

Planning Transportation Megaprojects: Paradoxes and Challenges in Planning Complex Projects

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Abstract. *Transportation megaprojects have become a routine feature in the development of cities and urban infrastructure. The failure of many megaprojects to achieve the desired performance levels is an issue that has been discussed in several studies in recent years, ascribing it to the inability to plan for complexity and uncertainty. This and other problems that are commonplace among megaprojects are yet to be solved despite the employment of highly experienced professionals and resources. The role of the decision-making process in the planning phase is critical in dealing with the complex and uncertain nature of megaprojects. This paper presents a review of literature related to this topic and argues that a major challenge in the planning phase is a cultural misunderstanding of transportation megaprojects, since the rationale behind the development decisions and planning approaches fails to manage complexity and uncertainty. In this study, we identified four paradoxes that occur in transportation megaproject practice that show that top-down and linear planning approaches should be reformed to become more open-minded, nonlinear, and open. Doing so may benefit regional development and broad communities in the future.*

Keywords *Complexity; Non-linear Planning; Open System; Transportation Megaproject; Uncertainty.*

Abstrak. *Megaproyek transportasi telah menjadi fitur rutin dalam pembangunan kota dan infrastruktur urban. Kegagalan banyak megaproyek untuk mencapai tingkat kinerja yang diinginkan adalah masalah yang banyak dibahas dalam beberapa penelitian dalam beberapa tahun terakhir dan dianggap sebagai ketidakmampuan dalam merumuskan tingkat kesulitan dan tingkat ketidakpastian. Masalah-masalah yang biasa terjadi di megaproyek transportasi tersebut belum terpecahkan meskipun telah mempekerjakan para profesional dan sumber daya yang sangat berpengalaman. Proses pengambilan keputusan dalam tahap perencanaan sangat penting dalam menghadapi sifat megaproyek yang kompleks dan tidak pasti. Makalah ini menyajikan tinjauan literatur yang terkait dengan topik ini dan berpendapat bahwa tantangan utama dalam fase perencanaan adalah kesalahpahaman terhadap karakter megaproyek transportasi, yang menjadi alasan kegagalan perencanaan dan pengambilan keputusan dalam mengelola kompleksitas dan ketidakpastian. Dalam studi ini, kami mengidentifikasi empat paradoks yang terjadi dalam praktik megaproyek transportasi yang menunjukkan bahwa pendekatan perencanaan top-down dan linier harus dirombak menjadi lebih berpikiran terbuka, nonlinier,*

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dan sistem yang terbuka. Hal tersebut akan memberikan manfaat bagi pembangunan kawasan dan bagi masyarakat di masa yang akan datang.

Kata kunci. *Kompleksitas; ketidakpastian; megaproyek transportasi; perencanaan non-linear; sistem terbuka.*

Introduction

Megaprojects are defined as extremely large-scale investment developments. They have a nature of complexity and uncertainty in the development context (Oureta and Fainstein, 2008). Lehrer and Laidley (2008) state that megaprojects, which began to flourish in the 1990s, have cost risks and require complex financial procedures and collaboration. In addition, megaprojects are characteristically large-scale projects that entail long periods of construction, complex financial problems, high financial risks, and close association with political dynamics (Flyvbjerg et al., 2003; Salet et al., 2013; Lehrer and Laidley, 2008). The term ‘mega’ is associated with great volume or scale. Thus, megaprojects are understood to inherently involve intricate problems that are difficult to manage. Most megaprojects are associated with development costs of at least 1 billion dollars in the USA (Flyvbjerg, 2014; Capka, 2004) or 100 million euros in Europe. The cost of development can also be defined based on GDP ratio, for instance, 0.01% of GDP for the USA, 0.02% of GDP for EU countries, or 0.05% of GDP for South Korea (Hu et al, 2015). The complexity and uncertainty of construction megaprojects have been acknowledged as prominent characteristics that influence the projects’ performance levels. Discussions frequently revolve around the success or failure of such projects according to their determined timeline and budget. Problems in building an efficient project management and risk management system lead to cost overruns and time delays (Rothengatter, 2018; Flyvbjerg, 2003; Dimitriou et al., 2013). While current planning approaches typically conform to linear thinking, this study attempted to challenge this approach by building an understanding of the complex and dynamic nature of megaprojects and introducing the possibility of applying complexity design thinking.

