 150 Cr. and above there will be 1 Project manager and 1 senior planning manager or package lead (More than 10 years of experience) . Hence, we can say that in the 119 projects there will be 119 senior project managers and 119 senior leads. In the Mega projects there will be 350 to 500 such profiles. Hence between 2015-2023 we can say there will be 600-700 such profiles.

The private sector investments are increasing (Parikh, 2023) reports 68% commitments from private sector of 10509 projects announced. However, private sector has been a minor investor prior to 2023. (Dhoot, 2023) informs only 6% contributable to private sector. Hence we may assume that this population of 600-700 project professionals shall be represent the entire population of project management professionals who can be suitable for our research.

3.9 Sampling Size, Sampling Frame & Sampling Technique

3.9.1 Sampling Frame

Our research aims to provide a generalized implication. However, the questionnaire / tool prepared needs an audience who have advanced knowledge of project management. This was also evident in the pre-testing stage and the expert interviews.

Since our objective is to find out factors in complex projects we choose projects of size more than Rs. 150 Cr. which have high level of complexity in terms of not only the domains of project management mentioned in PMBoK like Scope, Time, Cost, Contract, Communication, Procurement, Risk etc. but also because of scale. We select projects from the following domains:

Table 2: Sectors of study

Power	Coal Handling	Petroleum	Infrastructure

Steel	Atomic Energy	Ports	Water

The sample population have a certain level of experience to answer the questions on schedule crashing, trade credit and dispute resolution. Hence, preferably they should have 10-20 years of experience. However, if they are working in Mega project sites they may be considered below this age with exposure to such environment. Usually higher post graduate degree with 10 year experience this should be good.

3.9.2 Sampling Size

(Glenn, 1992) provides the following tables for sample size.

Table 1. Sample Size for ±5% and ±10% Precision Levels where Confidence Level is 95% and P=0.5.

Size of Population	Sample Size (n) for precision (e)	
	±5%	±10%
500	222	83
1,000	286	91
2,000	333	95
3,000	353	97
4,000	364	98
5,000	370	98
7,000	378	99
9,000	383	99
10,000	385	99
15,000	390	99
20,000	392	100
25,000	394	100
50,000	397	100
100,000	398	100
>100,000	400	100

Figure 16: Sample Size: Source: (Glenn, 1992)

From the above we may choose a sample between 222 to 286 for a $\pm$ 5% precision level.

(Singh A. S., 2014) informs the parameters for the right sample size as effect size, variability, statistical power, significance and one tailed or two tailed significance is planned. For our research we consider a precision level of $\pm$ 5%. Since we have a homogeneous population in these megaprojects, we can assume

it to be 20%. The effect size doesn't have much relevance in our research. The statistical power is relevant to random sampling and usually 0.90. However, our research uses purposive sampling. Another factor which is important is confidence level. We assume this as 95%.

Sample-to-item ratio

(Memon, 2020) reports that for exploratory factor analysis, the sample-to-item ratio is generally used to decide sample size based on the number of items in a study. (Gorsuch, 1983; Hatcher, 1994; Suhr, 2006) suggest the ratio should not be less than 5:1. For example, a study with 30 items (questions) would require 150 respondents. In our research we have 28 questions so it should be 140 respondents.

(Costello & Osborne, 2005) suggest a 20 : 1 ratio. In this case, would need 600 respondents will be required the same 30-item study. As our research has 28 items it would mean 560 respondents. Barrett and Kline (1981), on the other hand argued that sample-to-item ratio has little to do with factor stability and hence a small ratio is adequate.

Sample-to-variable ratio

(Memon, 2020) reports that preferred (Hair et al., 2018) suggest the sample-to-variable ratio should be a minimum observation-to-variable ratio of 5:1, but ratios of 15:1 or 20:1 are preferred. This implies that at least five respondents must be considered for each independent variable in the model, but 15 to 20 observations per independent variable are strongly recommended. One of the reasons the 5:1 ratio is not recommended is that it leads to underpowered studies. For instance, if a model with five independent variables would require only 25 respondents if one uses the 5:1 ratio. In practice, this is too small a size (Bartlett et al., 2001). Furthermore, the sample-to-variable rule should be used with caution if sampling or theory generalisability and data representativeness are a concern. This rule can be used for multiple regressions and similar analyses instead. In our research the number of variables are 16 so the number of observations should be 240.

Yamane (1967) and Israel (1992), provide the following formula the researcher can use the following to calculate the sample size when population size is known.

Equation 2: Sample Size Formula, Source: Yamane (1967) and Israel (1992

$$n = \frac{N}{1 + N(e)^2}$$

Where,

n = sample size

N = Population size

E = Acceptable magnitude of error

In our case this will be equal to 240-254.

As per Krejcie & Morgan (1970), the formula for sample size is as follows:

Equation 3: Sample Size Formula , Source : Krejcie & Morgan (1970)

$$n = \frac{X^2NP(1-P)}{d^2(N-1) + X^2P(1-P)}$$

Where,

n = sample size

X^2 = the table value of chi-square for 1 degree of freedom at the desired confidence level (0.10=2.71, 0.05=3.84, 0.01=6.64, 0.001=10.83)

N = the population size

P = the population proportion (assumed to be .50 since this would provide the maximum sample size).

d = the degree of accuracy expressed as a proportion (.05).

For our research this comes to 234 – 248.

Sample size guidelines for PLS-SEM The 10-times rule: Barclay et al. (1995) suggested the 10-times rule that was later accepted in the PLS-SEM literature. The 10-times rule recommends that at least the "sample size must be equal to the larger of (1) 10 times the largest number of formative indicators used to measure one construct or (2) (Hair et al., 2017, p. 24)10 times the largest number of structural paths directed at a particular latent construct in the structural model". But this has been criticized in literature.

(Roy, 2019) in his thesis on critical factors in risk management strategy uses 166 respondents. Though he assumes 5000 professionals in steel plant industry

and a margin of error of 7.55%. If we assume a similar error our sample size reduces to a similar number.

We therefore conclude from the above that a sample size of 263 respondents is adequate for our research.

3.9.3 Sampling Technique

For our study we use purposive sampling as the research is very specific and only those in the domain of complex projects can be suitable for this research.

(Campbell S, 2020) with case examples have shown how purposive sampling with proper sampling parameters to align with research methods. They show that the methodical rigour used improves trustworthiness of the results.

(Neetij Rai, 2004) Provide the advantages and disadvantages of purposive sampling. Oney key advantage of the wide range of techniques which include Maximum variation sampling for heterogeneous group, Homogeneous sampling critical case sampling, extreme case sampling and expert sampling. We shall utilize the homogeneous case sampling technique and expert sampling techniques. However, as projects are complex, the same data may be used as a heterogeneous when the reference frame is changed and we can analyze the same in future studies. Though it's a specific study, to generalize from a purposive sampling is not uncommon. With proper systematic approach this is possible.

In the disadvantage, they have cited bias, convincing readers on generalized results and lack of knowledge of population. All three which we shall take care in our research.

(Andrade, 2021) hits at the core of the issue. The author argues how the sample is representative of the population. So first let us understand what is our characteristic of interest. Our characteristic of interest is a "knowledge criterion" called project strategy. Since this is not a well known term, it is not easy to get the right response from the audience if we do not communicate properly. Hence, we shall structure the questions such that the response is

correct and idea is not misunderstood. Strategy may mean different things to different people. So we do not use this term except for the dependent variable questions. Rest of the questions are all scenario based questions. That being explained, our population is the project manager, project based organizations, project management offices of CAPEX project owners and contractors.

Taking the author's example of a drug depressant study, where if the sample is taken from out patients of a hospital in India using the drug, it is not representative of the entire population for which the drug is used, but rather of a sub-population. The article says this generalization will be applicable for the sub-population from which it is drawn. An example of study of learning disability from a sample of students in Karnataka rural government school is given. This states that such a sample cannot generalize results to private schools or all schools in India.

The author cautions specific respondents like researchers in a college or database based data. These samples are not randomized and hence are not generalizable. We will address this in the next section and during expert interviews.

Though there are drawbacks, the author takes it forward for the reason of such a sampling and how to read such results and informing the limitations. In our research we shall address such issues and how we can overcome the same. As the article mentions, that purposive sampling is a randomized sampling within the sub-population and a non-probabilistic in the entire population. This technique has excellent internal validity but external validity shall be limited by nature of the sample. This technique cannot generalize to everybody. However, in our research we shall choose the characteristic criterion such that our population specific to projects is covered.

(Denise F. Polit a, 2010) provides a perspective on how we can generalize a purposive sampling. He elaborates the three methods of statistical, analytical and transferability. While the first is most prominent in quantitative studies, the later 2 are useful for qualitative studies. In the first i.e statistical generalization the best method is random sampling. However, the author cautions, about

random sampling seldom resulting in random samples. In the analytical generalization rigour is required but researchers stop half way. The third or transferability is where the reader judges for generalization. The concept of proximal similarity is introduced. The author argues that finding a true generalization from particular is rare. Gradient of similarity and fittingness is what is required. A key concept is thick description about the sample is extremely useful in this proximal similarity.

In our research we shall use the strategies elaborated like replication of sampling,replication of studies, Integration of evidence and thinking reflexive and conceptually , mixed methods and the RE-AIM framework to affect generalization.

3.10 Data Collection

In our research data collection methods were focused on the followings basic techniques, including secondary and primary data collections focusing on both qualitative and quantitative data as defined in the previous sections.

3.10.1 Primary Data Collection

Primary data sources in our research were both qualitative and quantitative. The qualitative sources are expert interviews while that of quantitative data sources are survey questionnaires and simulation models. The next sections illustrate data collection from the primary sources.

3.10.2 Data collection through interview

Expert interviews with project directors, advisors with 40+ years of experience was conducted. These semi-structured interviews were conducted in a face-to-face setting which permitted the opportunity to seek new insights and ask questions to clarify issues which is difficult in other settings. It enabled the research to have an in-depth insight of project strategy. It was done in two stages one before the main survey to select key variables and next after the survey.

3.10.3 Data collection through questionnaire

- A Questionnaire is used as the main tool for gaining primary data.
- In this our thesis, each respondent is requested to reply to an identical list of questions. The questionnaire design was designed with a mapping to domains and variables unavailable to the respondents.
- The questionnaires developed were based on a five-item Likert scale, multiple choice questions and ranking questions.

3.10.4 Data collection tool pretest

The pretest for questionnaires, interviews, and tools were aimed to validate that the tool content is communicated to the respondents' understanding. Hence, content validity and internal validity is ensured.

Although it was 7 people we found that most of them have some common problems with the survey. Navigation was one of them. We had prepared the questionnaire online with Lime survey. So we improved it with instructions. Grammatical mistakes pointed out was corrected to communicate the same problems. There were also repeat questions which we removed. Some questions though not same appeared to be repeated, so we rephrased them for ease of response.

To have the proper feedback we asked them point blank to complete the survey while thinking out loud.

They were asked to complete the survey one at a time. The testers should completed the survey the same way we expected it to happen in the actual setting. 5 took it online and two were sent hard copies. This enabled us to address issues when some may want to take printouts before filling the survey online.

Some questions that came out were: how do I get to next section? I do not see question number. I don't understand this question and please correct the grammar in this question.

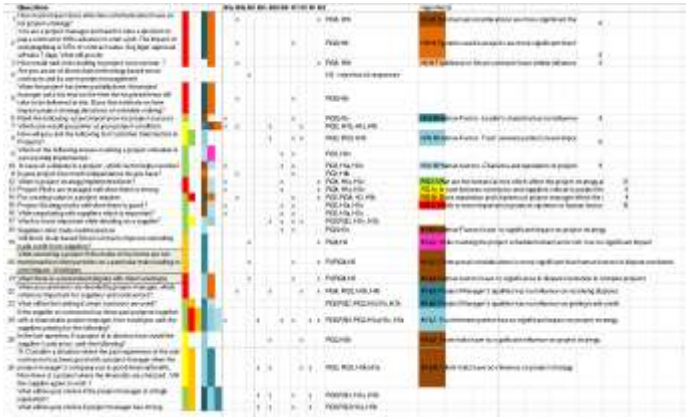
3.10.5 The Questionnaire Design

The questionnaire was designed as a multidimensional prism. It has been categorized into :

1. Human Factors V/s System Factors,
2. Project Strategy from the stakeholder point of view of project autonomy into
3. Risk Attitude

We depict this in the following table:

Table 3: Questionnaire Tool



Each research question is mapped to the hypothesis and item number of questionnaire.

Further more we also map the independence type :

Table 4: Questionnaire Design

3.10.6 Data collection from system dynamics model

Post analysis from the data collected, results are generated in Vensim to understand the impact of variables with possible scenarios. Objective was to understand the dynamic complexity and the tipping points.

3.10.7 Secondary data collection methods

The secondary data refers to data that was collected by sources other than the researcher. Literature review and industry documents and reports in both online mode and paperbacks were referred.

Nine databases viz Google scholar, Emerald Insights, SAGE, JSTOR, Science Direct etc. were researched to filter the top 16 variables of human factors. This was then used in the questionnaire. Furthermore, Ministry of Statistics was used to extract data on Megaprojects to arrive at the sample size.

3.11 Data analysis software

R programming on Windows 10 was used to analyze the dataset. Excel is also used to draw the pictures and calculate some analytical solutions. Vensim is used for the system dynamics model.

3.12 Pilot survey

The data collected in the pilot survey was analysed through R software and the descriptive statistics was derived.

In this questionnaire survey data is collected from 129 participants. The participants are chosen from project based companies. Majorly from energy and construction related projects which have large complex projects.

3.12.1 Measures

The dependent variable is Project strategy as a factor of project success, project goal, project plan and project direction. Independent Variables are the 16 mentioned above in 6 human factor clusters. The structures were studied for validity using Cronbach Alpha. Prior studies indicate that Cronbach Alpha (α=0.70) is adequate to test the construct. To do this we first check the validity

of the constructs using factor analysis with principal component analysis with promax rotation. The principal component analysis helps in reduction in number of variables to be studied. R programming is used to conduct the analysis. Based on the factors identified we formulate the hypothesis.

3.12.2 Data Analysis

Data is evaluated for correlation using corrplot in R. Eigen values of the covariance matix is calculated. The Kaiser-Meyer-Olkin (KMO) test is conducted to check sample adequacy. After the KMO Bartlett test is conducted to check the level of significance. After the test, a Scree plot is executed to see the number of factors. After this the factor analysis is done and finally a regression model to test the hypothesis.

After the correlation plot on 16 IV and 4 DV, we get low correlation in data.

A PCA analysis yields without the dependent variables. We thus see that 42%

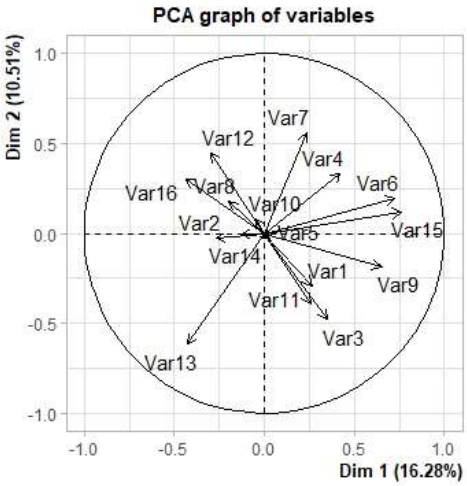


Figure 17: Principal Component Analysis Result

of the variation is only explained by the PC1 & PC2. If we go upto PC3, 52% and till PC7 80% of the variation is explained. In the figure we see, Var 15, Var 6, Var 4, Var 7 , Var 9, Var 11, Var 13, Var 3 and Var 16 as prominent.

From the KMO test we find that

Kaiser-Meyer-Olkin factor adequacy

```
Call: KMO(r = cor(X1))

Overall MSA =  0.49

MSA for each item =

Var1  Var2   Var3   Var4   Var5   Var6   Var7  Var8   Var9   Var10

Var11  Var12   Var13   0.41  0.49   0.36   0.45   0.26   0.67   0.45

0.39   0.75   0.46   0.47   0.32  0.41  Var14  Var15  Var16

0.42      0.67   0.63
```

We find that only Var 6 & Var 15 - Charisma of Project Manager & Reputation of Project Manager is near 0.7 i.e 0.67 (Average) Var 9- Trust between client and contractor is above 0.7 i.e 0.75 (Average) and Var 16 – Risk Personality is 0.63 i.e Mediocre.

Var 2, Var 4, Var 10 and Var 11 are just below acceptable & need further data for sufficiency. Others are below 0.5 and hence unacceptable. We therefore select these 4 variables belonging to cluster 2 and cluster 6 (refer fig on conceptual model). The results indicate that further data needs to be collected for structural equation modeling. The PCA shows that 7-11 variables impact the results.

Bartletts test for these 4 show the following :

```
$chisq [1] 42.27841  $p.value  [1] 1.620087e-07  $df [1] 6
```

Indicating significance as acceptable

Hypothesis

H1: Charisma of Project Manager has no influence on project strategy

H2: Reputation of Project Manager has no influence on project strategy

H3: Trust between client and contractor has no influence on project strategy

Results

A Scree plot shows the following, number of factors as 1.

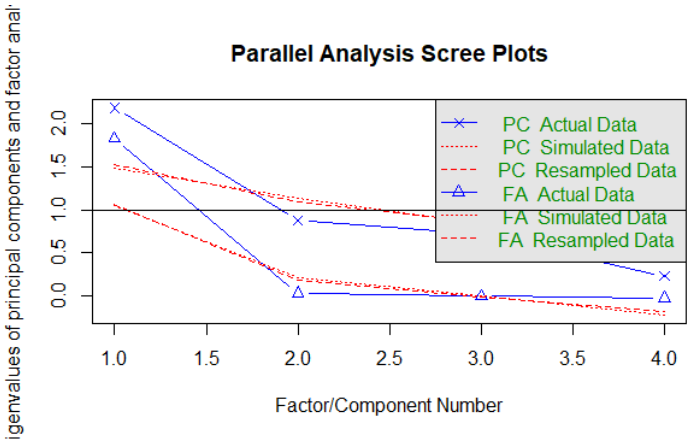


Figure 18: Scree plot

The number for factors for unreduced matrix shows 3 factors.

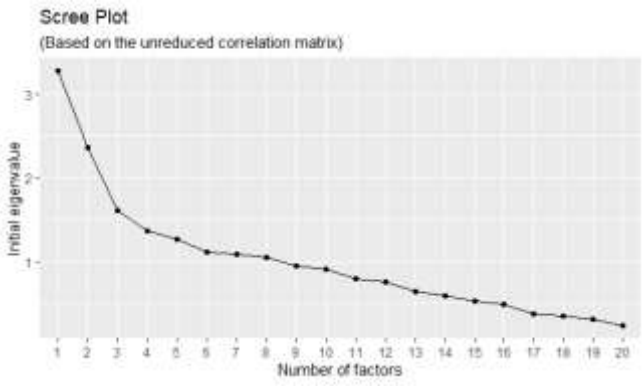


Figure 19: Scree Plot for unreduced matrix

With the reduced matrix from PCA we conduct factor analysis:

Call:

factanal(x = X, factors = Nfacs, rotation = "promax")

Uniquenesses:

Var6 Var9 Var15 Var16

0.26 0.37 0.07 0.70

Loadings:

[1] 0.86 0.80 0.97 -0.55

Factor1

SS loadings 2.60

Proportion Var 0.65

Test of the hypothesis that 1 factor is sufficient.

The chi square statistic is 1.57 on 2 degrees of freedom.

The p-value is 0.456

We get the factor loadings as:

Var1	Var2	Var9	Var15
0.3	-0.4	0.9	0.8

We check the Cronbach Alpha for the factor and find:

raw_alpha

0.8756496

This confirms reliability > 0.7.

We now use the pairs function to get a visualization as follows. We see there is a moderate correlation between (Var15) reputation of project manager and (Var6)charisma of project manager. (Var 9)- Trust between client and contractor also has a moderate correlation.

