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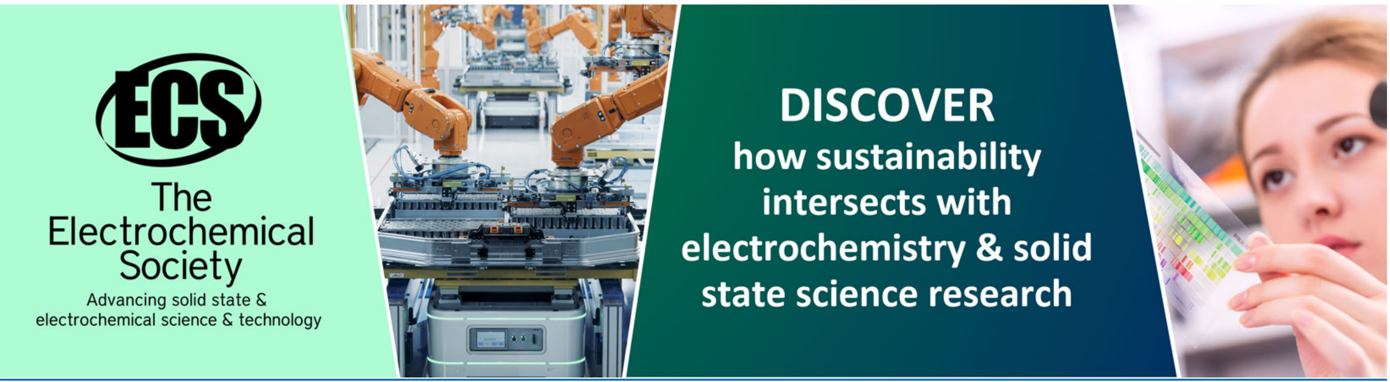

Determining duration of performance-based contracts based on fair payoff for the government and contractors

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Abstract. Conventional contracts are one of the road maintenance contracts based on the number of jobs measured and paid at an agreed level for different work items or referred to as unit price contracts. Meanwhile, performance-based road maintenance determines the minimum conditions of roads, bridges, and traffic assets that must be fulfilled by contractors. National road maintenance in several developed countries has successfully used integrated contracts, performance-based contracts. This is followed by the developing countries that previously had problems with the quality of national roads in which they were unable to provide the desired level of service. This performance contract prioritizes products and it is up to the contractor how to achieve this. Therefore, the choice of design, application of technology, innovation, process, and management are all determined by the contractors. This allocates higher risks to contractors compared to traditional contracts. But at the same time, it opens opportunities to increase margins where increasing the efficiency and effectiveness of design, process, technology, and management can reduce costs to achieve established standard performance. This study uses simulations to obtain the duration of fair and optimal contracts for the government and contractor. Duration 5 -7 years is determined a duration that can provide benefits for both parties.

Keywords: game theory, performance-based contract, risk sharing, system dynamic.

1. Introduction

As part of the national transportation system, traffic and road transport have a strategic role in supporting integrated national development as part of the efforts to advance public welfare in a country. The potential role of road infrastructure must be developed to realize smooth traffic, safety, security, comfort, order, and smooth road transportation in supporting economic and regional development. Increasing road access has a crucial role in improving people's quality of life [1]. Compared to neighboring countries, such as Malaysia and Thailand, Indonesia is still far behind in the field of quality and service level of roads in the period of 2010-2011. This condition shows that Indonesia is still far behind in an effort to improve people's quality of life. 90% of freight transports are carried out by land transportation by road; this creates inequality because most of them carry cargo with a greater capacity than the stipulated rules. As a result, road damage cannot be avoided. Every year, the government has tried to provide a relatively large development and road maintenance budget, but the funding needs to be provided cannot maintain all road assets in a stable condition [2].

The high percentage of road damage is mainly caused by (1) the low quality of construction work; (2) overloading and over-dimension of vehicles crossing the main road in areas on Java, Bali and Sumatra; (3) poor coordination between the competent agencies on national roads and limited resources so that they cannot carry out maintenance regularly [3]. Different perceptions of the causes of road damage still occur frequently among stakeholders. All agencies should have a common understanding and agreement to tackle the causes of damage to national roads. During this time, each agency considers that the damage to the road is not caused by the fault of the agency. If the Ministry of Transportation thinks that road damage is caused by road construction, water, and road drainage; while, the Ministry of Public Works thinks that road damage due to excessive load of vehicles. Both of these perceptions can be used as the basis for the cause of road damage; thus, it needs a solution that can solve the problem of road damage [4].