Transportation megaprojects (TMs) have become a new way of achieving national and international reach for businesses and services in global cities. The development of transportation infrastructure is important for the functioning of a country’s economy to ensure everyday mobility related to people and the production and distribution of goods. Thus, governments seek to invest in large-scale developments to place their cities in competition with other cities globally (Moulaert et al., 2002). Global market efficiency and economic excellence may not be the only strategic goals pursued by a state and other pro-growth actors. There are also efforts to expand the reach of the local economy, to gain global visibility, and to better maintain autonomy and local political identity. Financial capacity and economic background are important factors for the implementation of TMs in countries around the world, especially in less developed countries where the capacity of finance, technology, manpower, and governance are limited.

A TM is defined as an investment in transport infrastructure that connects major urban areas such as bridges, tunnels, roads, and railroads, or integration between them (Mišić and Radujković, 2015). TMs are complex projects with high investment costs, multiphase long-term development, and multiple stakeholders from various sectors and businesses. They include the construction of toll roads, airports, seaports, railroads, train stations, subways, tunnels, and other kinds of transportation facilities. TMs are being implemented around the world as instruments to build efficient public transportation networks, even though the majority of these ambitious projects are experiencing problems and poor performance (Flyvbjerg, 2004; Altshuler and Luberoff, 2003). As recorded in the literature, TMs have a high risk of experiencing overbudgeting, delays, or even postponement for long periods of time. Flyvbjerg (2004) found that 90% of transportation projects

failed to stay within their pre-determined budgets and that rail transport projects experienced a 45% increase in budget. Research by Rothengatter (2019) has shown that some megaprojects in the international transport sector faced problems regarding budgeting and planning risk mitigation in the early stages, and community protests, dynamic political problems, and difficult situations in the construction and operational stages.

The low success rates of megaprojects indicate that traditional planning approaches are incapable of dealing with the complexities and risks of such projects. Current planning methods put too much emphasis on deciding the right solution for the problem rather than thinking about the process that should be employed to make essential decisions (Rocha, 2014). Megaprojects are complex and involve a variety of interrelated political, social, and economic problems (Chapman, 2016). Political pressure, interests of various parties, and uncertainty in the course of a megaproject's implementation make it so that decision making and planning both before and during the construction process require proficiency in adapting, alliance-building, and learning among stakeholders and government institutions. The capacity to deal with complex problems remains challenging, especially pertaining to decision making in the procedural planning stages. One of the most frequent findings in existing empirical studies on megaprojects is that decision making processes are organized in a manner that is too simplified to enable adequate decision making on complex issues (Priemus et al., 2007).

Debate and discussion surrounding the complexity of megaprojects and their failure to achieve development and performance targets have emerged in recent decades. Critics argue that top-down, linear, closed system planning, and rational technique approaches are incompatible with the dynamic character of TMs.

This study looked at the debate concerning performance failure and challenges in TM projects. The current limited planning approaches have not succeeded in bridging the aspects of complexity and uncertainty. Planning requires strategic adaptation in the face of fast-changing information, new technology, and interests of multiple actors (Chapman, 2016; Aritua et al., 2009). Studies about transportation megaprojects are still limited to project management, which focuses on time, budget, and performance results. This study argues that the planning of transportation megaprojects should be understood according to their inherently complex nature rather than approaching it as a mission to be fulfilled according to a strict deadline and budget (as is the focus in most of the existing literature). Complex projects should adopt nonlinear approaches and improve their ability to adapt in uncertain and highly dynamic situations. This philosophy counters the top-down decision-making approach that is typical for megaprojects. A comprehensive literature review was implemented to gain a deep understanding of TM planning characteristics and current planning approaches to identify gaps between the two.

This paper is organized into four parts. After a brief introduction, we explain the method we utilized to review the literature, followed by a discussion of the available research. The conclusion presents the structure of the debate, emphasizing an open system concept, non-linear and adaptive planning, and analyzing the characteristics of TMs. It also explores the challenges of complexity theory and the rational communicative approach in the TM planning phase. This paper discusses the nature of TM planning, its failures and successes, and approaches that have been utilized in developed countries. The empirical study results promote an understanding of the complex and uncertain nature of TMs and the typical planning approaches that have been implemented.