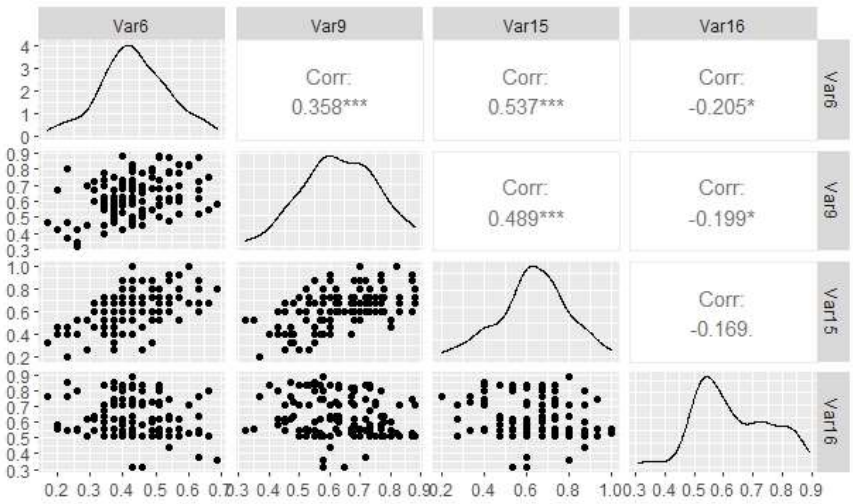


Figure 20: Pair Plot

We now conduct a multivariate regression with these 4 variables and the 4 DV:

Results for multiple regression

Table 5: Multiple Regression Results

Response Variable	Level of Significance	Coefficients
DV1- Goal	p-value: < 2.2e-16	Coefficients: Estimate Std. Error t value Pr(>|t|) (Intercept) -1.892e-15 1.997e-16 -9.473e+00 2.71e-16 *** pcdata$DV1 1.000e+00 2.330e-16 4.292e+15 < 2e-16 *** pcdata$DV2 -3.673e-16 2.635e-16 -1.394e+00 0.166 pcdata$DV3 2.725e-16 2.110e-16 1.291e+00 0.199 pcdata$DV4 -2.478e-16 2.397e-16 -1.034e+00 0.303
DV2- Ploy	p-value: < 2.2e-16	(Intercept) -4.135e-16 6.602e-17 -6.264e+00 5.86e-09 *** pcdata$DV1 -6.144e-16 7.705e-17 -7.975e+00 9.31e-13 *** pcdata$DV2 1.000e+00 8.715e-17 1.148e+16 < 2e-16 *** pcdata$DV3 -6.978e-17 6.977e-17 -1.000e+00 0.319 pcdata$DV4 9.563e-17 7.925e-17 1.207e+00 0.230
DV3- Plan	p-value: < 2.2e-16	(Intercept) 4.256e-16 8.605e-17 4.947e+00 2.44e-06 *** pcdata$DV1 1.561e-16 1.004e-16 1.555e+00 0.122551 pcdata$DV2 4.396e-16 1.136e-16 3.870e+00 0.000176 *** pcdata$DV3 1.000e+00 9.093e-17 1.100e+16 < 2e-16 ***

		pcdata$DV4 -6.524e-17 1.033e-16 -6.320e-01 0.528756
DV4-Direction	p-value: < 2.2e-16	(Intercept) 1.612e-16 5.792e-17 2.783e+00 0.006244 ** pcdata$DV1 1.602e-16 6.759e-17 2.370e+00 0.019361 * pcdata$DV2 1.579e-16 7.645e-17 2.065e+00 0.041034 * pcdata$DV3 2.197e-16 6.121e-17 3.589e+00 0.000479 *** pcdata$DV4 1.000e+00 6.952e-17 1.438e+16 < 2e-16 ***

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

3.13 Summary

This chapter presents the research methodology for our research. The broad framework as per the ancient thinkers and the modern method is proposed. The chapter lists out the research questions and moves through the 5 stages of research framework. The hypotheses to be tested are presented and then the method of sampling and data collection is elaborated. The chapter tries to establish how a relevant research foundation to generalize results has been put. To do this we have explained the technique for purposive sampling and precautions taken for generalization. We also illustrate the sampling population and justify our sample size and number of respondents chosen.

CHAPTER 4

DATA ANALYSIS AND INTERPRETATION

4 INTRODUCTION

In the previous chapter we discussed the methods of data collection. Our research has adopted a mixed research method. First we filter variables from literature survey. Then we have our first focus group interview with experts to choose the sorted variables. After sorting the variables we conduct a pilot survey. From the pilot survey we get certain insights which have been discussed in the last section. We then go for the main survey. After the main survey we analyze the data collected for Human v/s systems impact. Then we conduct an exploratory research with Principle Component Analysis. After finding the factors we go for a confirmatory test. After the factors are obtained, we test the hypothesis enumerated. Lastly, we develop the system dynamics models and validate the results.

In this section we shall analyse and interpret the data collected in the survey and model runs. applications including project risk management.

4.1 The Variable filters

We research the literature and conduct our first search on 8 databases viz:

1. Google scholar
2. ERIC
3. Proquest
4. JSTOR
5. Emerald Insights
6. PMI
7. Science direct
8. SAGE.

The data of the survey provided the following :

Table 6: Data from survey of databases

SL	VARIABLE NAME	TOTAL
1	Errors due to humans or Human Error	1482916
2	Effective Communication	253329
3	Stress	6463
4	Engagement of Project Manager	103467
5	Flexibility of Project Manager	113412
6	Decisive Client	236460
7	Trust Between Client and contractor	3122607
8	Experience of client	1282864
9	Support of senior management	60180
10	Contract Handling by Project Manager	2309514
11	Effective Feedback of project Team	263106
12	Anchor Bias	191377
13	Reputation of Project Manager	89302
14	Charisma of Project Manager	143447
15	Risk Personality	762333
16	Self Awareness	4226
17	Leadership of project manager	86924
18	Persuasiveness	25274
19	Organized Project Team	1262548
20	Technical Expertise Project manager	30826
21	Assertive Project manager	17187
22	Aggressiveness of Project manager	75883
23	Adaptability of Project Manager	33032

Refer Annexure for details of keywords used and search results.

After sorting them and finding the top 23 variables we conduct a expert interview round of 5 experts.

The experts have the following profile:

Table 7: Profile of experts

Sl No	Years of experience	Qualification	Experience	Discipline
1	44	B.E.	20 years in project management, 15 years in design and handled 40+ projects > Rs. 100 Crs.	Civil Engineering

2	50	M.E.	30 years experience in project management and 20 years in design engineering	Mechanical
3	30	BE, MBA	30 years in complex projects management	Mechanical
4	50	CA, MBA	50 years in project management, completed 3 megaprojects and 40+ projects >100 Crs.	Finance
5	41	BE, PhD	31 years in design and engineering and 10 years in project management. Completed 30+ projects of which 20 nos. > 100 Crs.	Electrical

The questionnaire is structured around … work which has been categorized as per the stakeholder view proposed by (K. Artto, 2008)

1. Innovative Leader
2. Obedient Servant
3. Strong Leader
4. Flexible Moderator

We also categorize into:

Team, Task, System, Leader, Human Factor , Transactional and Business

In line with ….

After the first focus group interview we eliminate 7 variables i.e. Stress, Aggressiveness, Assertiveness, Self awareness, Adaptability, Persuasiveness, Technical Expertise. This were majorly project manager qualities. Another

variable which was not found much in literature was empathy. Experts were questioned on this, which they related with leadership.

4.2 The Questionnaire

The questionnaire was designed online on limesurvey and can be accessed at https://www.limesurvey.org/

This was categorized in two sections :

Respondents and Questions.

Once the respondent has filled his details in first section is he allowed to go to the questionnaire section.

In this section the respondent had to fill Name, Age, Gender, Qualification, Designation, Email ID, Organization name (this was optional and data is sensitive so has not been reproduced in the results, keeping data privacy), Location, Type of organization, Control of projects, Number of stakeholders (these two questions help us categorize the respondents into the 4 categories of Innovative Leader, Obedient Servant, Strong leader and Flexible moderator), Sector in which the company operates.

The next section is Questionnaire with 29 questions, of which 4 are for the dependent variable and 25 are for the 16 independent variables. We will analyse each of these questions now. However, before that We shall have observe the data from the Lime survey.

4.3 Data from Questionnaire

A total number of 615 participants participated in the survey

Figure 21: Results from survey

Figure 22: Survey Response

Full responses were 242 and later another 6 responded i.e a total of 248. Of the incomplete 373, 21 more could be extracted so a total of 263 responses could be analyzed.

With a variable count of 15, we can say that 15 multiple suffices this sample size. Again of these 15 variables, 2 variables of bias and risk personality are actually moderating variables and hence we can say we have a count of 13 variable. So the 20x rule suffices.

Figure 23: Respondent details-1

Figure 24: Respondent details-2

Figure 25: Respondent details-3

Figure 26: Respondent details 6

*In the sector we operate, it was found that those organizations which operated in multiple sectors or energy like Nuclear which was not listed out participants chose others. Hence, this categorization was ignored in our interpretations.

The next section had results from the questions for the variables which we shall analyze one by one:

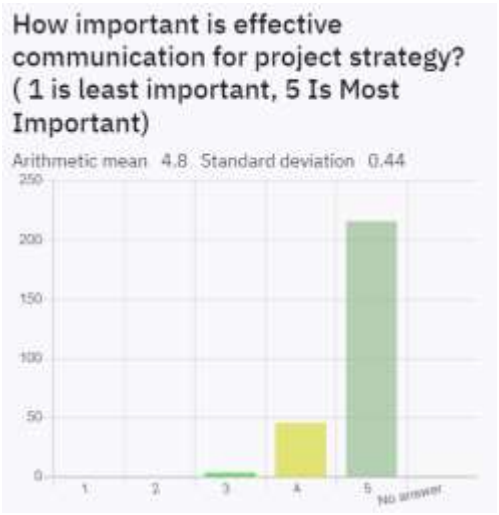


Figure 27: Question 1

This was unanimously seen as a very important factor. Communication is a human factor and hence we keep it as a separate cluster. However, communication is also system based. And this is something we will discuss in our results and taken up in our expert panel focus interview 2nd round.

Figure 28: Question 2

Observations: No R&D based company is risk averse. However, most risk averse answers came from project based companies.

Highest flexible managers or risk taker category is in project based companies.

Surprisingly, no strong leader responses !

Highest Risk neutral people in project based organizations.

Innovative leader indicators is insignificant

Results are highly skewed to Flexible moderators

From the Section 1 data of Number of stakeholders and control on projects we get the following data:

Let us now see the results from type of organization

44	13	185	12
Flexible Moderator (FM)	Innovative Leader (IL)	Obedient Servant (OS)	Strong Leader (SL)

Most participants indicated they are in an obedient servant (OS) environment

Next was flexible moderator (FM)

It is interesting to note that though obedient servant (OS) environments are **risk neutral**, most participants have exhibited flexible moderator (FM) attitude i.e **risk taking attitude**

We will analyze this in question no 6.

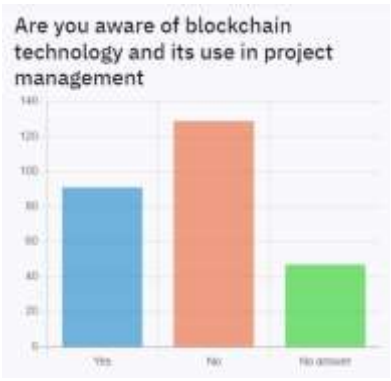
 **Figure 29: Question 3**	Most respondents are not aware of blockchain, for those who are aware we will assess their behavior separately.

 **Figure 30: Question 4**	This is a question on bias, 86% of the respondents believe that planners estimates impact the decision and hence evidence of anchor bias is prominent. We will observe this feature again when we go by distribution of human factors and system based questions.

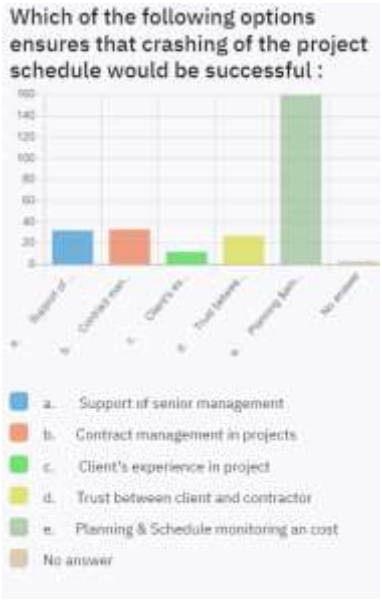


Figure 31: Question 5

HF/OS	Support of senior management
Trans	Contract management in projects
HF/OS	Client's experience in project
HF	Trust between client & contractor
Task	Planning & Schedule monitoring

HF: Human Factor |Trans: Transactional |OS: Obedient Servant. The above is the categorization in the questionnaire design.

The results show that compared to the Transactional , HF are given less weightage. Task is given clear highest weightage for successful projects. Option 1 and 3 are obedient servant questions, however, they have been rated low. Though most respondents are from OS environments. However, giving a task more weightage. is indicative of this environment to be task driven than people driven. It is interesting to note that in absence of the last option, OS nature is 2nd highest and very close to transactional aspect.

 # $H_0$2: While crashing the project schedule human factor risk has no significant impact

This may be said that the null hypothesis is proven true in this aspect.

Figure 32: Question 6

OS	Your project finance controller is centralized for all projects in company
IL	Each project has different finance control
FM	If project is cash crunched support from central finance is available
SL	It's a strategic business unit structure for projects
IL	Projects are very different and R&D based

This question is a reinforcement of the fact that most companies are OS type. The earlier data showed only 13 organizations as IL , we can find a similar number in the R&D based category aligned with the earlier result. We had found that as per the section 1 results, 185 were OS, but this data has only about 90. Hence, A 50% SL and FM environment is found.

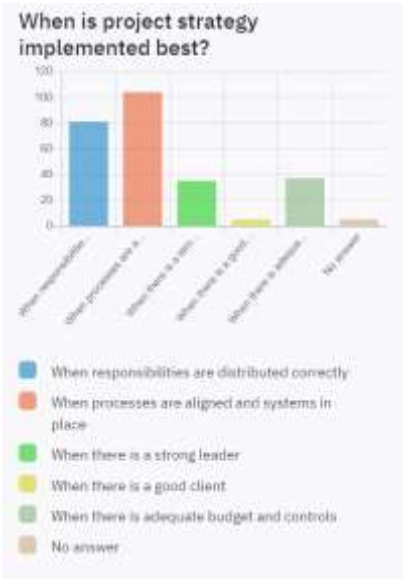


Figure 33: Question 7

Task	When responsibilities are distributed correctly
System	When processes are aligned and systems in place
SL/ Leader	When there is a strong leader
OS	When there is a good client
Trans	When there is adequate budget and controls

40% of the respondents gave systems the highest weightage when compared to HF. To see the impact of bias we see that in this question design, we have 3 system based questions and 2 HF based questions. Its balanced, but 30% of the responded gave Task as the 2nd highest factor after system.

Project Risks are managed well when there is strong ? (1: Means least, 5: Means Strongest)

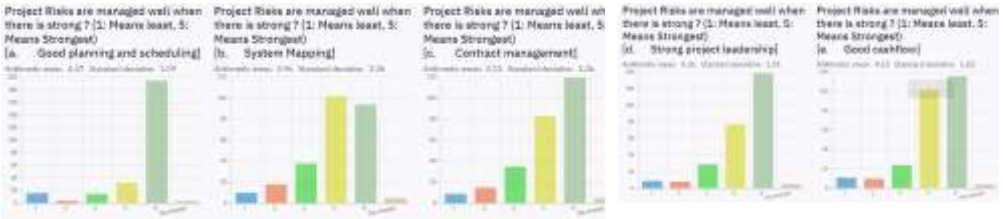


Figure 34: Question 8

Trans : Good planning and scheduling | System : System Mapping | Trans : Contract management | HF/Leader: Strong project leadership | Trans : Good cashflow

This question is populated towards the system factors. Here, the bias is towards transactional factors only 1 factor is human factor oriented. We see that Transactional factors are given more importance than system factors. However, despite this bias, Strong Leadership has been given the 2nd highest position.

While negotiating with suppliers which is important?

HF	[a.	Old relationship] |
HF	[b.	Charisma of project manager]
Trans	[c.	Size of supplier]
Trans	[d.	Type of competitors supplier has]
Trans	[e.	Time available for negotiation]

In this questioned we have a balance between HF and Transactional. HF question are relation based. Transactional factors are given more weightage in negotiations. This question was from the perspective of buyer.

Figure 35: Question 9

Suppliers offer trade credit based on

Figure 36: Question 10

Trans	Trust between supplier and purchaser
Trans	Price offered
Trans	Process of negotiation
Trans	Because competition is extending
HF	Charisma of project manager/ purchase manager

In case of trade credit, Transactional issues are given more importance. This question has 4 options on transactional category and these are given most importance when it came to trade credit. This was from perspective of Seller.

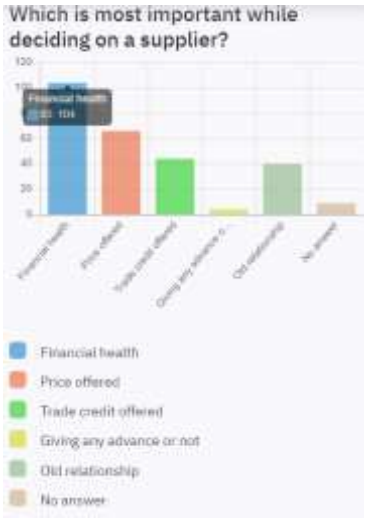


Figure 37: Question 11

Trans	a.	Financial health
Trans	b.	Price offered
Trans	c.	Trade credit offered
Trans	d.	Giving any advance or not
HF	e.	Old relationship

Transactional aspects are given more prominent positions when deciding a partner than HF, in this case relationship. This question was biased towards Transactional aspects.4 options were of transactional type. This is from perspective of Buyer.

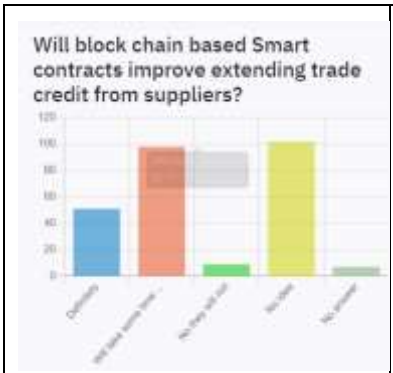


Figure 38: Question 12

Majority did not think technology can make a change. This may be due to lack of understanding of smart contracts technology as majority did not know about blockchain. Another indication is the importance of human factors.

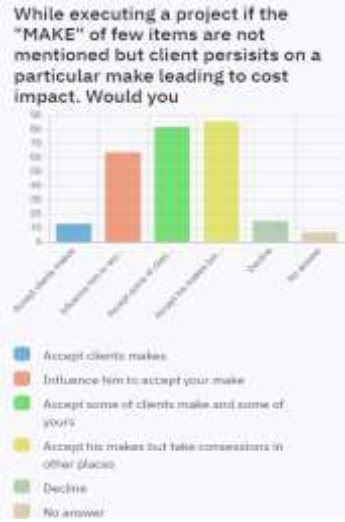
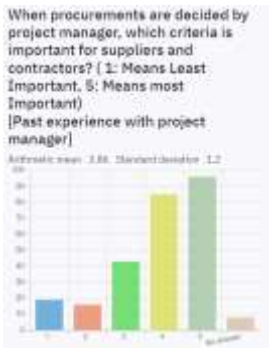


Figure 39: Question 13

Risk Averse	Accept clients makes
Risk Neutral	Accept his makes but take concessions in other places
Risk Neutral	Accept some of clients make and some of yours
Risk Taker	Decline
Risk Taker	Influence him to accept your make

This is a risk ability question. The maximum respondents 34% show a risk neutral profile. Minority are risk averse and 1/4th are risk takers. 1/4 have responded with a risk taker's attitude. The analysis has shown that most of environment are that of Flexible moderator, however since some have a Strong Leader environment



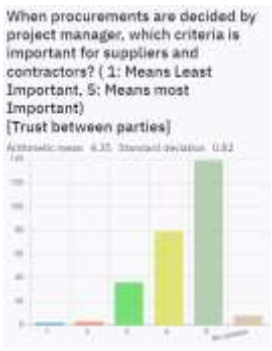


Figure 40: Question 14

HF	Past experience with project manager]
HF	Reputation of project manager
Trans	Rate at which order is finalized
Trans	Payment terms provided by project manager
HF	Trust between parties

Here the options are balanced between HF and transactional.