The problems that occur on national roads become a challenge to increase the accountability of road operators by increasing openness, being responsive to problems in the field, and handling issues effectively and efficiently. The risk management approach can be applied given that each road segment has a different degree of priority and risk profile. So far, all the risks that have resulted in poor road services borne by the government should be taken by the party who caused the chance to occur. Long-term road damage has not been able to encourage improvements in the quality of construction service products in a structured manner, and this is because the delivery system used still creates a gap between the service users and service providers, thus innovative forms of contracts and procurement are needed. The purpose of users and service providers with a fair and proportionate risk sharing scheme can be seen in the following figure [5].

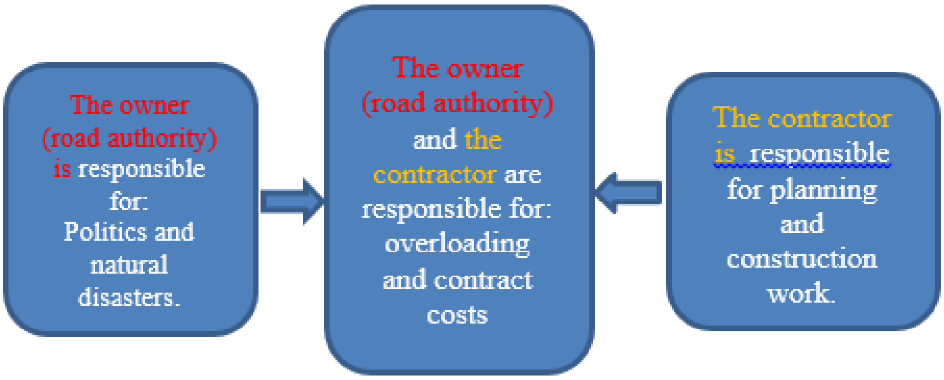

Figure 1. Recommended PBC Risk Sharing in Indonesia [6].

Identification of risks that may occur in the implementation of performance-based contracts (PBC) is necessary. Risk must control in a PBC; if too many risks allocated to the contractor, the price will be high, and if too little chance is diverted, the goal of obtaining the efficiency of the contract will not be achieved [7]. In PBC, traditional contract risk is transferred to contractors and they must ensure that network performance is in accordance with specifications in return for agreed lump sum payments [6]. The recommended risk-sharing approach for PBCs in Indonesia can be seen in figure 1. Figure 1 shows the risk sharing of PBCs is divided into 3 parts: government risk in the form of political conditions and natural disasters, contractor risk in the way of planning and construction work in accordance with requirements, and the risks that must be borne by the government and contractors are overloading and contract costs.

Currently, the the implementation of PBCs in Indonesia faces the following constraints, namely: (1) Policy issues including utility services, limited access to regulations, short duration of contracts (4-7 years), escalation of fees, interest in late payments by clients, maintenance data reports, management of traffic signs; (2) Legislative changes because of financial arrangements for multi-year contracts and vehicle overload control; (3) Contractual issues; benchmark data collection, organizational structure proposed in the agreement contract, selection of performance-based contract consultants, tender process, initial investment (in the form of work quality) to support and repair capacity during maintenance services, key performance measure, training and knowledge transfer, and construction industry development [8]. In the condition that the contractor bears the risk, the contractor carries out planning and implementation work following the stipulated requirements. However, the implementation of this PBC experienced difficulties especially with the risks received due to the lack of risk analysis before the procurement process was carried out [9] and very long life cycle project risks compared to traditional contracts [10].

Based on the described to solve the problems in the implementation of PBC, this paper analyzes the government strategy for PBC sustainability. Meanwhile, the goal of this study is to obtain an optimal duration for both parties, government and contractors, get a fair and balanced payoff.