2. Methodology

Despite the debate over the use of non-systematic vs systematic reviews (Hammersley, 2006), this study employed both a non-systematic literature review (Huelin et al., 2015) and a systematic literature review. Literature review as a method can be useful for creating a foundation of knowledge and advancing the development of a theory (Webster and Watson, 2002). By using this method, a literature review can effectively synthesize empirical findings and interdisciplinary perspectives. In the first phase of our review, using the non-systematic technique, we reviewed relevant literature on megaprojects and transport megaprojects in general and on TM in particular, aimed at finding recent compelling issues. In the first phase, we found that megaprojects require complex planning activities and that there are paradoxes in the current implementation of megaprojects. The second phase was a systematic review focusing on the issues generated from the first phase; we predominantly used peer-review papers published in academic databases on Scopus and Web of Science (e.g., ScienceDirect, Science Citation Index, ProQuest). We selected papers published between 1950 and 2020. Books and papers on topics other than planning were included for the benefit of gaining a deeper understanding for analysis. More than 286 papers in total were reviewed. These were further analyzed to examine theories, best practices, gaps, and issues related to the planning of transportation megaprojects. The final selection included around 49 papers. A systematic literature review was used to narrow down the discussion on the theme of complexity, performance, and planning. We used a narrative (qualitative) technique to synthesize the review results in the first phase and used meta-analysis for a deeper understanding of the issues selected in the second phase to analyze the debate and discussion related to planning and TMs.

The literature was examined to build the structure of the debate in understanding the nature of TMs as complex projects, the paradoxes identified in the planning process, and the perspectives of planning approaches that have been developed so far. We conclude that, based on the complex nature of TMs, different planning approaches should be considered.

3. Discussion

3.1 Complexity of Transportation Megaprojects

The complexity of TM planning and implementation is a result of their large scale, which involves multi-layered institutions and organizations across administrative boundaries, high demand for financial and resource capabilities, and political context. Uncertain dynamics emerge among TMs due to fast-changing conditions that require the adjustment of certain purposes, interests, and tendencies (Giezen, 2012; Chapman, 2016). TMs that require a long period of completion frequently face high risk, i.e. risk that an uncontrolled situation may emerge due to the complex interplay between social, economic, and political stakeholders. For instance, deterioration of state funding due to a situation of uncertainty such as a pandemic, world economic fluctuation, or severe natural disaster will impact infrastructure development policies and regulations. Rothengatter (2019) pointed out that TMs are becoming too complex to handle, incurring excessive time and costs due to the long duration of planning and processing permissions as well as clashes between the various values and interests of public and private stakeholders. It is indicated that legal and political issues create technical problems during project implementation (Altshuler and Luberoff, 2003). A long period of planning and development puts the project in a fluctuated state in which different ruling parties may have certain political engagements. The transformation of political power between the planning and implementation periods may lead to a demand to transfer tasks to the next administration or to adjust the project to fit a new development vision, thereby further impacting the project commitment.

Most TMs are national strategic projects in which development that extends beyond cross-regional or even international boundaries creates rapid changes in the landscape of a region (Santamaria, 2013; Gellert and Lynch, 2004). The projects often face potential problems of community preservation due to inevitable migration (Santamaria, 2013; Delphine et al., 2020). TM development affects land use and the spatial formulation of cities' design policies. It challenges sustainability in terms of dense land transformation and puts environmental quality at risk by aggravating urban sprawl (Gellert and Lynch, 2004). Land acquisition problems provoked by dissent from disadvantaged and environmentalist communities often hinder project implementation and cause projects to be delayed, eventually undermining their performance. Each project has different complex challenges related to its initial environmental, social, and political conditions as well as its financial aspects (Rothengatter, 2019). This complexity is defined in some studies as the presence of interdependency between various discrete units (Bacarrini, 1996) and coordination between organizations that utilize different strategies and methods (APM, 2008). Furthermore, Chapman (2016) noted that complex projects frequently change character, which inevitably leads to the fluctuation of planning and implementation processes. The complexity of TMs affects the project performance and accomplishment in accordance with time, budget, and quality standards (Rothengatter, 2019; Chapman, 2016; Dimitriou, 2013).

3.2 Failures and Risks in Transportation Megaprojects

TMs are closely related to urban transportation development. Altshuler and Luberoff (2013) posited that there was significantly high investment in megaprojects involving transport infrastructure between 1950 and 1960. These TMs were related to the transformation of cities that took place after the Second World War in developed countries. At the time, development was carried out on a massive scale in order to rebuild city infrastructures and to revive cities that were degraded from abandonment and damages left after the war (Oureta & Fanstein, 2008). TMs, especially those that occurred during the post-1970s transformation, were closely associated with neoliberal and post-Fordist city restructuring efforts that affected the spatial configuration of cities, functions, policies, and government roles (Peters & Novi, 2012).