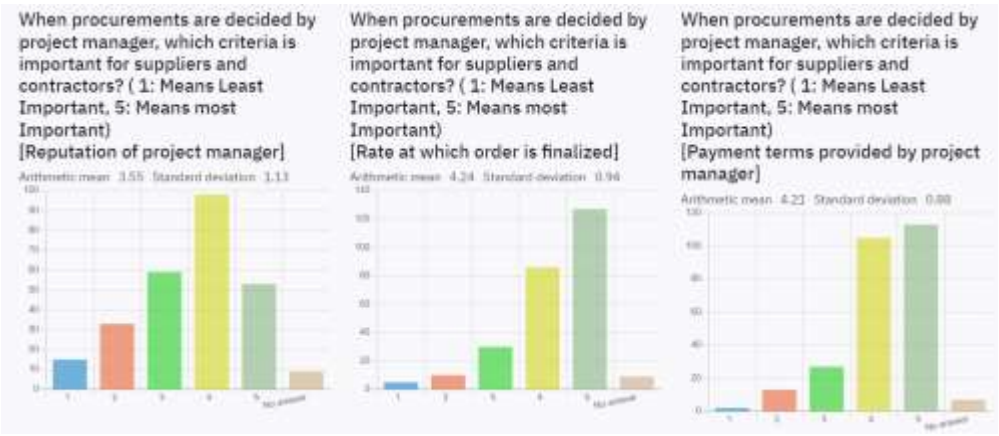


Figure 41: Question 15

The results shows that human factors are given more importance than transactional. However this is in contradiction to earlier questions. This is from the perspective of the Seller.This shows that when standing in suppliers shoes, the respondents gave more weightage to human factors. The earlier question from Seller's perspective was biased towards Transactional questions in the options. Hence, when asked on decision making, HF were given more weightage, but when it was a specific transactional question of trade credit, HF was weighed lower.

Figure 42: Question 16

Trans	[Payment terms provided]
HF	[Trust with project manager]
HF	[Reputation of project manager]
Trans	[Contractual terms in the order]
HF	[Charisma of project manager]

Here a balance of options of HF and trans are given.

Figure 43: Question 17

Transactional aspects are given more importance than HF wrt supplier project manager relationship. This is from a Seller's perspective again. Here, Contractual issues and payment terms are given more preference, showing that even with a charismatic project manager , reputation and charisma are not given importance.

How would you rank the following as risks which lead to project cost overrun ?

The question have 3 options on System based and 2 on human factor that too on a negative. It proves that bias of numbers is observable. It is observed that human factor variables have been given less importance(34%) than system variables in this response.

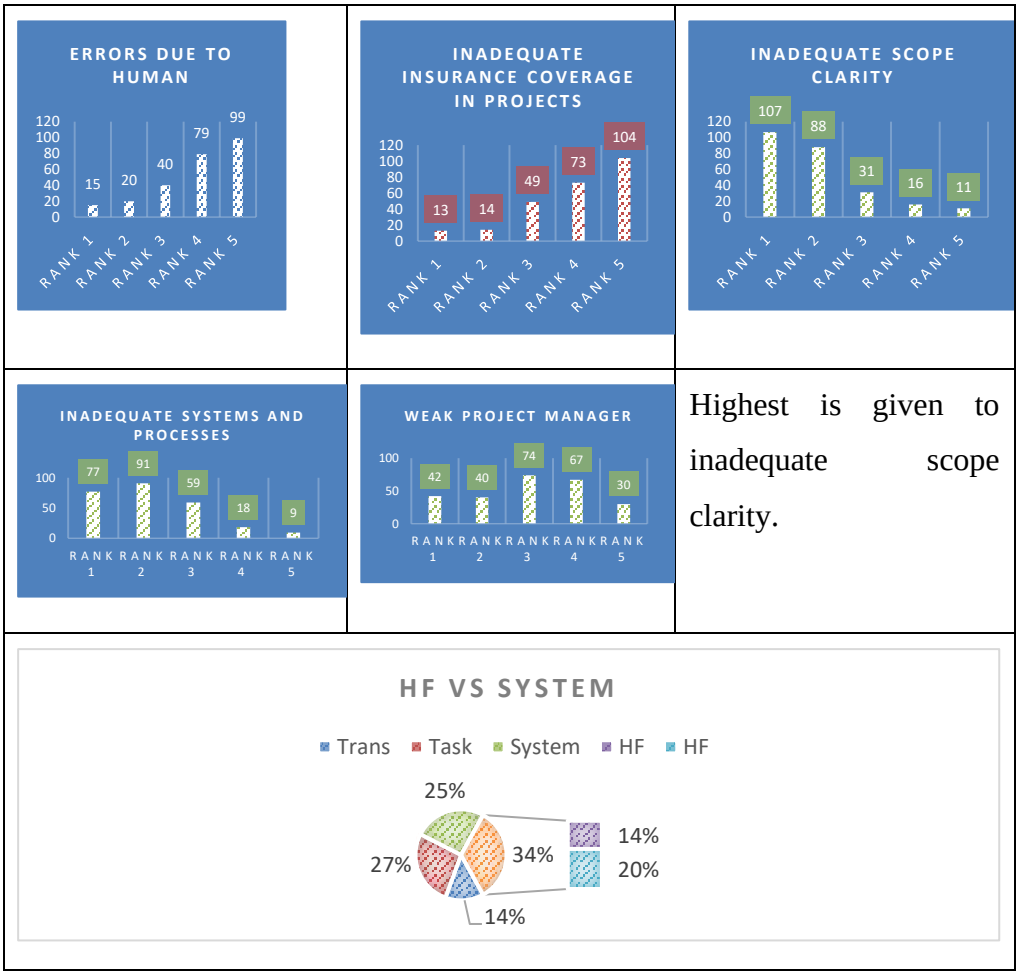


Figure 44: Question 18

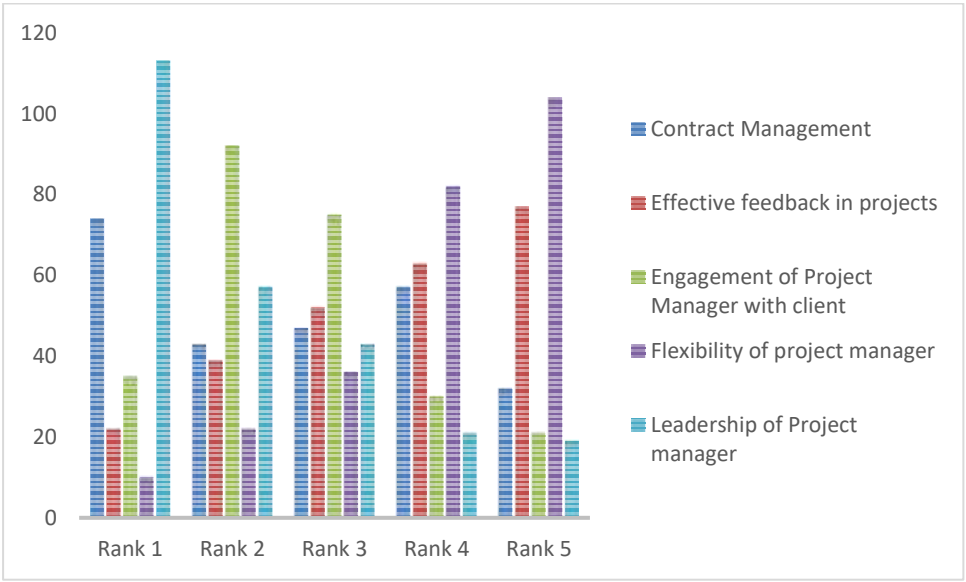


Figure 45: Question 19

Figure 46: Question 19

Project Success: The questions were from 2 clusters: Quality of Project Manager and Effective Communication . We can divide it also into Transactional V/s HF. Leadership was weighed much above this. Also though contract management is scored 3rd, effective feedback was the second highest rank from Rank 3 to 5 by most respondents, which shows it is a clear Rank 3.

Table 8: : Project Success Criteria

	Rank 1	Rank 2	Rank 3	Rank 4	Rank 5
Contract Management	74	43	47	57	32
Effective feedback in projects	22	39	52	63	77
Engagement of Project Manager with client	35	92	75	30	21
Flexibility of project manager	10	22	36	82	104
Leadership of Project manager	113	57	43	21	19

HF as the clear dominant factor.

Which one of the following options would you prefer as your project condition?

Table 9: Project condition criteria

		Rank 1	Rank 2	Rank 3	Rank 4	Rank 5
HF	a. Trust between client and contractor	4	16	50	60	123
System	b. Organized Project Team	29	46	71	67	40
Trans	c. Contract adherence by parties	68	29	34	51	71
HF	d. Charismatic Project Manager	101	80	39	24	10
Business	e. Good return on investment	52	82	59	51	9

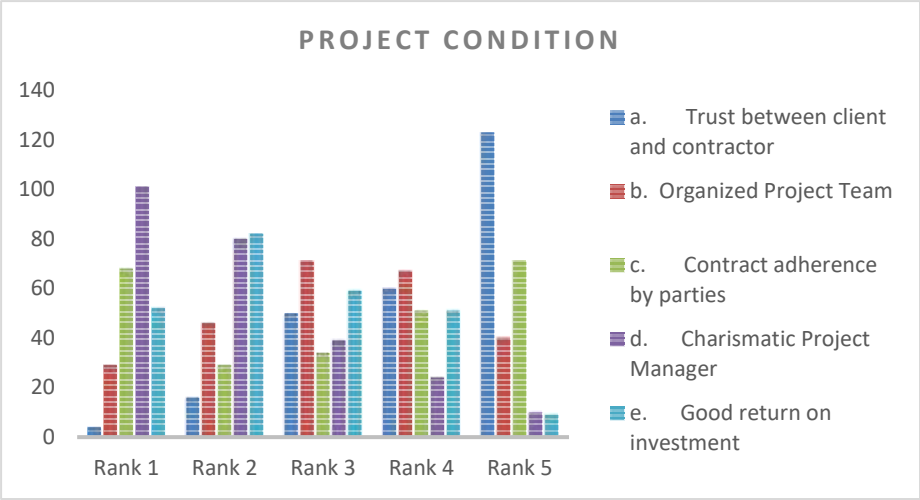


Figure 47: Question 20

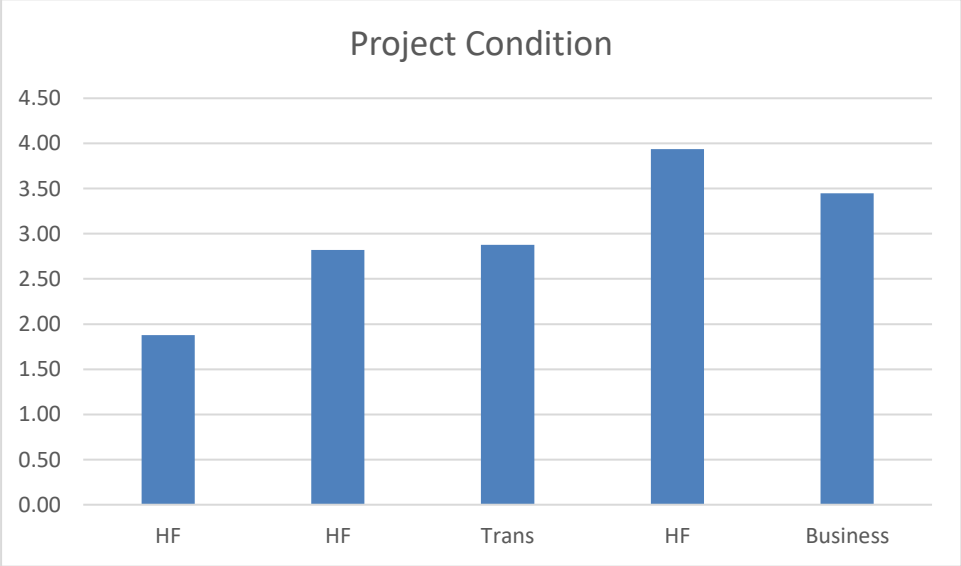


Figure 48: Question 20

In this question, Human factors and transactional factors were given, respondents felt, transactional conditions were slightly more important.

Business consideration was given rank 2 and even there with a thin margin to project manager quality.

How will you rank the following impacting Customer Satisfaction in Projects? This question was with human factors from Project manager quality, Project team and transnational or business considerations

Table 10: Customer satisfaction Criteria

		Rank 1	Rank 2	Rank 3	Rank 4	Rank 5
HF	a. Engagement of project manager with client	7	12	19	59	156
HF	b. Organized Project Team	67	73	53	41	19
HF/Trans/OS	c. Timely updates to client	66	47	62	65	13
Business	d. Scope Optimization	46	44	59	59	45
HF	e. Charismatic Project Manager	68	77	60	29	20

It shows that respondents has a close 1st rank, i.e Project manager quality, transactional and team traits were almost similar.

Figure 49: Question 21

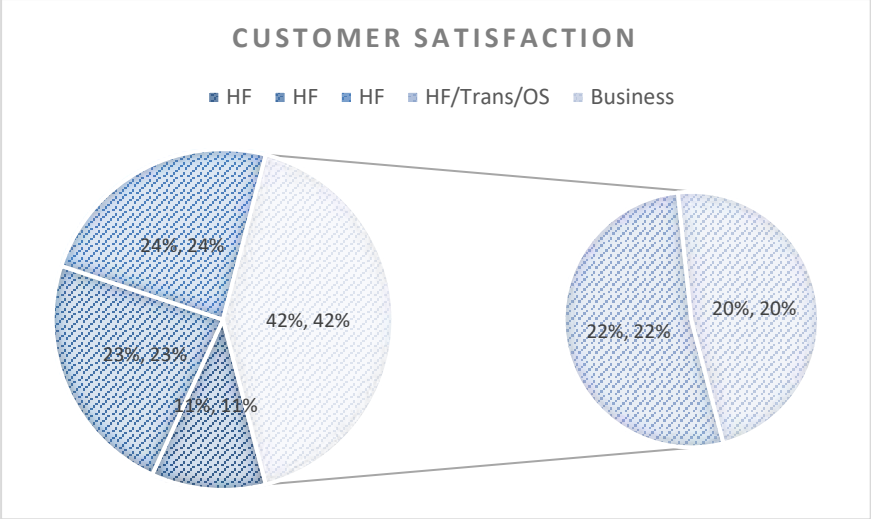


Figure 50: Customer satisfaction Criteria

It shows that respondents has a close 1st rank, i.e Project manager quality, transactional and team traits were almost similar. Rank 2 is a clear human factor and hence it shows they weighed it above transactional consideration.

Human factors are weighed 58% as majority against system /transactional factors.

For creating value in a project requires?

Table 11: Value Creation Criteria

System	a.	System design and alternative scenario planning
Trans	b.	Incentive planning
HF/team	c.	Teamwork
Business	d.	Return on investments
HF	e.	Charismatic Project Manager

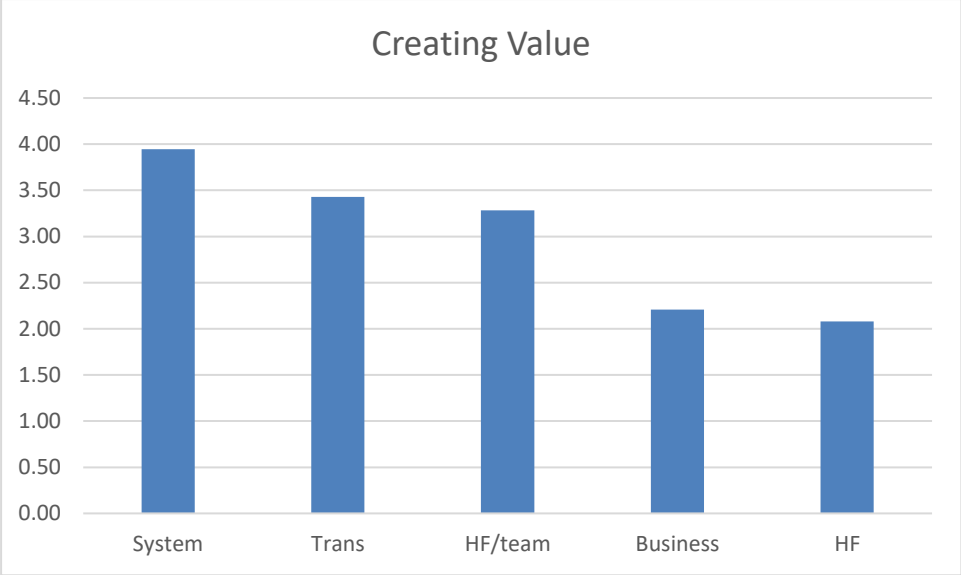


Figure 51: Question 22

Human factors were only 36% while system factors were given 74% when referred to value creation.

Project Strategy works well when there is?

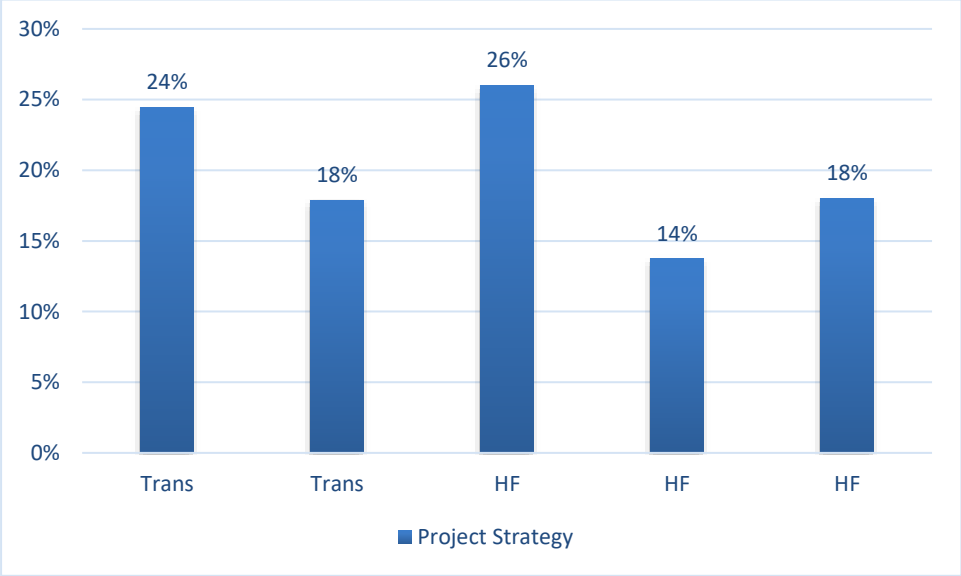


Figure 52: Project Strategy Criteria

Trans	Good margins
Trans	Good payment terms from client
HF	Reputation of Project Manager
HF	Strong contract management by Project Manager
HF	Trust between parties

For project strategy Human factors have been weighed more than transactional aspects. 58% accounted for human factors for success of project strategy.

When we run the results only for **SL environment** the results shift to Strong contract management from reputation of project manager.

Table 12: Project Strategy Criteria

	Rank1	Rank2	Rank3	Rank4	Rank5	
Good margins	1	2	1	2	6	2.17
Good payment terms from client	1	1	1	6	3	2.25
Reputation of Project Manager	2	1	5	3	3	3.17
Strong contract management by Project Manager	8	5	4	1		**6.17**
Trust between parties		3	1			1.25

Flexible Moderator (FM) shows the same trend.