2. Methods

This study used a System Dynamic (SD) simulation because the compiled model was not intended to make forecasting projections longer than the time available to achieve validity as accepted by many parties. SD has the power to show the relationship between variables, the right to use at a high level of aggregation (country or world) when the past affects the future and movement based on time becomes essential. The SD approach is also in line with the challenges of developing performance-based contracts that have high complexity characteristics such as multi-sector involvement consisting of several stakeholders from the government and the private sector. To get results in the form of a balanced payoff or income between stakeholders, in this case, the government and contractors, the output in the SD simulation was used as input in Game Theory, mathematic programming used for decision making on the issue of strategy selection involving multiple players. The results of mathematic programming directly show the strategy that must be chosen where this strategy produces the fairest and the optimal payoff for the government and contractors. Making a conceptual model by describing causal loop diagrams was the first step in system modeling. This causal diagram was used to visualize the system in general which was simulated by a dynamic system method through important risk components. These components became variables, parameters, and constants which were interdependent and affected the behavior of the system.

The SD model was completed using software specially designed for SD simulations such as Vensim, Stella, etc. Using the software, the model was made graphically with symbols on variables and relationships. There were two things, software structure and behavior. Structure is an element forming a phenomenon. Patterns that affected the interrelationship between stock (level) and flow (rate) factors, in representing activities in a feedback loop, were called stock (level) and flow (rate). Level states the system condition at any time and an accumulation in the system. The equation of a variable rate is a policy structure that explains why and how a decision is made based on the information available in the order. Rate is the only variable in the model that can affect the level. Auxiliary is a thing that can complement stock and flow variables, in modeling SD. Source is set of components outside the boundaries of the model created, and the termination of the system is also called a sink. After SFD (stock-flow diagram) formed, the formulation of the simulation model in the form of mathematical equations can enter into the formula column in the software. The simulation model can run if the SFD and mathematical formulations, and parameters determines the right initial conditions.

Furthermore, the game theory approach uses Gambit software. Using this software, several equilibrium criteria can be selected and appropriate to produce payoff. This software will process according to the chosen equilibrium criteria, and the results are determined by the data entered to provide the most optimal payoff for the concerned parties.

3. Results

Based on the simulations that have been done in the last paper, the parameters that greatly affected the success of PBCs were only the parameters with high sensitivity, namely: (1) available data, (2) human resources understanding to the PBC system, (3) the time of bid submission, (4) limited design time, and (5) coordination capacity between ministry. In this paper, model development could be done using a case study on a project with a PBC at the Semarang-Bawen section. The risk factors that have been generated were used as a benchmark or the main guideline in the formation of a simulation model. As a characteristic of an SD, it used parameters derived from previous research and based on project contract data and actual field conditions. The resulting model was simulated using a duration of 4 years, 7 years and 10 years. This was based on the duration of the pilot project that has been carried out in Indonesia, namely the duration of the 4-year, 7-year contract and the 10-year. In this paper, the simulation of PBC models with simulators was generated by interfaces in SDs. Simulations were carried out with controlled and uncontrolled inputs along with strategies from the government and contractors. The results of the simulation on the SD show that government payoffs and contractors were used as input to simulations with game theory to obtain an optimal payoff for the government and contractors. Figure 2 shows the simulator interface of PBC scheme in 7 years duration contract.