TMs are an important means for building the infrastructure of a city. Moreover, they have a significant impact on the pattern of activity networks, the development of local and national economic sectors, and income distribution – nationally and even internationally (Rothengatter, 2019). TMs require high financial capital, human resources, and technological proficiency. Accordingly, the success or failure of a megaproject can greatly impact the economic, political, and social stability of a state due to the significant centralization of resources. The measure of success depends on how efficiently a project can be accomplished in accordance with pre-determined planning. Problems in TM implementation have been identified as related to cost overruns, project delays, and failure to achieve standard public utility (Mišić and Radujković, 2015; Flyvbjerg et al., 2003). The iron triangle is a common standard used to indicate a project's success. However, Atkinson (1999) argues that one must consider a broader perspective to measure a megaproject's success or failure, based on the stakeholders' intentions.

Decision making is a significant feature in the early stages of a TM. The literature indicates that certain decisions lead to poor performance levels. These decisions are not only driven by a technical rationale but also by political ambitions. Optimism bias is indicated as a reason for the discrepancy between estimated costs and budget overruns (Flyvbjerg, 2008). Optimism bias creates a national risk because the allocation of funds and sources usually poses a risk to national finance. Moreover, the nature of long-term project planning and implementation is such that it cannot be finished within several governmental periods. As such, they are often laden with political constraints, making the economic, social, and political risks even higher. Risk is defined

as an uncertainty condition that can impact project activities (PMI, 2013). It is recognized that the risk as well as cost, ambition, and complexity of TMs have been growing over the past decade, affecting project implementation. Among post-failure project reviews, ineffective risk allocation was recognized as a failure factor in most megaprojects due to underestimated context and closed-system decision making. In contrast, cautious planning and understanding of uncertainties minimizes undesirable outcomes (Mišić and Radujković, 2015).

3.3 Paradoxes of Transportation Megaprojects

When projects experience distress in economic, environmental, and social enforcement, we often see paradoxes in megaproject implementation. Nevertheless, megaprojects are still being developed in cities around the world (Flyvbjerg, 2003). Projects with extensive budgets often encounter difficulties in delivering expected targets and experience problems during development due to underestimating budgets and overestimating source allocation and target achievement (Boateng et al., 2015; Flyvbjerg, 2003). Flyvbjerg (2011) has documented that cost overruns occur in 50% to 100% of megaprojects. Furthermore, problems of fallacies in feasibility studies occur about 20% to 70% of the time. The considerable work that goes into preparing a preliminary study for a multi-billion-dollar project is called into question and criticized in terms of its basic accounting principles. The risk of conducting a preliminary study based on limited data and time is that it becomes a justification for substandard work, delays, and unexpected environmental and social problems. We must question why unexpected performance levels and failures still occur during TM implementation. It seems as if we have not learned from experience.

Studying the nature of problems and failures related to target performance levels among TMs brings us to four paradoxes in TM development that deserve attention:

- *High Sustainability Risk (economy, social, environmental) – Low Risk Mitigation Planning:* TMs are expensive projects involving large-scale development that significantly impact the sustainability of the economy, social structure, and environment. Projects typically utilize a large proportion of GDP, thereby placing a nation's economic condition at risk (Eweje et al., 2012; Flyvbjerg et al., 2014). For example, Hong Kong's economy was impacted by the new Chek Lap Kok Airport that opened in 1998, losing a reported 600 million USD (Flyvbjerg, 2012). The High-Speed Railway Ulm-Stuttgart that was proposed in 1996 in Germany faced postponement due to financial problems and protest movements before it was finally implemented in 2010. The project was reported as a planning failure (Rothengatter, 2019; Flyvbjerg, 2012). Cost overruns showed that poor performance related to budget estimations occurred due to a tendency for gross estimation errors (Boateng et al., 2015), inducing a budget increase along with an increase in work volume (Jorgensen et al., 2012). Flyvbjerg (2002, 2009) explained this as optimism bias, wherein budget, time, environmental, and technological constraints and risks are undervalued and are often not taken into account at all. Low risk mitigation planning related to natural, technological, financial, and human resources increases a project's susceptibility to risk and failure.

- *Medium to Long-Term Impacts – Short-Term Planning Considerations:* TMs typically require a medium to long-term development period and an implementation process that requires appropriate preparation for possible uncertainties that may arise during the construction phase. Chapman (2016) explained uncertain situations within and outside projects in terms of the dynamics of the objectives and scope, organization, management and strategy, stakeholder expectations, and the connection between them. The extended planning and construction process poses a risk to maintaining mutual commitment between stakeholders due to ever-changing political and social situations. Short-term actions that do not invest much attention in risk assessment create the risk of uncertainty, improper decision making, and divergent values among

various stakeholders (Flyvbjerg, 2003). In fact, TMs that begin development before requirements are met, face various unanticipated issues (Morris & Hough, 1987) that lead to more intricate problems during the development process.