But in Innovative Leader we find the same trend as Obedient Servant where reputation of PM scores higher.

Q. When there is a unresolved dispute with client would you ?

This question is a risk personality question.

Risk Averse	Agree to client's demands considering future projects
Risk Taker	Go for Arbitration
Risk Averse/ OS	Refer the issue to top management
Risk Neutral	Stop project works unless issue is resolved
Risk Averse	To keep relations accept clients demands

Table 13: Risk Profile in dispute scenario

	Rank1	Rank2	Rank3	Rank4	Rank5	Score
Agree to client's demands considering future projects	30	68	71	67	17	3.09
Go for Arbitration	24	53	39	30	107	2.43
Refer the issue to top management	183	36	22	9	3	**4.51**
Stop project works unless issue is resolved	8	63	44	79	59	2.52
To keep relations accept clients demands	9	34	77	68	66	2.42

Most respondents showed risk neutral to averse attitude when disputes with clients are concerned. Furthermore, the an obedient servant in line with earlier analysis as this gets the highest score. However, we should note that the respondents had indicated Strong leadership for successful projects in the earlier

question for risk personality and that was in reference to a situation in benefit of client. This indicates that client's influence as a major stakeholder changes this decision. This is evident from the 2nd highest score of agreeing to client.

If we change the environment to Flexible moderator, or Strong leader we do not see a change in risk attitude.

Q. Consider a situation where the past experience of the sub-contractor has been good with a project manager when the project manager's company was in good financial health. Now there is a project where the financials are stressed . Will the supplier agree to work ?

Trns/ Risk Taker	Late payments
HF/ Risk Taker	Trust the project manager to get his payment done
Trns/ Risk Averse	Will not work.
Trns/ Risk taker	With extended trade credit terms
HF/ Risk taker	With extra risks in the contract

The question is from the Seller's perspective. 3 options are transactional and two are human factor based. Further this is a risk personality question.

Table 14: Risk Profile during dispute

	Rank1	Rank2	Rank3	Rank4	Rank5	
Late payments	12	38	88	95	19	2.70
Trust the project manager to get his payment done	102	57	45	35	14	3.77
Will not work.	14	2	9	32	195	1.43
With extended trade credit terms	81	104	44	17	6	**3.91**
With extra risks in the contract	44	51	66	73	18	3.09

The respondents become risk takers in distress situation based on past experience. The risk taker quality is biased in this question. And all exhibit risk taking attitude. But they give more importance to transactional method rather than human factor relation based. Human factors are 46% while transaction risk taking factors are 54%. Important to note that the 2nd highest rank is to a HF relation based risk taking factor.

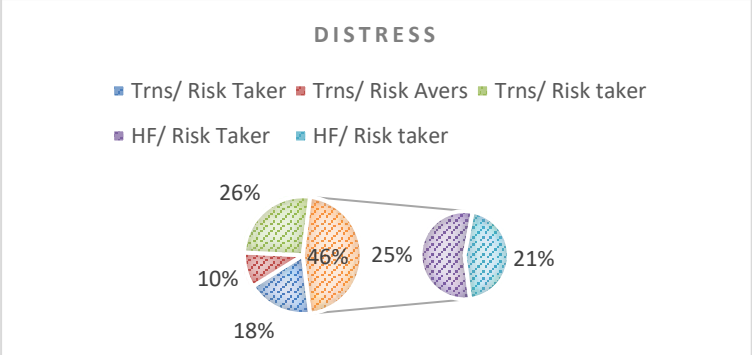


Figure 53: Distress situation

If we take only the Flexible Moderator(FM) environment, this changes to Human Factor. Which means the environment has a change in risk personality.

	Rank1	Rank2	Rank3	Rank4	Rank5	
Late payments	3	9	10	19	3	2.77
Trust the project manager to get his payment done	15	9	11	6	3	**3.61**
Will not work.	4	20	1	6	33	3.36
With extended trade credit terms	15		7	1	1	2.25
With extra risks in the contract	7	6	15	12	4	3.00

Figure 54: Ditress situation

Q. Consider a situation where the past experience of the sub-contractor has been good with a project manager when the project manager's company was in good financial health. Now there is a project where the financials are stressed . Will the supplier agree to work if the **project manager has high reputation**?

The same question but now with a qualifying the quality of PM. With this qualification, the Human factors are again prominent.

	Rank1	Rank2	Rank3	Rank4	Rank5	
a. With extended trade credit terms	81	94	48	19	11	3.83
b. Late payments	6	48	84	100	15	2.71
e. Will not work.	12	5	11	26	199	1.43
d. With extra risks in the contract	42	53	68	72	18	3.10
c. Trust the project manager to get his payment done	113	53	42	36	10	**3.88**

Figure 55: Distress situation

However, Instead of transactional, the rank has chaged to HF based method.

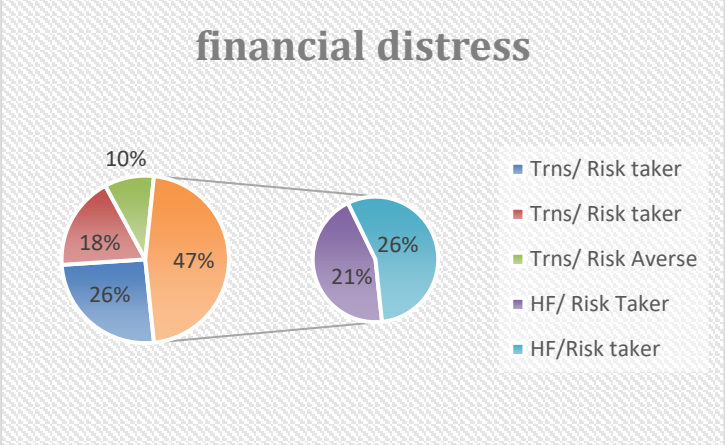


Figure 56: Financial Distress

We now observe how this varies with environment type:

A> Flexible Moderator:

Table 15: Distress Situation - Flexible Moderator

	Rank1	Rank2	Rank3	Rank4	Rank5	
a. With extended trade credit terms	13	17	9	2	3	3.80
b. Late payments	1	7	16	20		2.80
c. Trust the project manager to get his payment done	17	9	11	5	2	3.80
d. With extra risks in the contract	10	10	8	13	3	**4.00**
e. Will not work.	3	1		4	36	1.43

We observe that risk type has here that this has shifted to the earlier result when PM quality was not mentioned.

B> Innovative leader

Table 16:Distress Situation- Innovative Leader

	Rank1	Rank2	Rank3	Rank4	Rank5	
a. With extended trade credit terms	7	3	1	2		**4.15**
b. Late payments		2	5	4	2	2.54
c. Trust the project manager to get his payment done	6	4		2	1	**3.92**
d. With extra risks in the contract		3	5	4	1	2.77
e. Will not work.		1	2	1	9	1.62

In the Innovative Leader (IL) category we see a similar trend as the FM category.

C> Strong Leader

Table 17: Distress Situation- Strong leader

	Rank1	Rank2	Rank3	Rank4	Rank5	
a. With extended trade credit terms	2	5	3	2		**3.58**
b. Late payments		2	6	2	2	2.67
c. Trust the project manager to get his payment done	3	2	3	2	2	3.17
d. With extra risks in the contract	4	3		4	1	**3.42**
e. Will not work.	3			2	7	2.17

We now dissect the data as per the following categories mentioned by ():

Team, Task, System, Leader, Human Factor, Transactional & Business. Of these we keep Under Human Factors, Team and Leader whereas Under System we are keeping Task, Transactional and Business.

We get the following scoring from the data:

Table 18: Scoring of System and Human Factors

Team	Task	System	Leader	HF	Trans	Business
9.59	13.11	13.67	18.46	79.72	67.94	12.25

When we categorize into Human Factors and System Factors we get the following scoring:

Table 19: Human Factor vs System Factor

HF	**System**	
110.23	106.97	Scoring
43	43	No. of items
51%	49%	% scoring

We thus find that Human factors are slightly weighed above the System factors or we may say as much as the system factors when considering project strategy.

H01: Human Factors have no significant impact on project strategy

The first null hypothesis cannot be concluded from this but we may say it is significant.

The Questionnaire tool is used as a multidimensional prism in our research. It has been categorized into :

1. Human Factors V/s System Factors,
2. Project Strategy from the stakeholder point of view of project autonomy into
3. Risk Attitude

Of the Human factors 6 clusters viz. Errors due to Humans, Effective communication, Project manager quality, Project Team, Client and Trust is made. Of System Factors 4 clusters viz. Task, System, Transactional and Business clusters are made.The question, total 29 nos. are divided into the following categories and the data shows their inclination to which factor:

Table 20: Human Factor V/s System Category wise

	Human Factors	**System Factor**
Project Strategy	**14.08**	10.53
Project Success	**11.69**	5.72
Risk	13.5	**22.3**
Value	5.36	**9.58**
Project Crashing	1.3	**3.7**
Procurement	27.25	**31.6**
Project Condition	8.64	**9.15**
Customer	**12.18**	6.27
Situational / Project		
Distress	**7.3**	2.86
Dispute	**9.28**	5.17

System Factors considered were majorly processes, inputs and outputs of a project viz: Systems and Processes, Insurance, Scope Clarity, Contracts, Feedback, margins, ROI, Planning and scheduling, Resources, Organized team, Responsibility distribution, Alignment, Budgets and controls, System mapping, Cashflow, System design, Scenario planning, Payment terms, Size of supplier, competition, time for negotiations, Commercials, process of negotiation. Price.

From the above we observe that System factors were given more importance for Risk, Value, Schedule crashing, Procurement and Project Condition, i.e. for task oriented, commercial or conditions, the human factors were perceived less important.

When considering Strategy, Customer Satisfaction, and situational questions of distress and dispute, human factors were given more importance.

Hence, we may say that on a tactical level for subjective areas like Project strategy as a whole, customer satisfaction and relation based situations, human factors were given more importance. While for monetary, commercial and procurement issues, system factors were given more importance.

4.4 Exploratory data analysis:

Once we have completed the data analysis of the received data and derived a sense of the respondent's views from the obtained data we move to conduct our EFA in R.

The data collected in the main survey was analysed through R software and the descriptive statistics was derived.

In this main survey data is collected from 263 participants. The participants are chosen from companies involved in Mega projects or Complex projects.

4.4.1 Measures

The dependent variable is Project strategy as a factor of project goal, project ploy, project plan and project direction. Independent Variables are the 16 mentioned above in 6 human factor clusters. The structures were studied for

validity using Cronbach Alpha. Prior studies indicate that Cronbach Alpha (α=0.70) is adequate to test the construct. To do this we first check the validity of the constructs using factor analysis with principal component analysis with promax rotation. The principal component analysis helps in reduction in number of variables to be studied. R programming is used to conduct the analysis. Based on the factors identified we formulate the hypothesis.

4.4.2 Data Analysis

The detailed code for R programming is given in Appendix 2. We give a summary of the data results and their analysis here.

Following is the Summary of data obtained from the survey and then normalized:

	vars	n	mean	sd	median	trimmed	mad	min	max	range	skew	kurtosis	se
Var1	1	263	0.42	0.24	0.40	0.38	0.30	0.00	1.00	1.00	0.94	0.05	0.01
Var2	2	263	0.96	0.09	1.00	0.98	0.00	0.60	1.00	0.40	-1.97	3.06	0.01
Var3	3	263	0.68	0.19	0.70	0.70	0.15	0.00	1.00	1.00	-0.54	0.28	0.01
Var4	4	263	0.40	0.22	0.40	0.37	0.30	0.00	1.00	1.00	0.98	0.19	0.01
Var5	5	263	0.60	0.24	0.60	0.60	0.30	0.00	1.00	1.00	-0.01	-1.28	0.02
Var6	6	263	0.42	0.11	0.40	0.42	0.10	0.10	0.77	0.67	0.18	0.30	0.01
Var7	7	263	0.72	0.19	0.70	0.73	0.15	0.00	1.00	1.00	-0.43	-0.09	0.01
Var8	8	263	0.61	0.25	0.60	0.61	0.30	0.00	1.00	1.00	-0.09	-0.96	0.02
Var9	9	263	0.41	0.11	0.40	0.41	0.12	0.10	0.75	0.65	0.44	0.01	0.01
Var10	10	263	0.05	0.21	0.00	0.00	0.00	0.00	1.00	1.00	4.33	16.81	0.01
Var11	11	263	0.11	0.32	0.00	0.02	0.00	0.00	1.00	1.00	2.41	3.84	0.02
Var12	12	263	0.59	0.16	0.60	0.59	0.15	0.20	1.00	0.80	0.26	0.10	0.01
Var13	13	263	0.61	0.19	0.60	0.61	0.15	0.00	1.00	1.00	0.01	-0.47	0.01
Var14	14	263	0.86	0.35	1.00	0.94	0.00	0.00	1.00	1.00	-2.01	2.05	0.02
Var15	15	263	0.62	0.16	0.67	0.63	0.10	0.00	1.00	1.00	-0.47	0.38	0.01
Var16	16	263	0.57	0.11	0.56	0.57	0.10	0.19	0.83	0.64	-0.08	-0.22	0.01
DV1	17	263	0.85	0.17	0.80	0.88	0.30	0.00	1.00	1.00	-1.84	5.85	0.01
DV2	18	263	0.87	0.15	0.80	0.89	0.30	0.40	1.00	0.60	-0.86	0.01	0.01
DV3	19	263	0.87	0.16	1.00	0.89	0.00	0.00	1.00	1.00	-1.37	3.02	0.01
DV4	20	263	0.87	0.15	1.00	0.89	0.00	0.40	1.00	0.60	-0.79	-0.45	0.01

Figure 57: Results of summary of dataframe

The structure of the dataframe is as follows:

Figure 58: Structure of dataframe

The correlation for the independent variables is as follows:

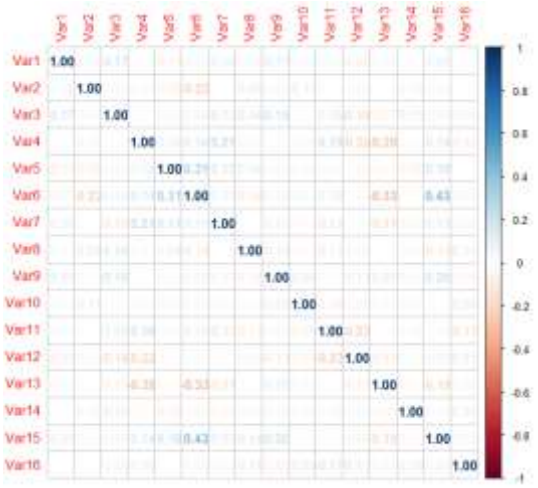


Figure 59: Correlation Matrix

The correlation plot for the dependent variables is as follows:

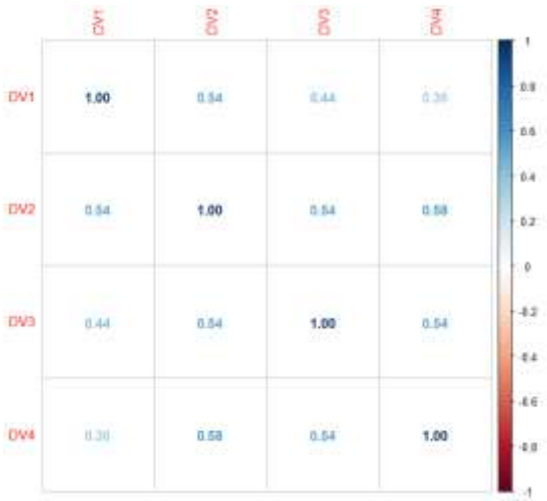


Figure 60: Correlation matrix dependent variables

We find that there is a strong correlation amongst the dependent variables i.e goal, ploy, plot and direction which constitute project strategy and slight correlation in the dependent variables. Therefore there is a possibility of underlying factors.

We do a Cronbach alpha test of the dataset which yields:

```
Reliability analysis
Call: alpha(x = data_survey, check.keys = TRUE)

  raw_alpha std.alpha G6(smc) average_r S/N   ase mean    sd median_r
      0.43      0.53    0.62     0.053 1.1 0.051  0.6 0.059    0.039
```

Figure 61: Reliability analysis

```
> alpha_result <- alpha(data_survey)
Number of categories should be increased  in order to count frequencies.
Some items ( var3 var8 var10 var13 var16 ) were negatively correlated with the first principal component and
probably should be reversed.
To do this, run the function again with the 'check.keys=TRUE' optionwarning message:
In alpha(data_survey) :
  Some items were negatively correlated with the first principal component and probably
should be reversed.
To do this, run the function again with the 'check.keys=TRUE' option
```

The above message indicates non-unidirectionality.

Raw_alpha of 0.7-0.8 is good reliability. It is used to test internal consistency i.e all items measure the same construct. This may be a bit difficult in our questionnaire designed. However, this is based on the assumption of unidirectionality, which is of question here.

Hence we use another test of reliability Omega.

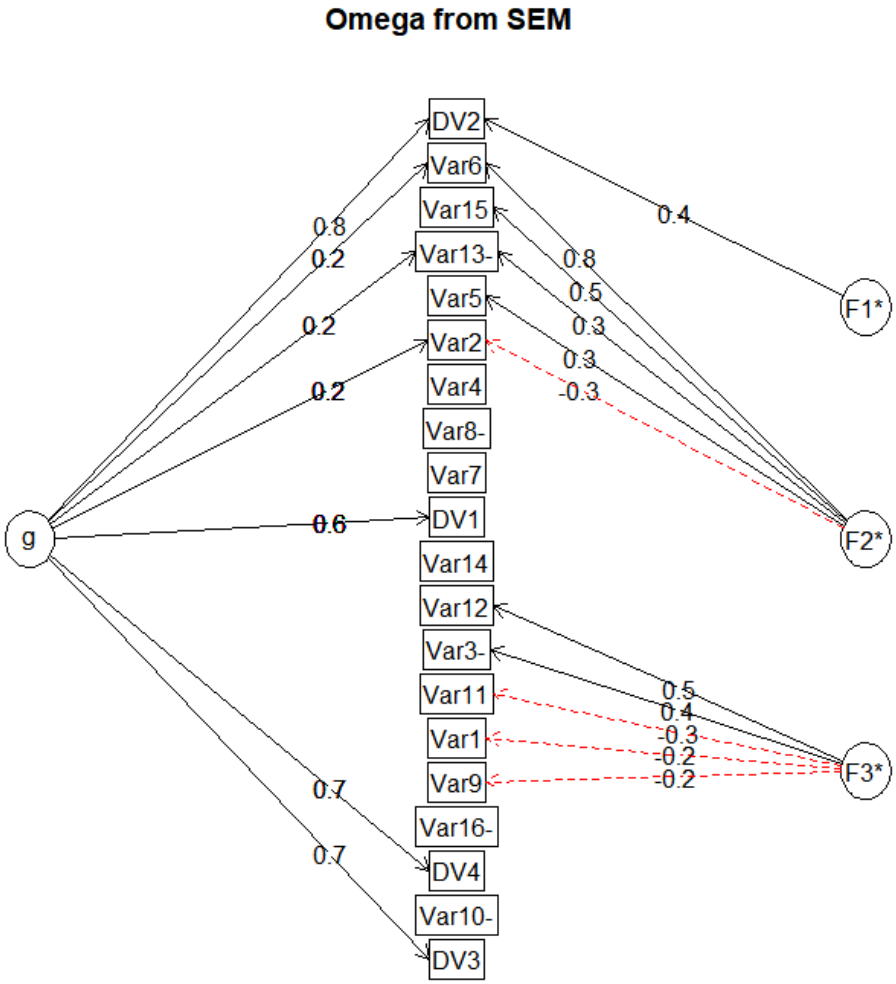


Figure 62: Omega results

The results are :

```
Call: omegasem(m = data_survey)
Omega
Call: omegah(m = m, nfactors = nfactors, fm = fm, key = key, flip = flip,
    digits = digits, title = title, sl = sl, labels = labels,
    plot = plot, n.obs = n.obs, rotate = rotate, Phi = Phi, option = option,
    covar = covar)
Alpha:                 0.51
G.6:                   0.61
Omega Hierarchical:    0.47
Omega H asymptotic:    0.78
Omega Total            0.6
```

Figure 63: OmegaSem results

A value of 0.65 of Omega and 0.7 or Alpha is considered reliable. Hence we have to reduce some variables and test again. The Omega H asymptotic is 0.78 which indicates this possibility. After testing for F1* and F2* we find the

following take Var 13,Var 5, Var 6 and Var 15:

```
Omega
Call: omegah(m = m, nfactors = nfactors, fm = fm, key = key, flip = flip,
    digits = digits, title = title, sl = sl, labels = labels,
    plot = plot, n.obs = n.obs, rotate = rotate, Phi = Phi, option = option,
    covar = covar)
Alpha:                 0.69
G.6:                   0.73
Omega Hierarchical:    0.58
Omega H asymptotic:    0.75
Omega Total            0.78

Schmid Leiman Factor loadings greater than  0.2
                        g   F1*   F2*   F3*   h2   h2   u2   p2  com
data_survey.Var13-                0.36  0.34 0.28 0.28 0.72 0.13 2.52
data_survey.Var5                  0.33 -0.30 0.22 0.22 0.78 0.06 2.25
data_survey.Var6     0.21         0.83       0.74 0.74 0.26 0.06 1.13
data_survey.Var15                 0.50       0.26 0.26 0.74 0.03 1.07
data_survey.DV1      0.61                    0.41 0.41 0.59 0.91 1.20
data_survey.DV2      0.82                    0.68 0.68 0.32 0.99 1.02
data_survey.DV3      0.71                    0.51 0.51 0.49 0.99 1.03
data_survey.DV4      0.70                    0.49 0.49 0.51 0.99 1.03
```

Figure 64: Omegah results

This is moderate to high range for Alpha and high for Omega.