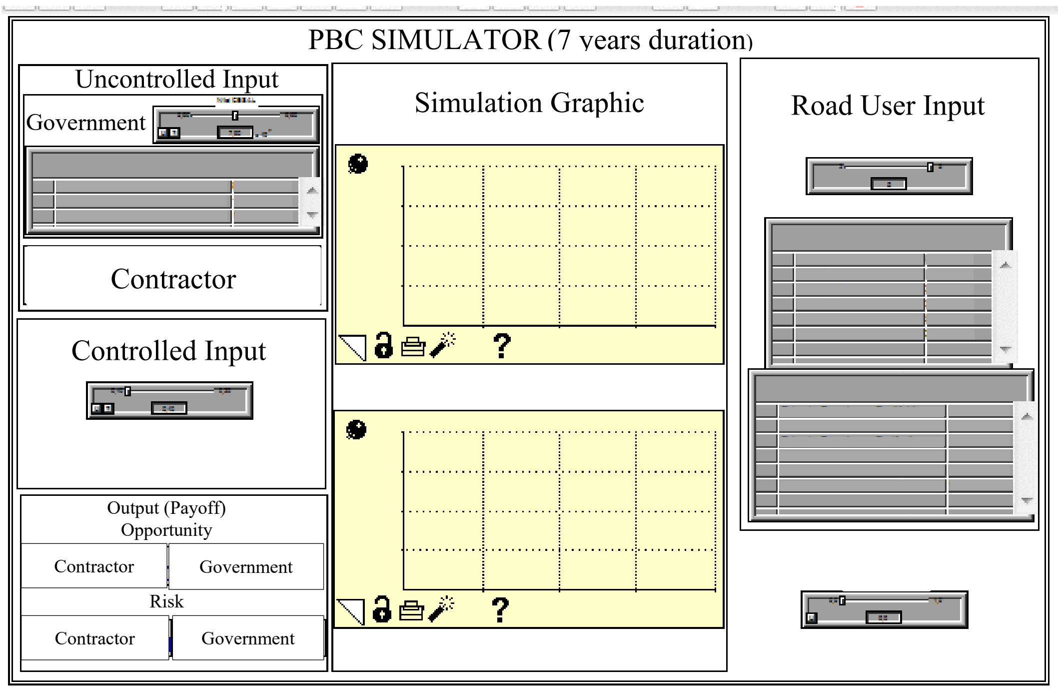

Figure 2. Simulator Interface of PBC Scheme [11].

The strategy formation with game theory involves 2 (two) parties. First, the government adopted PBC hoping that it will reduce the risk of repairing national roads showing early damages due to vehicle overloading, poor planning, poor construction work, and poor supervision. The government handed over the risk to parties who were supposed to be responsible for the planning, construction, and supervision of national roads. Second, the contractor, as the third party that has the assignment of implementing an integrated contract. As a service provider, contractors are only willing to bear the burden that is the responsibility of the contractor without being burdened with overloading. Prohibition against overloading vehicles should be the government's policy not to allow these vehicles to throughout a national road with PBC contract. However, in Indonesia, there are laws that prohibit vehicles overloading and over-dimension to passing national roads. The SD framework in controlled inputs comes from the government and from the contractor which is a system behavior that can be controlled by each player in the game. Uncontrolled input is a system behavior that cannot be controlled by each player and the output destination is the result of each player based on controlled and uncontrolled input. SD simulation is a tool to get results in the game theory matrix. The strategy chosen for all players uses Nash-equilibrium which is a game theory approach.

The strategic form in game theory is a payoff diagram of results, in this case, the 2-player outcome diagram. The players involved and the strategies they have are as follows:

Government's Strategy: duration of maintenance services. As we know, the maintenance service period is the longest duration in PBCs, empirically a long duration will increase the risk of the contractor. To reduce the burden on contractors during this maintenance service, the government needs to consider the optimal duration of maintenance services so that contractors can still feel the payoff of implementing the PBC.

Contractor's Strategy: duration of construction realization and overloading compensation for vehicles through national roads with PBC contract. In implementing this contract, the contractor is well aware of the great risks faced by this long duration contract. Therefore, the contractor needs to make efficiency in the construction work. The contractor chooses to carry out work innovations with the duration of completion of the work done faster without reducing the quality and performance indicators specified in the contract. The contractor also has the obligation to provide a weigh in motion (WIM) tool to detect overloading and over dimension for vehicles crossing national roads with PBC contract. Thus, overloading compensation is also a contractor's strategy of getting a balanced payoff between the government and contractors. When the project is running, there are things that cannot be controlled, namely average daily traffic.

The payoff for each combination of strategies was in rupiah units. For the government, it was the positive payoff with the existence of the PBC project. Meanwhile for the contractor, it was the positive payoff (income) received while working on the project with a PBC contract. Figure 3 shows tree diagram to get optimal payoff for government and contractor.