- *High Experience – Low Learning Impact:* TMs have been implemented for decades, but empirical studies have shown that TM failures continue to occur despite preparation and consideration of previous project failures. Failure to learn from previous mistakes and understand the context of TM projects is the main reason for TM failure (Pinto, 1996). In conjunction with growing experience, knowledge, and understanding, TM projects should operate more smoothly than their predecessors (Chapman, 2016). Pinto (1996) states that failure to learn from previous mistakes and understand the complex character of megaprojects are the main reasons for project failure. Further, there has been a failure to share knowledge and experience due to avoidance of reflective feedback (Mišić, Radujković, 2015).

- *High Standards – Low Performance:* Megaprojects require very large investments that frequently place state finances in a critical position due to abundant development needs and demand for high-quality sources. As such, the expected performance standard is necessarily high as a justification for the resources used, including the professionals, technology, and skills involved. The technology used is sometimes imported from other countries and requires a significant allocation of time, finances, and capable human resources to master its use. However, successful implementation of a megaproject is often difficult to achieve considering that such projects require proper scopes of work and re-assessments (MPA, 2013). This often leads to failure to sustain the business through finance mechanism enforcement (Mišić, Radujković, 2015).

These paradoxes imply that the significance of the TM planning phase needs to be examined further. Inaccurate planning and unsteady financial frameworks appear to be the norm in TM planning and construction (Rothengatter, 2018). Expected future economic and social benefits seem unfairly measured in terms of cost estimation and resources utilized. Should TM planning approaches not improve, project failures and serious economic, social, and environmental problems are sure to persist in the future.

3.4 Potential Planning Approaches

Aside from the high-cost requirements, TMs also involve complex, ambiguous organizations, full of uncertain political ambitions, and high risks of failure (Baccarini, 1996). According to Mišić and Radujković (2015), megaproject planning failures occur due to the closed system of decision making involved in the planning. Moreover, the context of complexity and uncertainty in the planning process is often underestimated. This is related to a top-down and technocratic system, which tends to encourage the planning process to move linearly. In contrast, the highly dynamic and protracted development period affects the open and complex reciprocal process and adjustment efforts (Baccarini, 1996; Chapman 1998). TMs involve multi-layered stakeholders and actors, and the decision-making process is complicated due to the interplay of different views, interests, and rationality between them. Existing complexities are related to time constraints, diverse interactions among stakeholders, complex technology, high demand for human resources, and a high degree of uncertainty (Dimitriou et al., 2013; Flyvbjerg, 2014). As explained by Chapman (2016), the complexity of TMs stems from high ambiguity originating from the context and culture of the project itself. Giezen (2012) argues that complexity arises from a dynamic environment, ‘a context that often changes’, which he considers to arise from the interests, goals, constraints, and ambitions developed. This complexity can also be seen from unexpected changes in the scope of the project arising from the need to meet the requirements of external stakeholders,

thereby threatening the project's ability to achieve its performance levels and mission-based targets. The failure to understand these characteristics leads to poor decision making and complicated problems in the future.

The success of a TM depends on the complexity and uncertainty involved in the decision-making phase (Dimitriou et al., 2013). The reduction and management of uncertainty among TMs was studied by Giezen (2012), using the Beneluxlijn project as a case study. The findings showed the benefit of maintaining uncertainty factors within a safety zone. Giezen also argues that disadvantages come from focusing only on cost and time targets and that oversimplification will potentially lead to underperforming projects due to limited vision and goals. Planning approaches tend to be linear and technocratic, because such approaches are regarded as effective and the only way to face complexity and uncertainty by reducing the processes and centralizing the power for decision making. Technocratic thinking emphasizes using rational science to control state and political conditions or decisions. In TM planning, a multi-stakeholder and multi-layered agency will influence the effectiveness of the decision-making process, while the failure of TMs is often caused by stagnancy in communication and an unsuccessful learning process between participants and actors involved (Mišić and Radujković, 2015; Flyvbjerg, 2003).