If we remove Var13, we get a higher Omega and Alpha.

```
Omega
Call: omegah(m = m, nfactors = nfactors, fm = fm, key = key, flip = flip,
    digits = digits, title = title, sl = sl, labels = labels,
    plot = plot, n.obs = n.obs, rotate = rotate, Phi = Phi, option = option,
    covar = covar)
Alpha:                 0.69
G.6:                   0.72
Omega Hierarchical:    0.6
Omega H asymptotic:    0.73
Omega Total            0.81

Schmid Leiman Factor loadings greater than  0.2
                        g   F1*   F2*   F3*   h2   h2   u2   p2  com
data_survey.Var5                  0.33            0.13 0.87 0.12 1.37
data_survey.Var6     0.20         0.85       0.75 0.75 0.25 0.05 1.11
data_survey.Var15                 0.49       0.25 0.25 0.75 0.03 1.07
data_survey.DV1      0.53                0.84 0.99 0.99 0.01 0.29 1.69
data_survey.DV2      0.76                     0.60 0.60 0.40 0.96 1.08
data_survey.DV3      0.70                     0.49 0.49 0.51 0.99 1.03
data_survey.DV4      0.79                     0.62 0.62 0.38 1.00 1.02
```

Figure 65: Omegah reduced matrix 1

Further reduction of Var 5 gets a high Omega and High Alpha:

```
Omega
Call: omegah(m = m, nfactors = nfactors, fm = fm, key = key, flip = flip,
    digits = digits, title = title, sl = sl, labels = labels,
    plot = plot, n.obs = n.obs, rotate = rotate, Phi = Phi, option = option,
    covar = covar)
Alpha:                 0.71
G.6:                   0.73
Omega Hierarchical:    0.6
Omega H asymptotic:    0.72
Omega Total            0.84
```

Figure 66: Omegah reduced matrix 2

All other combinations result in Alpha between 0.5- 0.7 and Omega 0.6-0.84.

Though the alpha values are acceptable and not ideal, as there is

multidimensional scale, we see Omega as a better measure. We now proceed for factor analysis.

Eigen values of the covariance matix is calculated. The Kaiser-Meyer-Olkin (KMO) test is conducted to check sample adequacy and whether factor analysis can be done:

```
Kaiser-Meyer-Olkin factor adequacy
Call: KMO(r = cor(data_survey))
Overall MSA =  0.62
MSA for each item =
 Var1  Var2  Var3  Var4  Var5  Var6  Var7  Var8  Var9 Var10 Var11 Var12 Var13 Var14 Var15 Var16   DV1   DV2   DV3   DV4
 0.44  0.61  0.46  0.54  0.53  0.61  0.52  0.48  0.49  0.39  0.49  0.50  0.57  0.43  0.65  0.47  0.71  0.71  0.76  0.74
```

Figure 67: KMO factor adequacy

The mean MSA= 0.62

(Napitupulu, 2017) conducts a test with 215 samples of measurement results and the amount of data to be processed and analysed by factor analysis approach. (JP, 1954) recommended 200 as a minimum number of samples required to perform factor analysis. (Cattell, 1978)also suggested the good and acceptable as a minimal 200. (Comrey A, 1992) mentions the number or size of the sample 200 as acceptable. (Napitupulu, 2017) mentions testing the feasibility of the variables used by the value of KMO (Kaiser-Meyer-Olkin) as follows:

1. KMO value ranges from 0 to 1 and if the value is equal to or greater than 0.5 and with significant values (sig) or probability (p) is less than 0.05 then it means the data already eligible for further analysis in the factor analysis.

After the KMO Bartlett test is conducted to check the level of significance.

```
$chisq
[1] 817.8545

$p.value
[1] 9.473956e-79

$df
[1] 190
```

Figure 68: Chi Square Value

We thus see that data is fit for factor analysis.

After the test, a Scree plot is executed to see the number of factors.

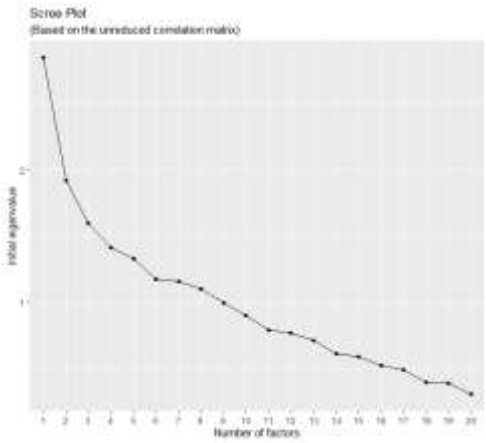


Figure 69: Scree Plot Main Survey

```
Parallel analysis suggests that the number of factors =  7  and the number of components =  6
```

It shows 7 factors and 6 components.

After this the factor analysis is done which gives the following result:

```
Factor Analysis using method =  pa
Call: fa(r = X, nfactors = 7, rotate = "varimax", max.iter = 100, fm = "pa")
Standardized loadings (pattern matrix) based upon correlation matrix
        PA1   PA3   PA6   PA4   PA2   PA5   PA7    h2    u2 com
Var1   0.02 -0.06  0.01  0.04  0.29  0.07  0.04 0.098 0.902 1.3
Var2  -0.16 -0.04 -0.05  0.00  0.08  0.08 -0.33 0.151 0.849 1.8
Var3   0.04  0.07  0.15 -0.05  0.37  0.62 -0.03 0.555 0.445 1.9
Var4   0.10  0.01  0.29  0.56  0.01  0.00  0.01 0.409 0.591 1.6
Var5   0.18  0.95  0.03  0.09 -0.12  0.02 -0.01 0.967 0.033 1.1
Var6   0.79  0.16  0.08  0.11  0.06  0.05  0.26 0.734 0.266 1.4
Var7   0.06  0.12 -0.15  0.45  0.01 -0.13 -0.03 0.265 0.735 1.6
Var8  -0.19  0.10 -0.14  0.11 -0.12  0.34 -0.08 0.215 0.785 3.0
Var9   0.05  0.00  0.02 -0.09  0.49 -0.04  0.00 0.255 0.745 1.1
Var10 -0.03 -0.03 -0.07 -0.03  0.10 -0.03  0.35 0.141 0.859 1.3
Var11  0.10 -0.01  0.67 -0.05 -0.06  0.01 -0.11 0.477 0.523 1.1
Var12  0.23 -0.08 -0.47 -0.17 -0.27 -0.02 -0.24 0.445 0.555 3.2
Var13 -0.41  0.10  0.01 -0.41  0.13 -0.16  0.11 0.402 0.598 2.8
Var14  0.06 -0.11  0.02 -0.08  0.01  0.20 -0.08 0.067 0.933 2.6
Var15  0.51  0.12 -0.06  0.15  0.34 -0.13 -0.06 0.443 0.557 2.3
Var16  0.01  0.01 -0.24 -0.10 -0.11  0.25  0.21 0.185 0.815 3.7
```

Figure 70: Factor Analysis

Variable 8,12,13,14,15,16 show high complexity and shall be noted when factors are analyzed.

```
                       PA1  PA3  PA6  PA4  PA2  PA5  PA7
SS loadings           1.23 1.02 0.90 0.80 0.74 0.68 0.44
Proportion Var        0.08 0.06 0.06 0.05 0.05 0.04 0.03
Cumulative Var        0.08 0.14 0.20 0.25 0.29 0.34 0.36
Proportion Explained  0.21 0.17 0.15 0.14 0.13 0.12 0.08
Cumulative Proportion 0.21 0.39 0.54 0.68 0.81 0.92 1.00

Mean item complexity =  2
Test of the hypothesis that 7 factors are sufficient.

df null model =  120  with the objective function =  1.49 with Chi Square =  380.65
df of  the model are 29  and the objective function was  0.11

The root mean square of the residuals (RMSR) is  0.02
The df corrected root mean square of the residuals is  0.04

The harmonic n.obs is  263 with the empirical chi square  27.85  with prob <  0.53
The total n.obs was  263  with Likelihood Chi Square =  27.75  with prob <  0.53

Tucker Lewis Index of factoring reliability =  1.02
RMSEA index =  0  and the 90 % confidence intervals are  0 0.045
BIC =  -133.85
Fit based upon off diagonal values = 0.96
Measures of factor score adequacy
```

Figure 71: SS Loadings

The 6 factors explain 36% of the variance. TLI of 1.02 shows goodness of fit.

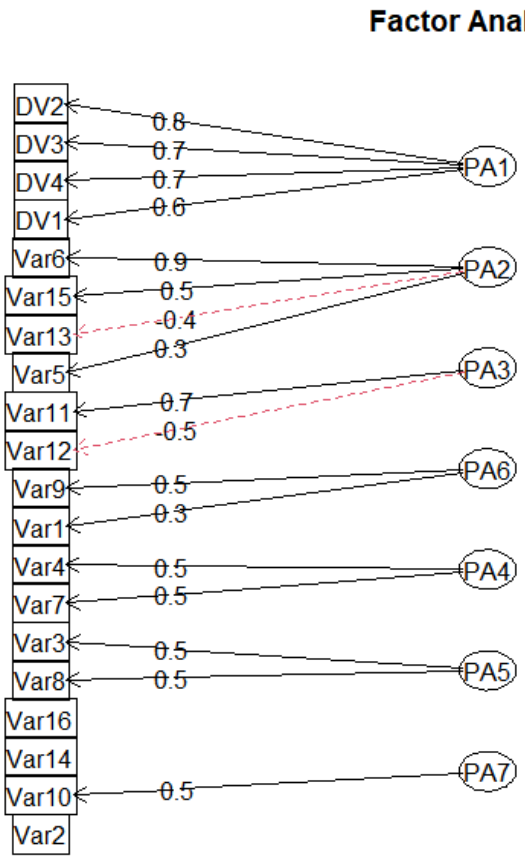


Figure 72: Factors from factor analysis

Var1	Errors due to humans	Var11	Support of senior management
Var2	Effective communication in projects	Var12	Contract handling by project manager
Var3	Engagement by Project Manager with client & Project Team	Var13	Effective feedback of project team
Var4	Flexibility of Project Manager	Var14	Anchor bias
Var5	Leadership of Project Manager	Var15	Reputation of Project Manager
Var6	Charisma of project manager	Var16	Risk Personality
Var7	Organized Project Team	DV1	Goal
Var8	Decisive client	DV2	Ploy
Var9	Trust between Client and Contractor	DV3	Plan
Var10	Client's experience in project area	DV4	Direction

Figure 73: Variables in research

The above are the 7 factors

The above has PA1 as dependent variable as Project strategy.

PA2 has Var 6, Var 15, Var 5 and Var 13 i.e charisma of project manager, reputation of project manager, leadership of project manager and negative

relation with effective feedback by project team, i.e. Effective feedback has a negative correlation with project strategy. We can call this factor Strong Leader.

PA3 has support of senior management and contract handling by project manager, which again has a negative relation. This is an obedient servant factor.

PA4 has flexibility of project manager and organized project team as components we can call this Flexible moderator.

PA5 has Engagement by project manager with team and client and Decisive Client. We can call this as Innovative Leadership.

PA6 is Trust between client and contractor and errors due to humans. This is the Trust factor.

PA7 is Client's experience in the project. Though no weights are given, risk personality, anchor bias and effective communication has been put under this factor. This is the communication factor.

We thus find the 4 categories of Project Strategy mentioned by Artto.

We shall proceed for a regression model based on these factors. But first we shall do a Principal Component Analysis and check reliability.

The Eigenvalues obtained are as follows:

	eigenvalue	variance.percent	cumulative.variance.percent
Dim.1	2.8485646	14.242823	14.24282
Dim.2	1.9189317	9.594658	23.83748
Dim.3	1.5971184	7.985592	31.82307
Dim.4	1.4127137	7.063569	38.88664
Dim.5	1.3309135	6.654567	45.54121
Dim.6	1.1749469	5.874734	51.41594
Dim.7	1.1366843	5.683421	57.19936
Dim.8	1.1021604	5.510802	62.71017
Dim.9	0.9932698	4.966349	67.67652
Dim.10	0.9010505	4.505253	72.18177
Dim.11	0.7896942	3.948471	76.13024
Dim.12	0.7692963	3.846481	79.97672
Dim.13	0.7103251	3.551626	83.52835
Dim.14	0.6095340	3.047670	86.57602
Dim.15	0.5907388	2.953694	89.52971
Dim.16	0.5223818	2.611909	92.14162
Dim.17	0.4897827	2.448913	94.59053
Dim.18	0.3932332	1.966166	96.55670
Dim.19	0.3851711	1.925855	98.48255
Dim.20	0.3034893	1.517447	100.00000

Figure 74: Eigen Values

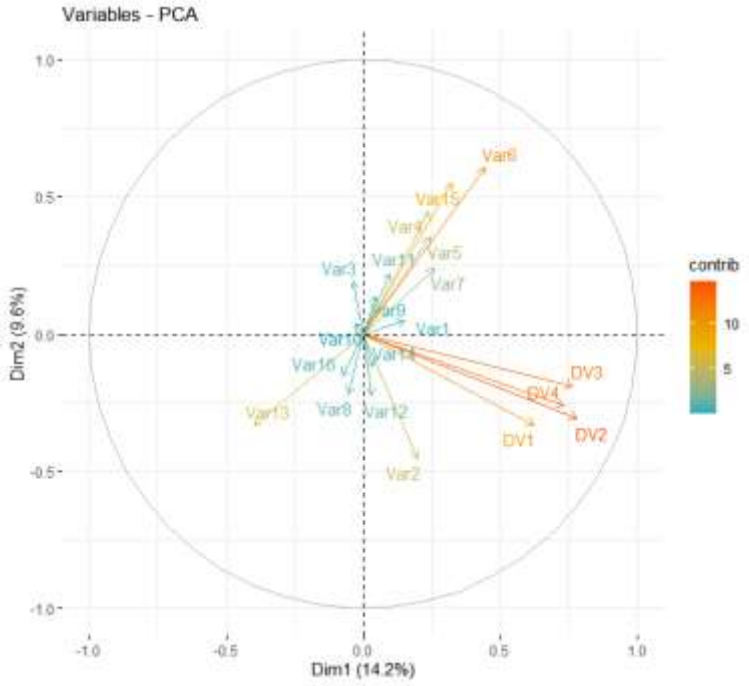


Figure 75: Principle Component Analysis

PCA analysis yields the following:

In the figure we see, Var 15, Var 6, Var 4, Var 2 , Var 9, Var 11, Var 13, DV1,DV2,DV3, DV4 as prominent.

We find that only Var 6 & Var 15 - Charisma of Project Manager & Reputation of Project Manager is near 0.7

With the reduced matrix from PCA we conduct factor analysis:

We check the Cronbach Alpha for the factor and find:

raw_alpha

0.7

This confirms reliability > 0.7.

We now run a regression model with each of the dependent variables.

For DV1: Goal

```
Call:
lm(formula = Y ~ ., data = train)

Residuals:
     Min       1Q   Median       3Q      Max
-0.41140 -0.05604  0.01634  0.06104  0.24500

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept)  0.857021   0.008135 105.352  < 2e-16 ***
PA1          0.125071   0.008966  13.950  < 2e-16 ***
PA2         -0.009760   0.008575  -1.138    0.257
PA3          0.008724   0.010308   0.846    0.399
PA4         -0.004631   0.011671  -0.397    0.692
PA5          0.017687   0.011414   1.550    0.123
PA6          0.010493   0.012363   0.849    0.397
PA7          0.067656   0.013373   5.059 1.05e-06 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.1093 on 176 degrees of freedom
Multiple R-squared:  0.5562,    Adjusted R-squared:  0.5386
F-statistic: 31.51 on 7 and 176 DF,  p-value: < 2.2e-16
```

Figure 76: Regression Analysis DV1

We see that for Goal communication factors is the only significant.