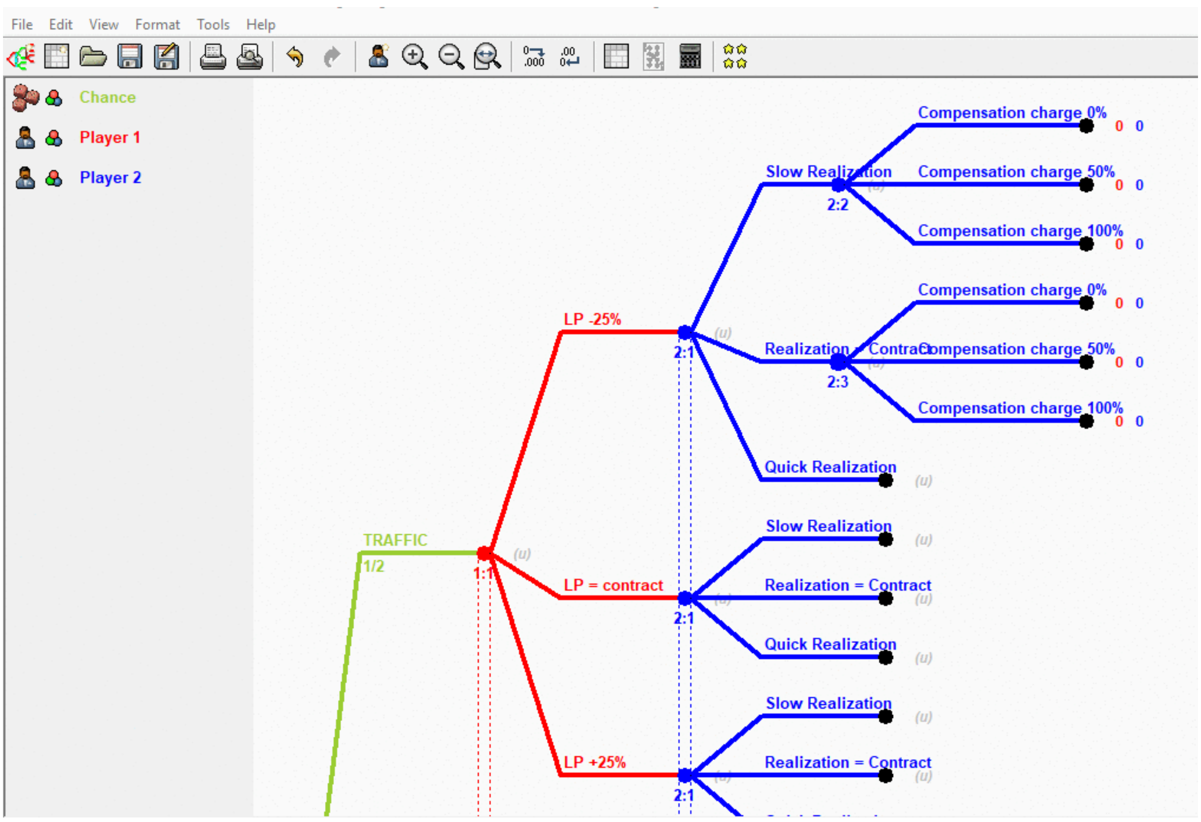

Figure 3. Tree Diagram.

4. Discussions

The simulation and determination of the optimal payoff for the government and contractors show a payoff in the condition of 50% overloading compensation. The planned 4-year contract will produce a mutually beneficial payoff for the government and contractors if it us done faster with a duration of 2 years. The contracts with a term of 7 years leads to an optimal payoff if it is done for a term of 5 years. The 10 years contract will provide a reasonable payoff for both parties if it is done with a duration of 7 years. The PBC contract contains high risk, the contracted value already contains the amount of the risk that must be borne by the government and the contractor. In the countries that have succeeded in implementing PBC on national roads, basically, they have freed the roads from overloading or use other modes of transportation such as trains. The obligation to install weigh in motion (WIM) equipment as required in the PBC contract in Indonesia has not helped contractors much prevent vehicle overloading through the roads with PBC contract. Although, the WIM required with specifications of financing and operation was charged to the contractor and the consequences of vehicle overloading were also borne by the contractor. If this continues, the purpose and objectives of the application of the PBC will not get optimal results. The PBCs are risk sharing, thus, if one of the two parties is still experiencing a loss, the government’s decision to implement the PBC that can be considered unsuccessful.

5. Conclusion

In this study, it was proven that the risk level in the PBC with a duration of 7 years tended to decrease until the end of the contract period, while in the conventional contract the risk level would decrease until the completion of the planning period and the construction period would increase again during the maintenance service. This means that the implementation of performance-based contracts can reduce the risk of road maintenance compared to using traditional contracts. Risk management in this study is the discovery of government strategies and contractor strategies, the results of which are beneficial for both parties which have included variable overloading compensation if there are vehicles that violate the weight regulation. The government as the road manager gets a payoff if the national road can be passed by road users safely, comfortably, and faster travel time so that the operational costs of road users can be reduced while the contractor benefited from the profits earned while working on the project with the PBC.

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