The paradoxes identified show that TM complexity cannot be ignored. The project dynamic requires preparation for change and an ability to adapt and learn over time. Flyvbjerg (2003) proposes that stakeholders consider risk and accountability by improving transparency and arranging institutional decision making. The study suggests using carefully acquired information, as misleading projections will risk a substantial loss of resources. In fact, TMs often face changing situations that necessitate the revision of outdated planning concepts and designs (Rothengatter, 2018). Limited cognition in the early stage of projects, including misinformation on geographical conditions, environmental and social constraints, and the utilization of new technology will lead to the accumulation of intricate problems during the planning and construction phases. Long-term transportation planning must be robust, especially under fluctuating political and economic conditions.

Decisions in the planning process involve joint adjustments between different viewpoints and competition between various interests, objectives, and methods, as explained in the incremental approach (Lindblom, 1959). TMs typically adopt a linear, incremental, and rational technical approach to simplify and properly manage activities and processes, while the linear planning process is mostly applied at the construction level, typically treating interactions between subsections that can be managed by a single flow in parallel or overlapping sessions. The process lacks suitability to deal with the dynamic nature of changing political, economic, and social situations that impact the scope and design of a project. Chapman (2016) states that the linear approach tends to neglect the feedback loops essential to the decision-making process. The incremental approach has also been criticized for its alignment with the dominant group and maintenance of the status quo, which defeats weaker interests and limits innovation in the planning process (Bertolini, 2010). TMs cannot be approached in this way; rather, they require an approach that can accommodate constructive reviews and aspirations from diverse actors in situations that are dynamic and difficult to predict (Giezen, 2012).

The main goal of planning is to gather the best in knowledge, skills, and imagination to solve complex problems and create successful solutions (Salet, 2013). The TM planning paradoxes described above illustrate that the current planning approach cannot mitigate risk. Planning should have the ability to deal with complexity, adapt to fast-growing information and remain open to opportunities as well as challenges. Research has shown that an open system approach is needed to frame various decisions relevant to dynamic conditions (Dimitriou, 2013). Soderlund et al.

(2018) explain that the problem in megaprojects lies not only in the technical rationale but also in the social-technical aspect, which is often not considered. De Roo (2010) emphasizes that planning needs to be shifted from technical rationality to communicative rationality to address modern complexity in planning practice. The planning stage involves a struggle of political influence and power through lobbying, mediating, and the involvement of public participation in the decision-making process. Communicative planning allows people to develop, confirm, and revive their relation to others in their group. Moreover, it has the potential to reconcile itself with a completely different approach to reach an agreement in the planning process (Healey and Hillir, 1995). Thus, the dominance of rational, rigid, and linear planning is considered irrelevant because careful judgment will be difficult to obtain, and the limitations of human intellectual capacity will never allow for an adequate understanding of the increasing complexity of TMs (Webber, 1973).

3.5 Challenges in Transportation Megaproject Planning

The implementation of megaprojects has often drawn criticism related to their top-down and technocratic authority systems (Scott, 1998) and their negative impact on communities due to often unavoidable population displacement (Fainstein et al., 1986). This is also driven by the politically charged nature of megaprojects. Developing an inclusive city requires sensitivity in the planning process to avoid injustice and exclusivity. Inclusive regional design, financing, and governance will reduce the negative impacts of MPs on the community and even encourage cultural socio-economic justice. Appropriate design, financial, and inclusive governance mechanisms will encourage the creation of more socio-economic development areas (Lane, 2017). TMs require involvement from multi-layer stakeholders; therefore, public participation and transparency are crucial. Accordingly, uncertainty and problems cannot be detected during the early stages of a project, and future social and political problems will increase the difficulty of project completion.

The dynamic and escalating problems involved in MP planning are caused by conventional approaches, wherein the planners define project goals and success based on limited financial, time, or specification goals and neglect the wider potential impact of the TM on the community and the environment. Dimitriou et al. (2013) emphasized the importance of planners carefully considering the benefits as well as the risks of TM developments for the broader community and region. Decision making is ultimately carried out by attempting to simplify or divide problems into stages among agencies that are closely connected with the implementation of urban infrastructure development and transportation projects. Problems also arise when dealing with bureaucratic bodies, which have multi-layered institutions and regulations. It is known that public authorities have an unfavorable culture of preserving uniform routine activities with a limited capability to achieve predefined targets and goals. They are not equipped to deal with complex and rapidly changing problems (Innes and Booher, 2010). The development of the communicative planning approach in the 1990s highlighted the potential for conflict due to the emergence of various goals of various actors during the planning process. The communicative approach conceived by Forester (1989) and explored further by Innes and Booher (1995) offers a consensus-building approach that promotes collaboration and encourages the participation of various stakeholders in the planning process. Such consensus-building offers a way to resolve conflicts and achieve planning objectives. Of course, such a process is essentially political.