For DV2: Ploy

Strong leader, Obedient Servant, Flexible Moderator, Trust and Communication are significant. However, of these Strong leader and Trust are most significant.

```
Call:
lm(formula = Y ~ ., data = train)

Residuals:
      Min        1Q    Median        3Q       Max
-0.164424 -0.036761 -0.000403  0.031960  0.229379

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept)  0.865563   0.004412 196.183  < 2e-16 ***
PA1          0.139658   0.004863  28.721  < 2e-16 ***
PA2          0.013797   0.004651   2.967 0.003430 **
PA3         -0.014018   0.005591  -2.507 0.013072 *
PA4          0.022407   0.006330   3.540 0.000512 ***
PA5         -0.001370   0.006190  -0.221 0.825063
PA6          0.041396   0.006705   6.174 4.48e-09 ***
PA7         -0.017992   0.007253  -2.481 0.014050 *
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.05927 on 176 degrees of freedom
Multiple R-squared:  0.845,     Adjusted R-squared:  0.8389
F-statistic: 137.1 on 7 and 176 DF,  p-value: < 2.2e-16
```

Figure 77: Regression Analysis for DV2

DV3: Plan: For this PA3: Strong Leader, Obedient servant, trust and communication are significant.

```
Call:
lm(formula = Y ~ ., data = train)

Residuals:
     Min       1Q   Median       3Q      Max
-0.56220 -0.03466  0.00607  0.05802  0.21169

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept)  0.865393   0.006991 123.782  < 2e-16 ***
PA1          0.149954   0.007705  19.462  < 2e-16 ***
PA2          0.008595   0.007370   1.166  0.24506
PA3          0.036232   0.008859   4.090 6.56e-05 ***
PA4          0.013311   0.010030   1.327  0.18622
PA5          0.012894   0.009809   1.314  0.19040
PA6         -0.029024   0.010625  -2.732  0.00694 **
PA7          0.034696   0.011493   3.019  0.00291 **
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.09392 on 176 degrees of freedom
Multiple R-squared:  0.6999,    Adjusted R-squared:  0.688
F-statistic: 58.64 on 7 and 176 DF,  p-value: < 2.2e-16
```

Figure 78: Regression Analysis DV3

For DV4: Direction: Strong Leader, Obedient Servant, Trust and Communication are significant. Flexible moderator of lesser significance

```
Call:
lm(formula = Y ~ ., data = train)

Residuals:
      Min        1Q    Median        3Q       Max
-0.235894 -0.047079 -0.005946  0.043725  0.194485

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept)  0.8754148  0.0062076 141.022  < 2e-16 ***
PA1          0.1172010  0.0068415  17.131  < 2e-16 ***
PA2          0.0217507  0.0065435   3.324  0.00108 **
PA3         -0.0182567  0.0078662  -2.321  0.02144 *
PA4         -0.0089813  0.0089062  -1.008  0.31463
PA5         -0.0005355  0.0087097  -0.061  0.95105
PA6         -0.0390386  0.0094342  -4.138 5.42e-05 ***
PA7         -0.0573800  0.0102046  -5.623 7.25e-08 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.08339 on 176 degrees of freedom
Multiple R-squared:  0.6849,    Adjusted R-squared:  0.6724
F-statistic: 54.66 on 7 and 176 DF,  p-value: < 2.2e-16
```

Figure 79: Regression Analysis DV4

We run a machine learning model with linear regression and get the following results:

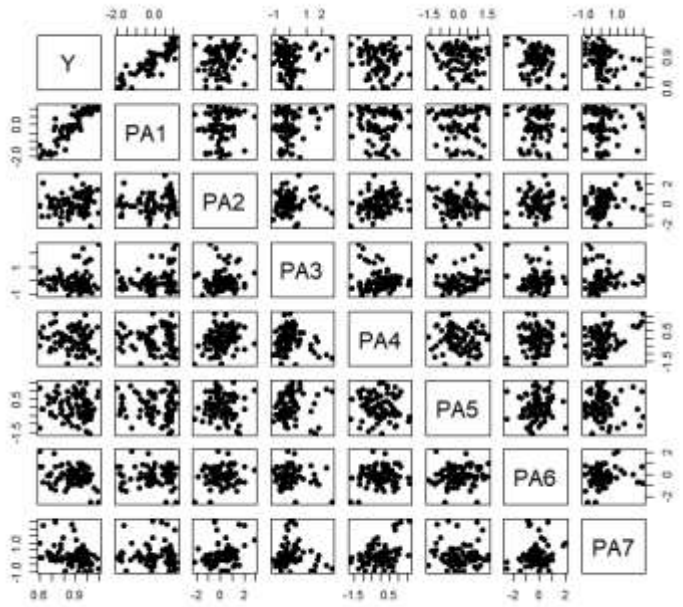


Figure 80: Scatter Plots

We now run a confirmatory factor analysis and obtain the following model

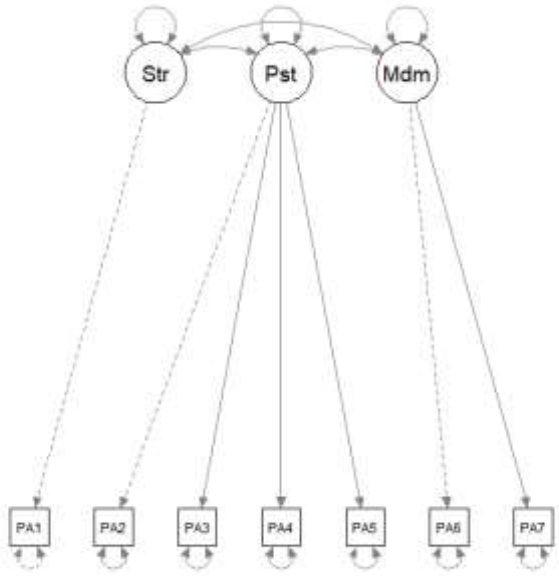


Figure 81: Confirmatory Factor Analysis

```
'data.frame':   263 obs. of  8 variables:
 $ Y  : num  0.6 0.8 0.6 0.8 1 0.8 0.8 0.8 1 1 ...
 $ PA1: num  -1.8292 0.0288 -1.6561 -1.1004 0.8828 ...
 $ PA2: num  -0.617 1.085 2.083 0.374 2.025 ...
 $ PA3: num  -0.194 0.456 -0.227 -0.583 1.811 ...
 $ PA4: num  0.361 0.1691 0.7255 -0.0466 0.5417 ...
 $ PA5: num  -0.0319 -0.1948 -0.107 0.7202 0.3924 ...
 $ PA6: num  -0.932 -0.358 -0.751 -0.622 -1.194 ...
 $ PA7: num  -0.632 0.506 2.182 -0.407 -0.303 ...
```

Figure 82: CFA results

 # $H_0$3: Contract Handling has no significant impact on project strategy

We thus see PA3 which has contract handling variable has significant impact on project strategy and this hypothesis is rejected.

 # $H_0$4: Human factors have has no significant impact on ploy and direction

This null hypothesis is rejected.

 # $H_0$5: Project Manager's qualities has no influence on project strategy.

This null hypothesis is rejected.

 # $H_0$6: Project Manager's qualities has no influence on ploy and direction

This hypothesis is rejected.

 # $H_0$7: Trust between contractor and client has no impact on project strategy.

This hypothesis is rejected.

 # $H_0$8: Team traits have no significant influence on project strategy

This hypothesis is proven correct

 # $H_0$9: Client traits have no influence on project strategy

This hypothesis is rejected.

 # $H_0$10: Error due to human no significant level of influence on project strategy

This hypothesis is rejected.

However, if we consider the reduced matrix, only hypothesis #H05 & H06 are rejected.

4.5 System Dynamics Model

Once the Human factor are identified we move forward to analyze the behavior in a system dynamics model.

However, the model is developed in 3 steps. Firstly, we observe the impact of human factors in a system dynamics model with the cashflow. Secondly, we develop the Project strategy model of stakeholder view. Finally, we integrate all these model into one system dynamics model and observe the results.

The integrated model is shown below:

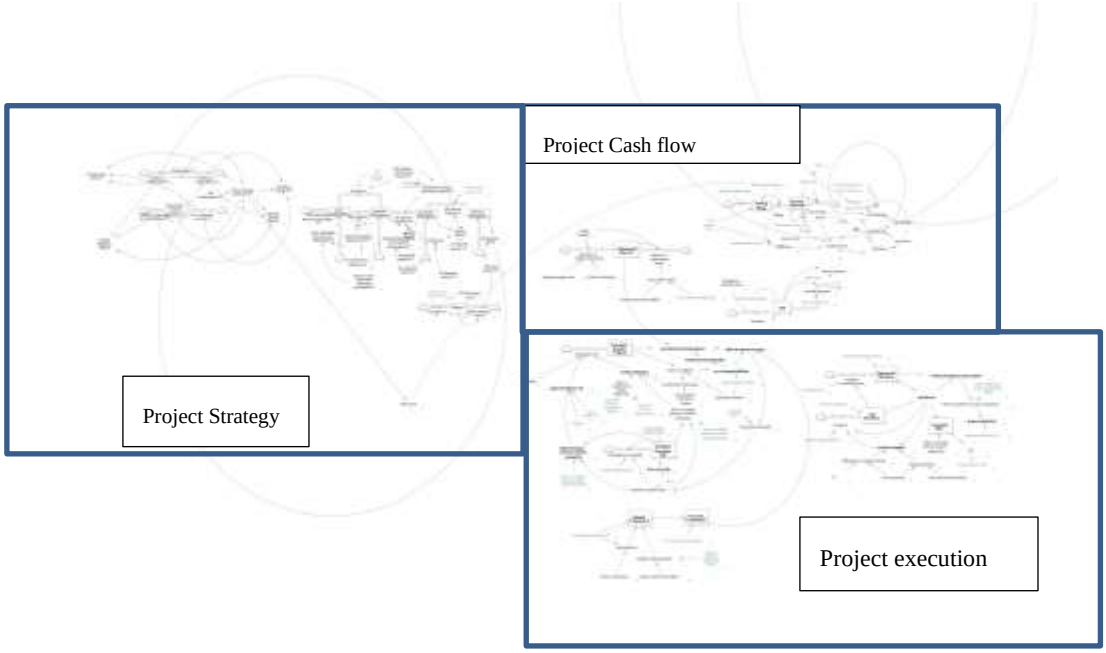


Figure 83: System Dynamics Model

Model Creation 1:

The first model created is the Project execution model. This has 4 parts:

The parts are the project progress model, the workforce model, productivity model and then the rework model. The project progress model is shown below:

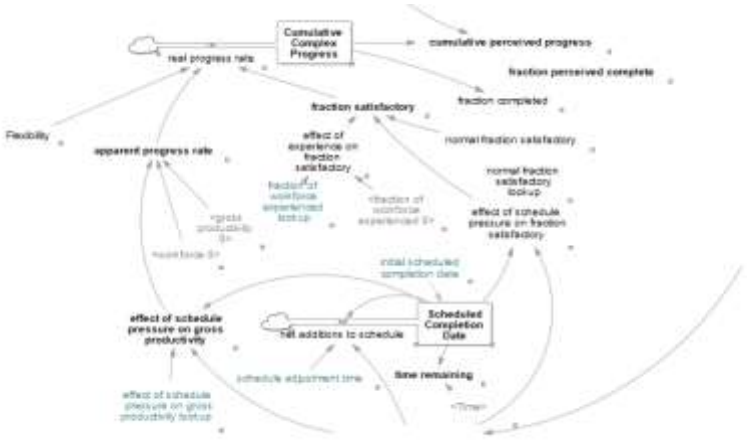


Figure 84: Model Part-1a

The model has 2 stocks, Cumulative progress and Schedule completion date. This is the time portion of the project.

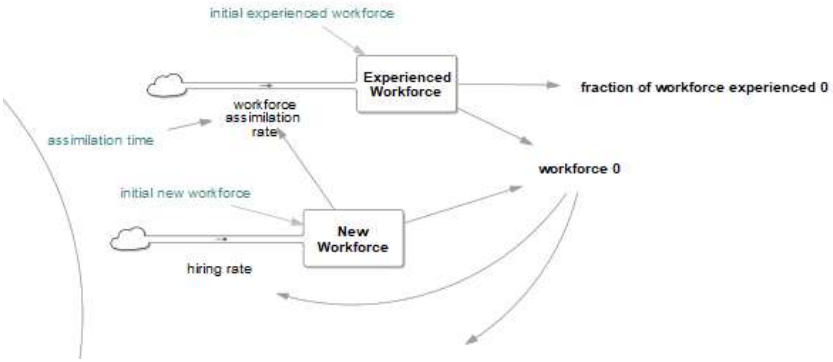


Figure 85: Model Part 1b

The above model is the workforce model and has 2 stocks, Experienced workforce and new workforce. This is the resource view of human capital.

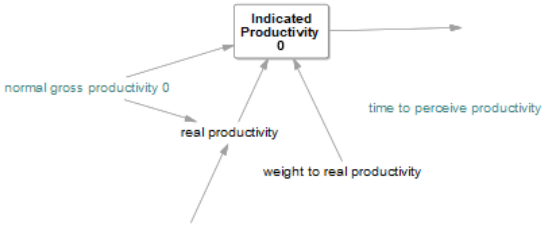


Figure 86: Model Part 1c

The model above is the productivity model. This has 1 stock, Indicated productivity.

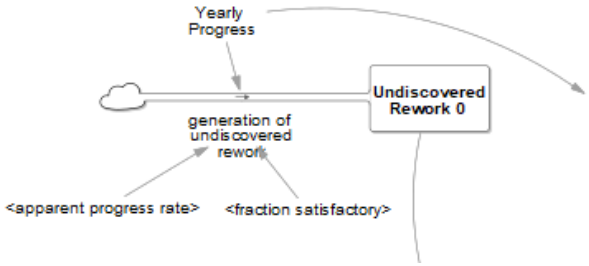


Figure 87: Model 1d

The last is the rework model portion with 1 stock undiscovered work. This has impact on time, quality and cost.

The 4 parts consist of the Project execution portion of our integrated model.

The 2nd portion is the cashflow model shown below:

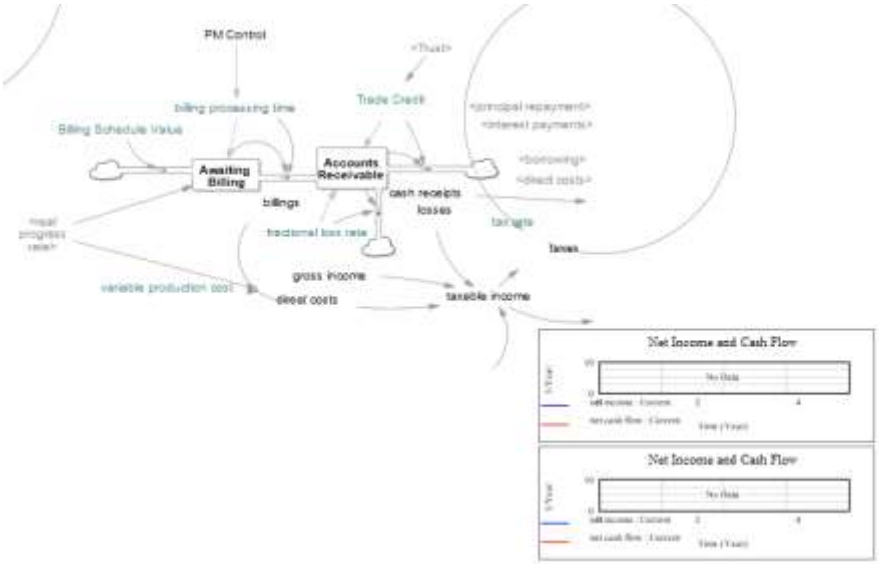


Figure 88: Model 1e

This has 2 stocks Awaiting billing and Accounts receivables. This has the output for valuation of the project.

The 3rd portion is the project strategy model and has 2 parts: the stakeholder view of strategy and the stakeholder type model. We have shown this below:

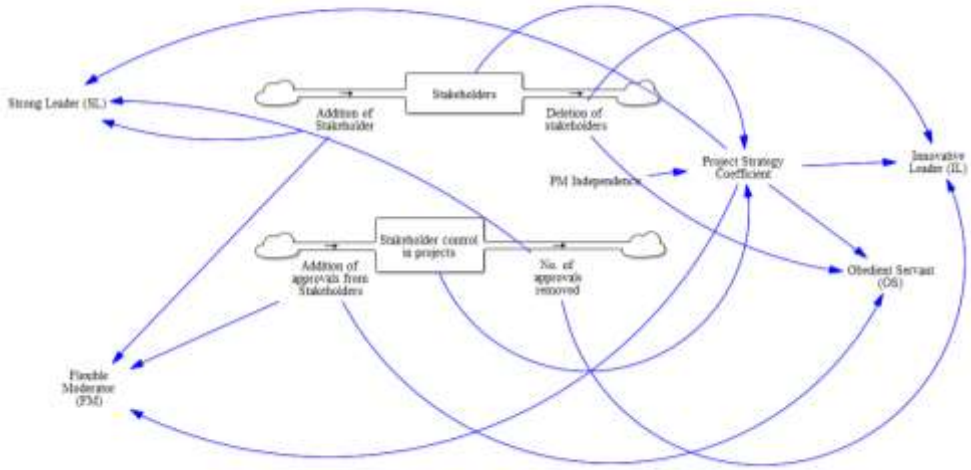


Figure 89: Model 2

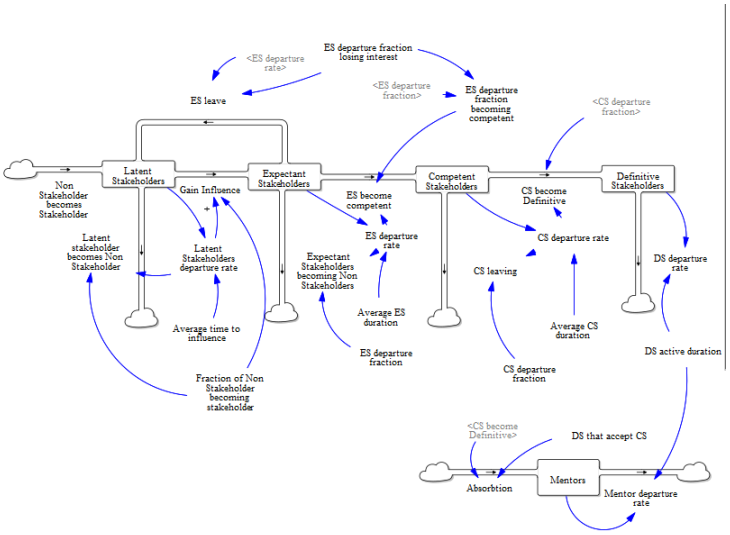


Figure 90: Model 3

We have enumerated the variables, their equations and units in our appendix.

We run the model and get the results as shown in appendix. We will analyze this in our next chapter. Here we are presenting the major data obtained.

The above shows the Net Income and Cashflow, which is -ve and decreasing overtime with the base setting at 0.9 PM Independence.

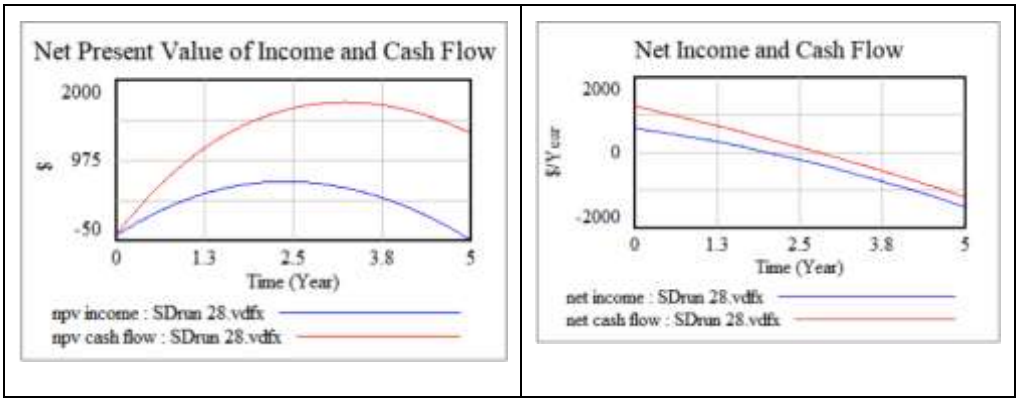


Figure 91: NPV and cashflow results

With change in PM Independence to 1.388 the following results. A positive NPV of Income and Cashflow but negative net flow indicating gap funding requirement.

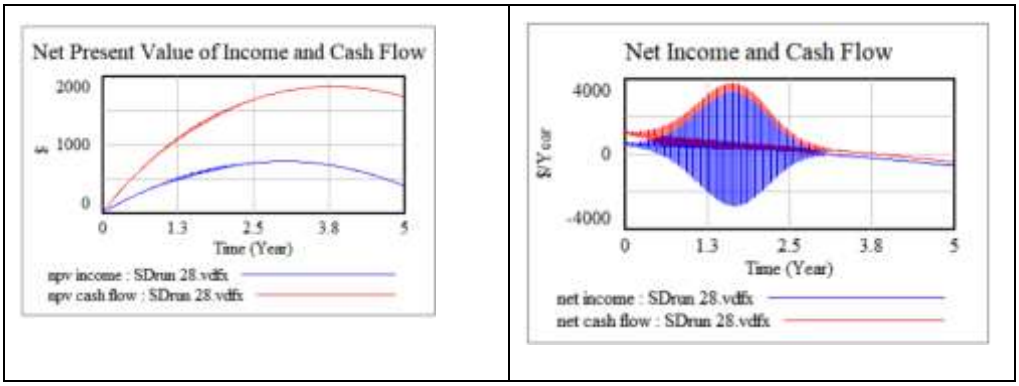


Figure 92: NPV and Cashflow scenario 2

At PM Independence1.425, we get an amplified flow and gap funding.

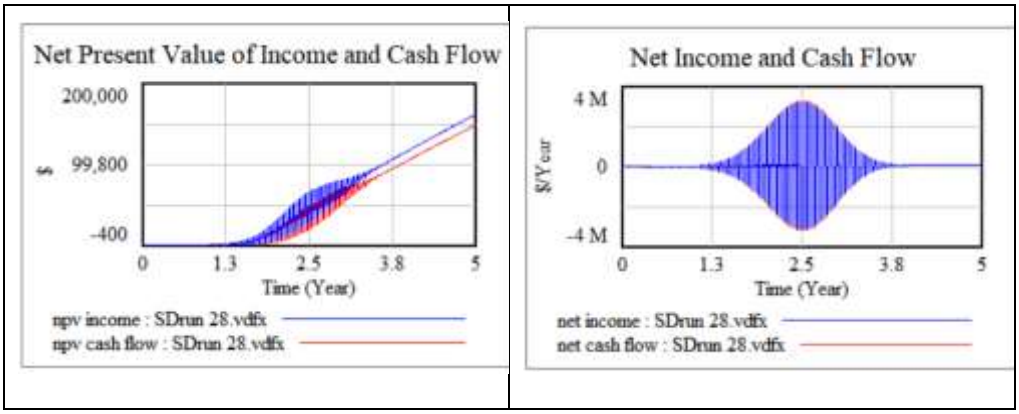


Figure 93: NPV and Cashflow scenario 3

However, net income and cashflow variation starts after 2.3 years.

With the same PM Independence and increasing Schedule Crashing from 1 to 3.35 we get a funding requirement of $10Mil instead of $3.5 Mil. Also this could mean a surplus of $10 Mil and $3.5 Mil due to faster completion.

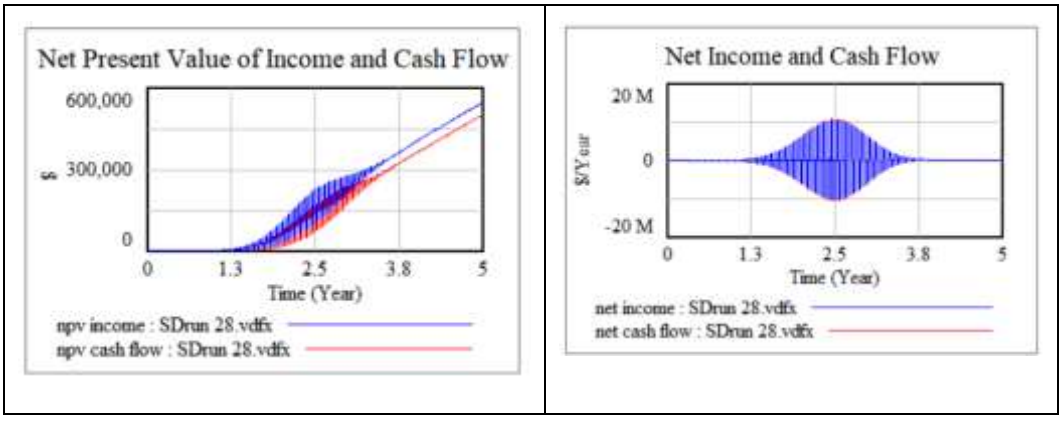


Figure 94: NPV and Cashflow scenario 4

With the change in competent stakeholder average duration from 15 to 22, we get $40,000 funding and lower net cashflow. Which is reduction of risk in the project.

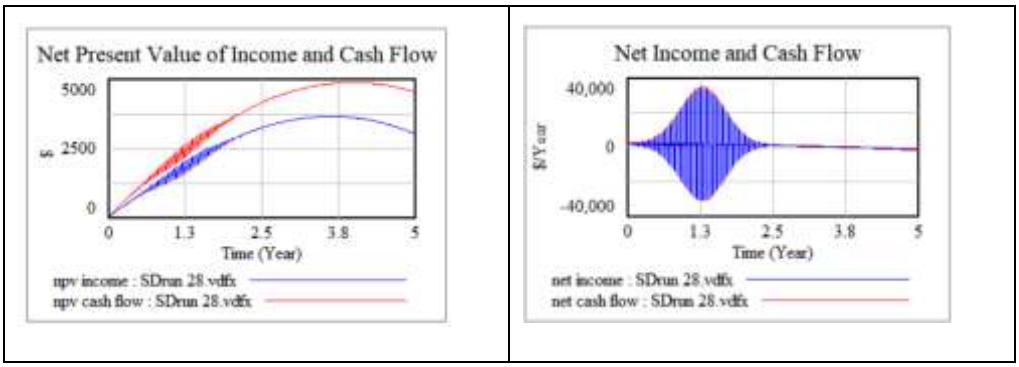
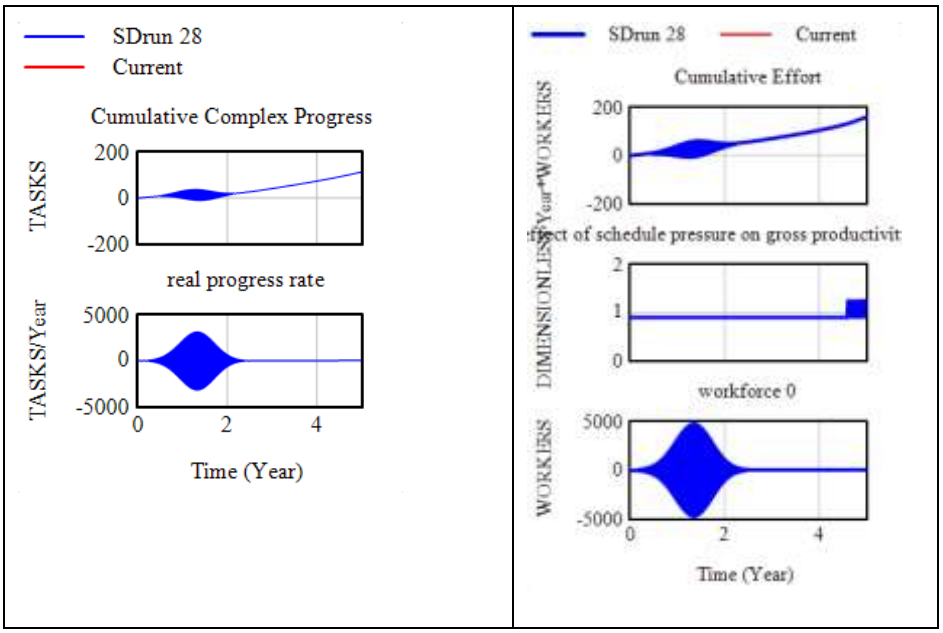


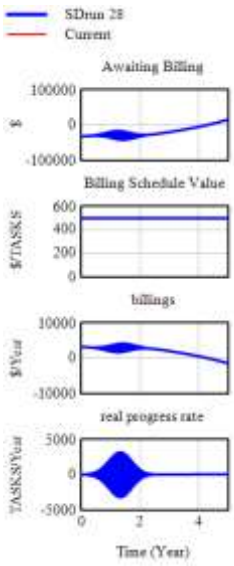
Figure 95: NPV and cashflow Scenario 4

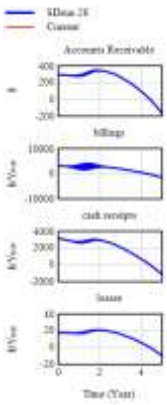
Other results are as follows:

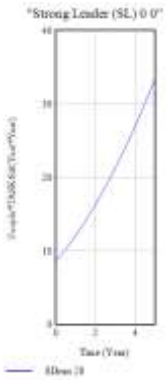
Table 21: Other Results

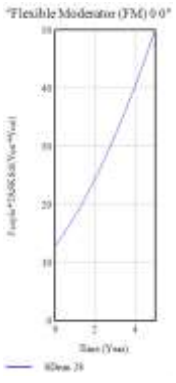


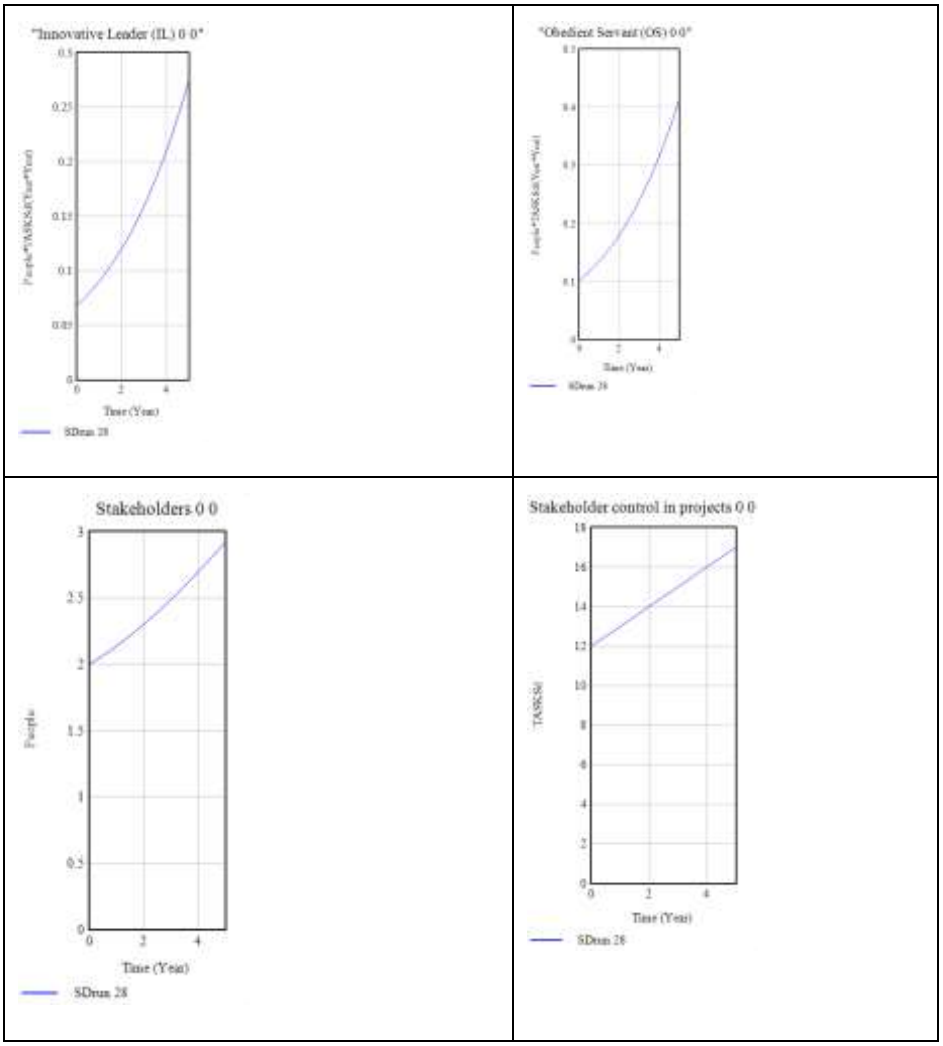

SDrun 28
Current
New Workforce
WORKERS
5000
0
-5000
hiring rate
WORKERS/Year
1 M
0
-1 M
0
2
4
Time (Year)


SDrun 28
Current
Awaiting Billing
100000
0
-100000
Billing Schedule Value
600
400
200
0
billings
10000
0
-10000
real progress rate
5000
0
-5000
0
2
4
Time (Year)









4.6 Summary

The chapter presents the data obtained from the questionnaire survey and then the exploratory analysis. It then compares the human factors v/s system factors from the data and identifies the particular factors which impact the project strategy. We then present the system dynamics model which captures the integrated view of stakeholder theory and the task perspective of project execution. The stakeholder view is also modified by introducing a category of competent stakeholders which is a contribution to body of knowledge of sustainable practices. The data from the model and the EFA from questionnaire is then used to test the hypothesis and research questions.

CHAPTER 5

RESULTS AND DISCUSSION

5 RESULTS AND DISCUSSION

5.1 Introduction

In this chapter we shall summarize the results obtained from the data and analysis done thereof. The results from various studies are presented in a integral for here. We further extend this to development of theory of project management and specifically theory of project strategy. We present here the limitations of our research and further research which shall be done from here. Our attempt is to provide a tool for practice apart from academic body of knowledge.

5.2 Summary of findings of Main Survey

The objective of the research was to find the impact of human factors identified from literature survey and from experts on project strategy. We provided a theoretical base for project strategy and then moved on to build a system dynamics model to observe the impact of such factors. To understand the impact on scenarios we provide an online interface at fario.com Epicentre.

From the literature survey, 23 human factor constructs were filtered and then experts interview screened 16 variables /constructs. A questionnaire developed with multidimensional goal of capturing data under systems and human factor category resulted in showing that impact of human factors is 51% and system factors 50%. In earlier research in literature human factors had been reported as having little impact when empirical research was done. A major factor is the design of questionnaire. We designed the questionnaire over various scenarios and therefore the human factors impact was found to be higher. We further categorized the variables into clusters of Communication, Errors due humans, Project Manager Quality, Trust between client and contractor, Team traits and Client Traits.

From the questionnaire we found the following :

Table 22:Questions in questionnaire

Question No.	Category	Result	HF	System
Q1	Communication	Human Factor is highly scored	√	
Q2	Risk and strategy	Obedient Servant is Major respondent category. Flexible Moderators are most risk takers		
Q3	Technology	-ve awareness		
Q4	Anchor Bias	Evidence of anchor bias is observed		
Q5	Scenario Schedule Crashing	Transactional (System) factors more important than human factors		√
Q6	Autonomy	Low, evidence of Obedient Servant		
Q7	Project Strategy Implementation	System factors more important than human factors		√
Q8	Risk Management	System factors more important than human factors		√
Q9	Procurement (negotiation)- Client perspective	Transactional (System) factors more important than human factors		√
Q10	Procurement Risk (trade credit)- supplier perspective	Transactional (System) factors more important than human factors		√

Q11	Procurement (Supplier Selection)- Client perspective	Transactional (System) factors more important than human factors		√
Q12	Technology risk (Smart Contracts)	No impact		
Q13	Risk profile	Risk Neutral/ Averse		
Q14	Procurement (negotiation) – Supplier perspective	Human factors more important than System Factors	√	
Q15	Procurement - Contractual	Transactional (System) factors more important than human factors		√
Q16	Project Risk- Cost overrun	System factors given more important than human factors		√
Q17	Project Success	Human factors more important than System Factors	√	
Q18	Project Condition	System factors given more important than human factors		√
Q19	Client Satisfaction	Human factors more important than System Factors	√	
Q20	Value Creation	System factors given more important than human factors		√
Q21	Project Strategy	Human factors more important than System Factors	√	

Q22	Risk Personality-dispute	Risk averse to risk neutral		
Q23	Financial Risk-Sellers perspective	Risk taking – transactional – evidence of bias – change of environment changes risk profile to human relations from transactional		
Q24	Financial Risk-Sellers perspective	Risk taking – human factor based- trust-change of environment changes risk profile		
Q25	Project Strategy	Goal, Plan, Ploy , Direction score equivalently		

From the above we find most respondents coming from large projects handling organizations and complexity index is high. Their environments are of Obedient Servant and risk profile is risk Neutral to risk Averse., however with change in environment the risk profile changes and swings between relational based to transactional based.

When the questions were on project risks like schedule risk, cost risk, strategy implementation, risk management, contractual risk, value creation (margins) and project condition – System factors were weighed more and in these transactional category the most.

Table 23: Human v/s system factors

Team	Task	System	Leader	HF	Trans	Business
9.59	13.11	13.67	18.46	79.72	**67.94**	12.25

When it was on procurement risk, from client side it was system factors which were weighed more, but from Seller's perspective it was Human factors. Evidence of bias is strong in many questions, and shift of perspective exhibits how the perspective of factors change. Most respondents as clients in their

obedient servant, risk averse profile feel transactional factors as important, however, the moment their perspective is shifted to the Seller's perspective, they shift to Human factors.

When the questions were on Project success, Client Satisfaction, Project Strategy : Human Factors were weighed higher. We may thus see that when a Goal, Bird's eye view and Supplier's perspective is given Human factors are perceived more important, but when and operational, tactical, risk perspective is given System factors are weighed more. We further see through the distress questions that change of environment shifts the preference from contractual to trust factors. However, overall human factors is given more importance in Financial Risk – Dispute and Distress condition questions.

We then proceed for exploratory data analysis and find a very strong correlation in the dependent variable Project strategy with goal, plan, ploy and direction as constructs.

We then check for validity of Cronbach Alpha and observe that unidirectional assumption is violated. Hence, we proceed for Omega test and discover Project Manager Quality of Charisma and Reputation as a underlying factor. We thus see that factor reduction from 16 to 2-3 has to be done for reliability. However, the questionnaire tool is reliable for factor analysis is proven and validity is established.

Factor Analysis illuminates the presence of 6 factors of independent variables and 1 of dependent variable which clearly is project strategy.

Of the independent variables:

The first factor composed of Project manager quality (leadership) and effective feedback of team is reflective of the environment of Strong Leader. In the data collected we found that most respondents belonged to obedient servant category, however, a risk attitude shift from neutral to risk taking indicated a latent presence of this attitude.

The second factor support of senior management and contract handling (team traits) is seen as an Obedient Servant environment.

The third factor Flexibility of project manager and organized project team we call Flexible moderator factor.

The fourth factor Engagement of project manager with team and client & Decisive client is reflective of Innovative Leader factor.

The fifth factor trust between contractor and client and error due to humans is the Trust factor. This is specifically interesting as a system-human factor or we can call the missing link. Very crucial when we discuss impact of AI in our next section.

The sixth factor is not so prominent but we call it communication factor. This includes though weakly evident client trait, communication, anchor bias and risk profile.

We observe here that the definition of Project strategy from stakeholder perspective is linked to Mintzberg's and Rumelt's definition and human factor variables. We summarize this in the table below:

Table 24: Integration of theories Project Strategy

Project Strategy (K. Artto)	Positioning	Human factor	Mintzberg/Rumelt
Strong leader	High Autonomy / Multiple Stakeholder	Project manager Charisma, Reputation, leadership, Effective feedback	Goal , Plan, Ploy, Direction
Obedient Servant	Low Autonomy, Few stakeholders	Senior management support, Contract handling	Goal , Plan, Ploy, Direction

Flexible moderator	Low Autonomy / Multiple Stakeholder	Flexibility of project manager, Organized project team	Goal , Plan, Ploy, Direction
Innovative Leader	High Autonomy / Few stakeholders	Decisive client, Engagement of project manager	Goal , Plan, Ploy, Direction

We thus see that data results show even in the obedient servant environment (most respondents belonged to this category) certain human factors when amplified can change the project strategy!

We then perform a PCA analysis Which exhibits the violation of the unidirectional assumption and validity with reduction of factor to project manager charisma and reputation with an Alpha of 0.7. which confirms reliability.

A regression model confirms impact of factors on dependent variable constructs and related to project strategy as follows:

Table 25: Regression results for Human Factor

Human factor variable	Project Strategy Positioning (K Artto)	Mintzberg / Rumelt	p-Value
Communication		Goal	2.2e-16
Project manager Quality (Charisma, Reputation, leadership, Flexibility of project	Strong leader, Obedient Servant, Flexible Moderator, Trust and Communication	Ploy	2.2e-16

manager), **Team Traits** (Effective feedback, Senior management support, Contract handling, Organized project team)			
Project Manager Quality (Project manager Charisma, Reputation, leadership), **Team Traits** (Effective feedback, Senior management support, Contract handling), **Trust** and **Communication**	Strong Leader, Obedient servant, trust and communication	Plan	2.2e-16
Project Manager Quality (Project manager Charisma, Reputation, leadership), **Team Traits** (Effective feedback, Senior management support, Contract handling), **Trust**	Strong leader, obedient servant, trust and communication	Direction	2.2e-16

and **Communication**			

We thus find that of the 6 clusters we have 4 clusters having significant impact on the dependent variable constructs while Errors due to Human not being prominent. But We also observe that Innovative leader positioning is not significant.

We also observe an interesting fact that Goal is not impacted by any other human factor but client trait and communication. This reaffirms the fact that goal is an *emergent* principle and not a causal factor in project strategy.

We may thus merge client trait and communication into one cluster and Errors due to human and trust between client and contractor merged into the other. The other two being Project Manager Quality and Team Traits.