Healey (1992) further developed this communicative and collaborative approach by broadening the Habermasian view and the power structure in planning proposed by Forester (1989). Recognizing the increasing complexity of MP planning, rational collaborative theory promotes a synthesis between participatory action and political science. In their book, *Planning with Complexity*, Innes and Booher (2010) examine the extent to which the science of complexity

provides a framework for rational collaboration. The decision-making process requires extensive communication and negotiation between organizations to resolve the conflict between organizational interests and goals. The negative impact of ineffective communication between competing teams and organizations based on OMEGA case studies occurred in 40% of transport projects, leading to failure and delays in TMs (Dimitriou et al., 2011). Long-term relationships between organizations and stakeholders should be maintained, especially in the case of political commitments. Interestingly, the Japan Railway Project was discovered to have successfully created a long-term institutional scheme because the railway industry is part of a large national coalition with political support (Muromachi et al., 2010; Dimitriou, 2012). The consultation process of gathering early perspectives from experts and the community was significant in the first study. For instance, the Big Dig in Boston and the Train Grande Vitesse (TGV) in France stated that they experienced an effective public dialogue (Dimitriou, 2013). The rational communicative approach is undeniably dominant in the planning stages of TMs, whereas the technical aspect still requires consideration. Both have a reciprocal impact that can make the planning process either more effective or more complicated.

Complexity in TMs involves dynamic and non-linear realities that are continuously being updated by the planners. This complex nature of generative interaction in the social world greatly depends on human actions and interactions. The main task of planners is to work with various active permits to determine various strategic decisions and to complete actions that will produce the desired future, with requests determined through supported processes (Byrne, 2003). The Theory of Complexity is still being explored in the world of practitioners. The current academic debate concerns various definitions or meanings of the term 'complex' itself, which translates into various planning issues that are not well understood. Both are considered to be very different — complexity refers to the qualifications of a temporary situation, while planning refers to a rational process that guides actions from existing situations towards imagined future situations (De Roo and Silva, 2010). The growing complexity within planning that stimulated opposition towards the object-oriented attitude of technical rationality and the existence of general principles independent of social forces by critical rationalists shows a shift from modernist assumptions to postmodern attitudes. Thus, planners have the potential to have intersubjective orientations which are as important as efforts to focus on the objectives of planning itself (De Roo, 2001).