We also perform a confirmatory factor analysis where we discover Project Strategy as the dependent variable factor, Obedient Servant, Strong Leader , Innovative leader and Flexible moderator as the positioning factor and Trust and Communication as the Medium (flow) factor.

So far we have tested the hypothesis and answered the research questions :

1. What is project strategy?
2. What are the human factors which affect the project strategy and risk?
3. Do human factors impact project strategy more than systemic factors?

The first was done in our introduction where we defined project strategy and then in the data analysis of integrating the views of Project Strategy from Stakeholder point of view and that of Mintzberg and Rumelt.

The second question was answered from filtering factors from literature survey, then data collection, exploratory and confirmatory data analysis.

The third was answered through hypothesis testing and data collected.

We are thus left with one research question :

4. How can we study the impact of dynamic complexity on project strategy?

To answer this we use a System Dynamics Model.

However, in this process we also develop the theory on Project strategy from a stakeholder perspective and providing an integral view of the definition.

The model provides the illustration of the definition we set out in our theory

$$\textbf{Strategy} = \int f\,(task_d, S_h, t)\,dt$$

Equation 4: Project Strategy

From a System Dynamics perspective, it is a Stock Variable where the decision task flow rate and stakeholder flow rate determine the nature of this stock variable. We shall further this in our discussions.

In the results from the model we can observe from the change of autonomy of project manager which we have modelled as variable Project Manager' Independence the NPV of Income and Cashflow increases but the Net Income and Cashflow has increased variability. However, the decreasing trend changes to a stable horizontal trend.

We further observe from the model that when we introduce schedule crashing the funding requirement blows up to $10Mil from $3.5M. We had seen that data collected had exhibited, System and transactional factors in particular to be more important. However, the model shows how feedbacks and dynamic complexity is driven by Autonomy, though perceived as system factors!

Our model adds to the theory of stakeholder by introducing a new kind of stakeholder Competent stakeholder. This is a stakeholder at the boundary of Expectant Stakeholder and Definitive Stakeholder, i.e who posses two of the 3 dimensions of Urgency, Legitimacy and Power. We model this as a continuous variable to indicate power rather than number of stakeholders and hence qualify the Number of Stakeholders of K. Artto's Project Strategy dimension to Stakeholder Control.

When we increase this parameter we see a significant reduction in risk as the fund requirement and variability reduced from $10Mil to $40k. We also observe from the model that Cumulative progress is 0 to 200 tasks and the flow rate is 5000 tasks /year. We also see a fluctuation in number of workers from 0 to 5000 and a high attrition rate. In the model we find billing rate and receivables

decreases and with trade credit cashflow improves. The result shows an increase in Awaiting billing which is a delay in billing and hence an increase in accounts receivable resulting in a decreasing net cashflow. A company may thus decide to improve factor by varying the PM Control.

We also find the Strong leader and Flexible Moderator as the prominent Strategies Emerging from the model results.

5.3 Conclusion and Discussion.

Our first research objective was to evolve an integral definition of project strategy, which we have crystallized to a great extant with our results and then the system dynamics approach. Risk has been an integrated feature and not separately dealt with as we set out by saying strategy and risk are coupled, one without the other is like discussing only about risk. When we state strategy, risk is implied. Many previous works have defined risk into political, strategic etc. However, we see risk in our research from the point of view of strategy.

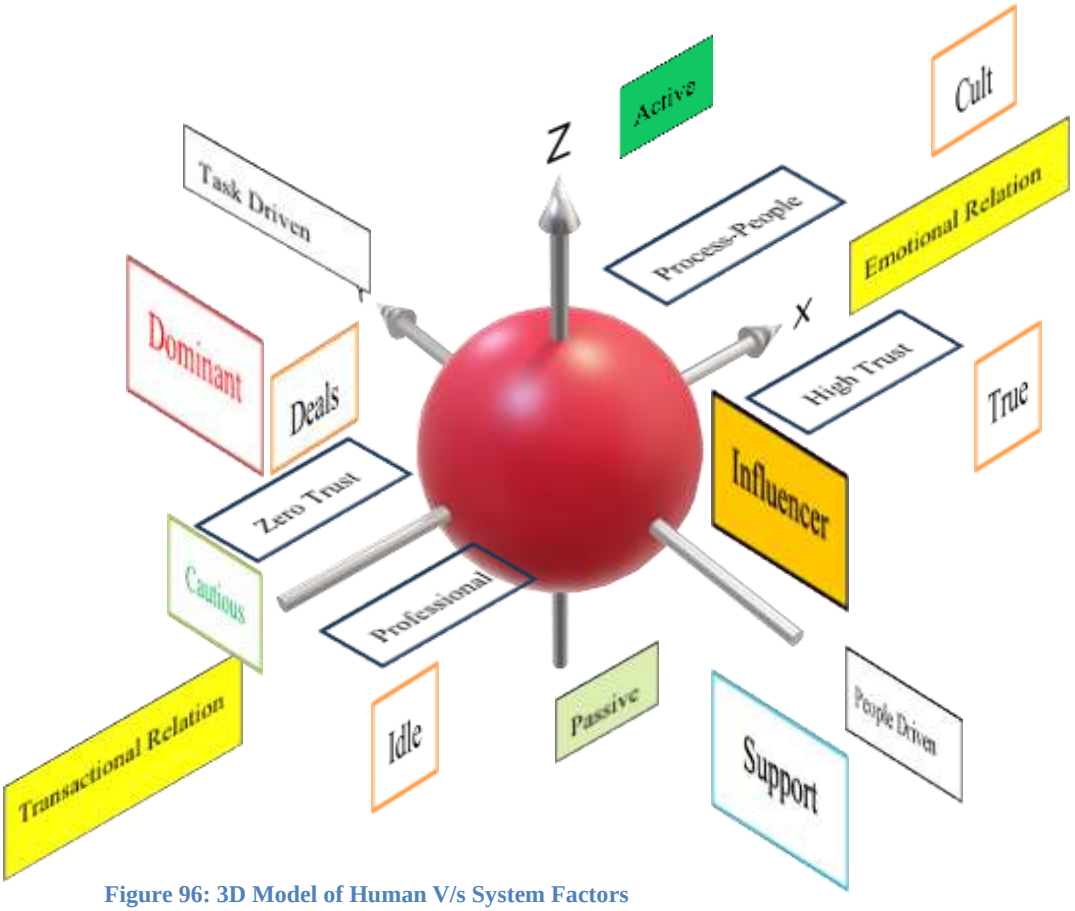


Figure 96: 3D Model of Human V/s System Factors

The second objective was to find the degree of impact or extant of influence of human factor over system factor. In results section we found that human factor have significant impact, but the perspective is very important. If seen from a different lens system factors shall appear more significant!

While doing factor analysis we discovered a latent factor Trust and this was a combination of Trust between contractor and client and Errors due to Humans. We mentioned we shall elaborate it in our discussions section and we shall do that now.

The relevance of our research is very crucial to be mentioned in this age of Artificial Intelligence. We hear that most of the tasks shall be delegated to computer algorithms. One of the issues is this variable “Errors due to humans”. Majority of Human factor literature has been around this variable. In fact it became synonymous with Safety! The reason is the obsession of the western world with scaling up without error. We will bring out the relevance with the following figure. We must mention that this integral figure is a novel contribution of our research. This is not to be found anywhere else:

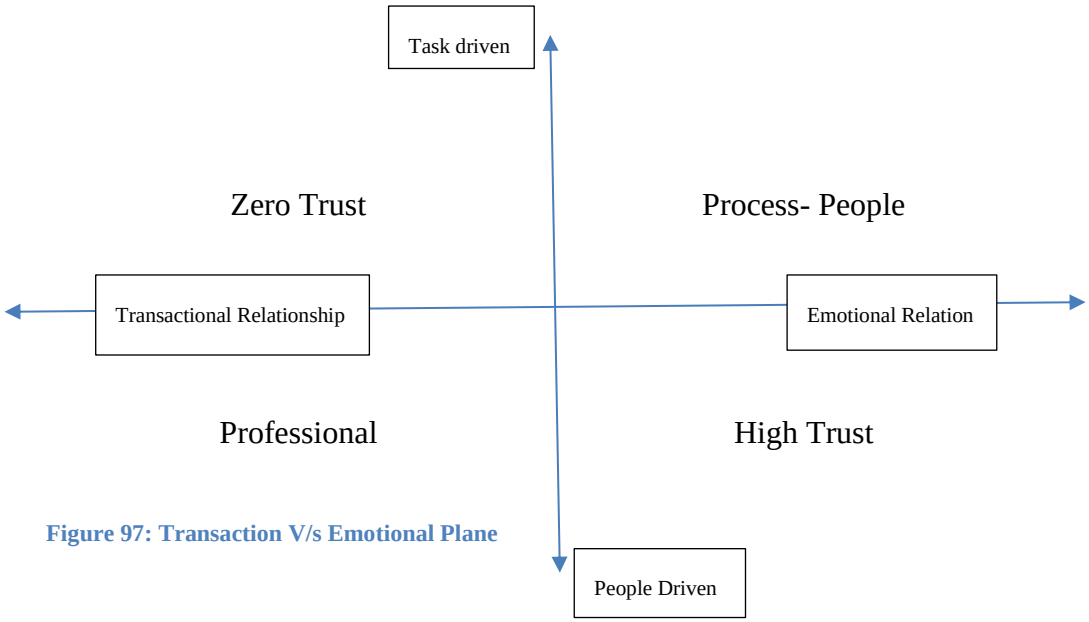


Figure 97: Transaction V/s Emotional Plane

In the above figure we have plotted the human factors relation based or emotional v/s system based or transactions. We see that the concept of zero error emerges from the task and transactional view while an entire universe revolves around human factors due to the emotional connect.

From the above if we see the leadership type i.e Project manager tendency required Dominant personality shall be compatible with the Zero Trust environment and evolve the incentivized motivation (carrot and stick) or Deals category. The Influencer personality on other hand shall be effective in High Trust environment and shall evolve the Cult category.

The **Supportive type** project manager shall be effective in a Professional Environment and evolve the **True category**.

The Cautious type project manager shall be effective in Zero trust and evolve the Idle category.

Now if we reflect the strategies of Obedient Servant, Strong Leader, Flexible Moderator and Innovative Leader we may map them in the following table:

Project Strategy	**Environment**	**Personality**	**Category**	**Human Factor Variable**
Obedient Servant	Zero Trust	Cautious	Idle	Senior management support, Contract handling
	Professional	Support	True	
Strong Leader	Zero Trust	Dominant	Deals	Project manager Charisma, Reputation, leadership, Effective feedback
	High Trust	Influencer	Cult	

Flexible Moderator	Professional	Support	True	Organized project team, Flexibility of Project Manager
	Zero Trust	Cautious	Idle	
Innovative Leader	Zero Trust	Dominant	Deals	Decisive client, Engagement of project manager
	High Trust	Influencer	Cult	

Figure 98: Summarized Table for personality in environments

All strategies operate in all environments.

One environment is not mentioned above the Process – People environment. This will the key to the future when AI moves in. The organization is Task Driven but has an emotional relational with the employees and customers. In such an environment, The Dominant and cautious personality can only thrive with cultivation of people skills.

We have also modelled trust in our system dynamics model. Now we come back to the definition of strategy modelled as a stock variable.

$$\textbf{Strategy} = \int f\,(task_d, S_h, t)\,dt$$

In the above we model Project strategy as an outcome of Stakeholder Power and Stakeholder Control of Projects which we model as no. of approvals / control points. This diminishes Project Manager Autonomy. An interaction of the PM Independence, a proxy for autonomy and the Stakeholder controls determine which strategy evolves. Now if we map this with the environment and personality we can understand which strategy will be effective.

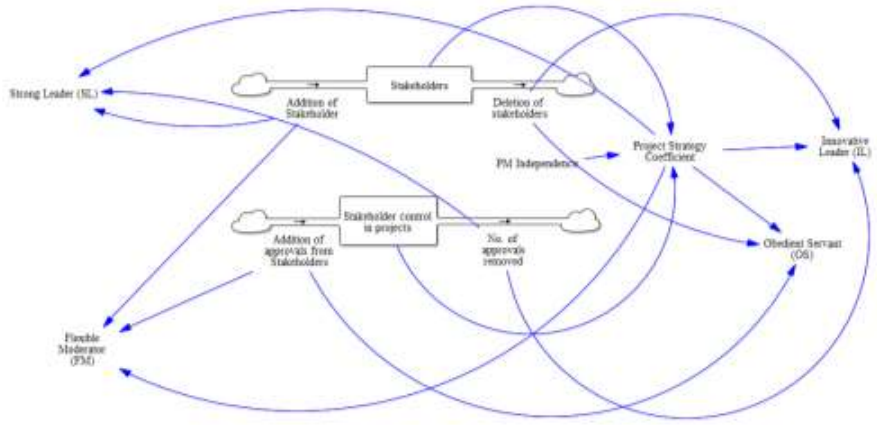


Figure 99: Model Part 2

Our model is coupled with the type of stakeholder. The power of stakeholder is derived from competent stakeholder, as that decides how much influence definitive stakeholders shall put.

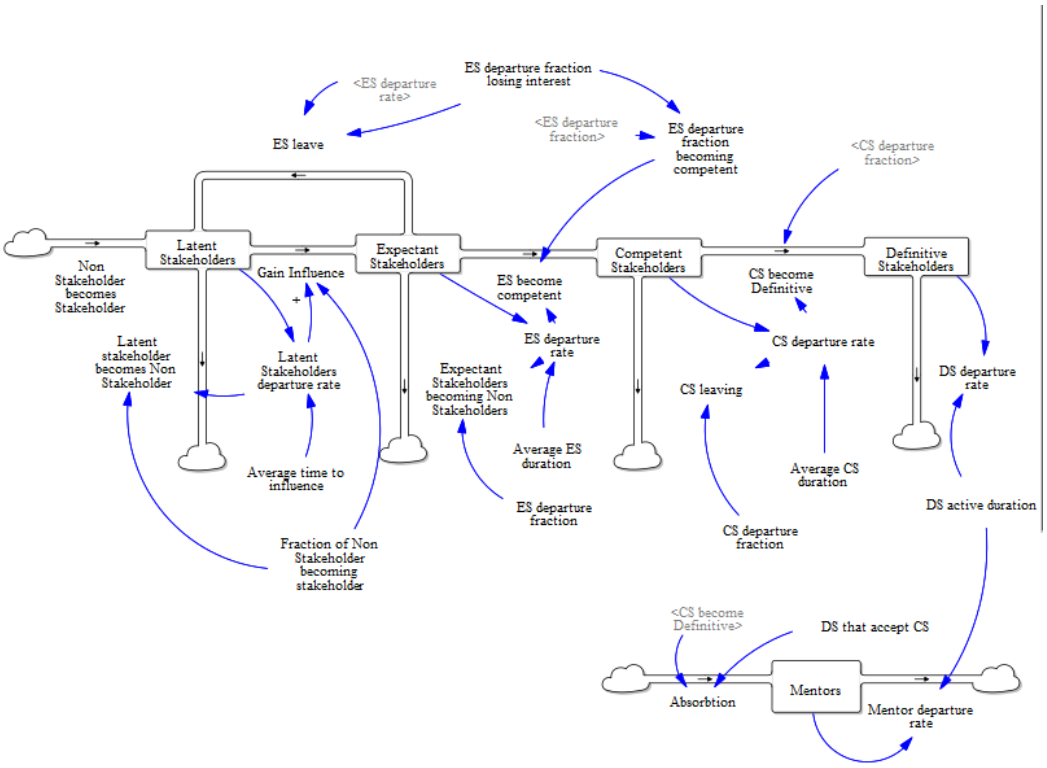


Figure 100: Model Part 3

This determines the project strategy.

Our system dynamics thus integrates the dynamic complexity, and provides a scientific basis for the definition of Project Strategy as a stock variable which expresses itself as a positioning of OS,SL, IL or FM based on Autonomy/Control and Stakeholder Influence. Further with the 3 dimensional environment presented as Transactional-Emotional relationship vis a vis the task driven – people driven organization shall determine which project manager personality type shall thrive in this environment and thus choice of strategy shall evolve with degree of autonomy and influence of stakeholder power.

We had previously discussed about Management as technology i.e. Management being a parameter in the production function along with Labour and Capital. In the parlance of projects, we can say that Project strategy is the technology that results in emergence of the goal of the project. Just as The Carnot Cycle presented area under the curve as work done under the P-V curve or T-S (Temperature – Entropy) and Otto cycle the work done for a car engine , Project Strategy is the area under the Degree of Autonomy and Stakeholder Power. We may take the analogy of entropy i.e Thermal energy per unit temperature, Degree of Autonomy is the Project Strategy per unit of Influence of Stakeholder Power. Further we can extend the analogy to Exergy i.e "Work Potential" i.e. available energy. We may also note that degree of autonomy is decided by the quality of *decision task*. Which has the "will" of the system implied in it. This "will" or purpose of the project shall determine how much effective the Project Strategy shall be, just like *exergy*.

While entropy is the capacity of the system, exergy is the maximum availability. Similarly, the *decision task* quality shall be defined by *will* and qualify the effectiveness of the Project Strategy.

5.4 Limitation of Research

The present research work is an attempt to provide a theory of project strategy. In doing that we filtered variables from literature survey and through an expert panel. However, there can be latent variables other than what we have presented. Our data provided an acceptable level of factor analysis where most participants

were from a Obedient Servant Environment. Samples from Strong leader, Flexible moderator, Innovative leader environments could improve the results.

Our system dynamics model developed was an attempt to establish a tool to handle dynamic complexity and illustrate how human factor variables impact can be quantified and project strategy determined accordingly. However, we could not validate the model with realistic data from projects.

5.5 Contribution of Research:

The research is a novel attempt at coining the definition of project strategy as a stock variable extending the work of K. Artto. However, it improves the work by modifying the No. of Stakeholder dimension to Influence of Stakeholder. This dimension is further qualified into type of stakeholder from the salience model of stakeholder theory. The silence model is also improved in the research by introducing competent stakeholder which brings sustainable organizations. This is used as measure of stakeholder influence.

Our research for the first time in literature provides an integral view of the models proposed by Mintzberg and K. Artto. It further undines this finding by identification and mapping of human factor constructs in literature to the environment in which project operates.

The 3D model of environment and project manager personality is seminal and presented for the first time in literature.

Our research was an attempt to provide a foundation for developing Project Strategy as a technology. Technology is application of scientific knowledge and hence we have illustrated this with a system dynamics model to benefit the project management world with not just a theory but a way to decision making. We therefore illustrated this with financial goals of net cashflow and net income.

We had taken data from secondary research and most projects in India have a huge cost and time overrun. The research provides a method to apply project strategy to ensure such delays to be avoided.

5.6 Future research

This work is the foundation of development of theory of project strategy. It can be tested with real world data with various variables included in the model. Such a study will bring in an invaluable body of knowledge.

Our stakeholder stock and flow model can be improved by providing a degree or weightage for different kinds of stakeholders (latent, expectant, competent and definitive). Combinations of influence of these power influences can be studied.

In the model, stakeholder control has been modelled as no. of approvals. However, influence can be imposed with other means which may be modelled into a unit of influence.

The underlying human factor constructs can be refined by empirical research for each of these constructs.

Alternative combinations of human factor and system factors can be tested in the model to prepare a portfolio or range of mixes for a sustainable solution.

The novel 3D model provided can be used to generate various combinations of environments and suitable project manager quality.

In complex projects we also encounter corruption through procedural delay, hurdles to make process a bottle neck to extract money. These models can be improved to capture and arrest such practices. This is a vast area of future research to develop project strategies which have an anti- corruption immune mechanism.

Cybernetics is a field growing with development of AI and allied technology. Our research has an overlap with this field. The viable model proposed by Stafford beer and Syntegration model by Mallik can be researched in collaboration with project strategy.

The tipping point of complex systems may be found and how project strategy as a technology can be used to unlock the knowledge of tipping point and hidden patterns is a future possibility of research application.

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