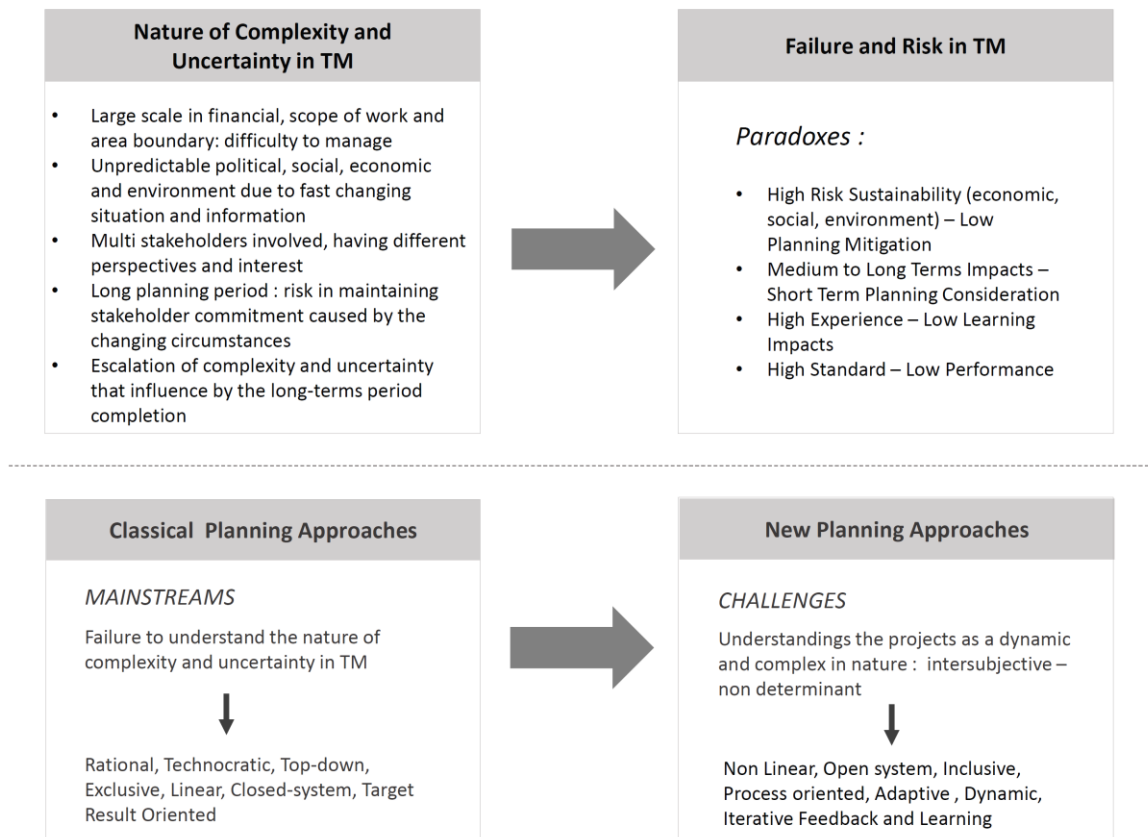


Figure 1. Literature Review of TM Planning

The paradoxes mentioned above show that TM planning should transform to be more adaptive to the nature of complexity. Decision making plays a significant role in the planning phase and is closely related to the capability of learning (Giezen, 2012) and flexibility to deal with uncertainty. Nonlinear and deterministic approaches will open the possibility for planners and stakeholders to explore more flexible, more open aspirations and ideas, and encourage effective learning processes in every planning stage. A dynamic situation will enforce adaptive planning (Chapman, 2016), while proactive planning with reciprocal feedback builds more responsiveness in the TM planning process. Learning through continued adaptation will build a fundamental knowledge base for decision making. A complex system will continue to adapt, co-evolve, and self-organize regarding the interaction between actors and institutions (De Roo and Silva, 2010). The four above-mentioned paradoxes are interrelated because a small change can elicit certain effects within the planning stage as well as in the planning process as a whole. Within this complex system, a small shift could bring about a significant impact. As such, one must consider the entire system rather than only focusing on one individual part.

4. Conclusion

Failure to understand the nature of complexity in TMs causes most projects to fail to attain the expected benefits and outcomes. The paradoxes discussed relay how TMs struggle over decades to deal with political distress and financial constraints that lead to the problems of low risk mitigation planning, short-term planning considerations, low learning impact, and low performance indicated by this study. These paradoxes have a significant correlation with the

planning approaches and procedures that are currently applied. TMs have drawn criticism for their top-down and technocratic authority systems (Scott, 1998) and their negative impact on the environment and communities due to population displacement (Fainstein et al., 1986). The nature of TM planning, decision making, and governance processes is complex. These factors are influenced not only by rational thinking, which usually guides the direction of modern urban planning, but also by various externalities that are dynamic and uncertain. Rationality and linear planning in megaprojects are always limited and imperfect in action. Planners and decision makers usually try to solve problems with insufficient information and resources (Baccarini, 1996; Williams, 2010). Brockman et al. (2016) believe that the intricate and difficult problems that arise in the planning of complex projects have the potential to encourage an innovative and adaptive approaches. A new approach is needed to build a framework for understanding the complex relationships between the process and the roles of the multiple actors involved in TM planning.

TMs must be understood through their complex nature. Complexity theory can explain how a nonlinear view of planning through adaptation, co-evolution, and self-organizing suits the character of such dynamic projects. Awareness of the intricacy of the planning process is important, as support or opposition of multiple stakeholders may be encountered during project planning and implementation. The uncertainty of complex projects makes communication and interaction increasingly important (De Roo and Silva, 2010). A rational communicative planning approach to TMs should be explored to improve stakeholder commitment and adaptivity within a dynamic situation due to unpredictable socio-economic and political circumstances. Collaborative and collective actions play an important role in the TM decision making process. Innes and Booher (2010) suggest that collaborative processes are more effective when seen as complex adaptive systems. Involvement of stakeholders from the early phases of a TM project is crucial. Through sufficient diversity of ideas and knowledge, they will adapt and reorganize independently. Complexity thinking offers an understanding of the intricate problems related not only to rational techniques but also to social and political distress as defined in the paradoxes. New TM approaches should consider building an understanding of the complexity and uncertainty involved in TM planning that demands a new creative approach to dealing with complex projects. The gap between the nature of technocracy and the focus on the result should be strategically eliminated. The challenge remains to figure out how planning can be a part of the solution in complex projects.

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