Modeling the Evolution of National Road Procurement Strategies

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Abstract— Many transportation agencies have discovered that traditional highway contract administration procedures and project delivery methods do not meet current demands. In response, they are turning to alternative contracting. Four trends are perceived in road management. First, with respect to project delivery, more and more projects are contracted for the whole life cycle of the road. Second, contractors are given increasingly more freedom or design space, as the indicators used for monitoring their work become less operational and more performance based. Third, governments follow a dual track strategy; managing a portfolio of directly and indirectly financed projects; dependent on the project characteristics. Fourth, contracts are granted for longer term. These innovative forms of contracting are expected to yield more flexibility in the road sector; more innovation, higher performance and consequently lower costs while keeping up service levels on public values.

This paper presents how by using a combination of institutional economics theory and engineering design theory, our aim is to build a systems dynamics model that can capture the institutional context and is able to indicate what contracting practices are likely to occur and which ones are likely to succeed in view of the meeting the public values and demands.

Keywords— System Dynamics, System Analysis, Road contracting, Procurement Strategy of Roads.

1. Introduction

Many transportation agencies have discovered that traditional highway contract administration procedures and project delivery methods do not meet current demands. Some of the problems being faced by Road Administrations around the world are; insufficient funds to meet satisfactory levels of all roads (Miller 2000; Cox, Molenaar et al. 2002; Pakkala 2002), little innovation (Manley and McFallan 2003), little value-added services for the client and a general lack of integration between the phases of the road life cycle.

In response, they are turning to alternative contracting procedures to keep up with the reconstruction and growth needed. Four trends are perceived in road management (Altamirano and Haraldsson 2005; Altamirano and Herder 2006). First, with respect to project delivery, more and more projects are contracted for the whole life cycle of the road. Second, contractors are given increasingly more freedom or design space (Herk, Herder et al. 2004), as the indicators used for monitoring their work become less operational and more performance based (Cervera and Minchin 2003). The third trend, concerns project financing in which private investors are playing and increasingly higher role and governments follow a dual track strategy (Miller 2000); managing a portfolio of directly and indirectly financed projects; dependent on the project characteristics. Fourth, contracts are granted for longer term.

These innovative forms of contracting are expected to yield more flexibility in the road sector; more innovation, higher performance and consequently lower costs while keeping up service levels on public values such as mobility, safety and the environment. However, the limited application of these innovative contracts and the continuous reform in all the different dimensions of the procurement strategy (i.e. project financing, project delivery methods) do not allow to reach consensus about the effects of these practices in terms of performance and economic efficiency. Moreover, as the government agencies advance in the use of these innovative procurement practices and its role become more that of a regulator and quality monitor, than a direct operator of the road network; the more urgent is to research the possible complementarities and tensions between the (technical) aspects of flexibility and those regarding public values.

Consequently, the problem being faced by national road infrastructure systems and by many other network bound infrastructures in the last decades can be pictured as an important trade-off of "How to achieve the results expected from innovative contracting –mainly improvements in efficiency and innovation-, while keeping the room for strategic behaviour (of contractors) and the effects of it at the minimum possible?"

The paper presents the research framework being proposed for the analysis and study of how different countries have given solutions to this problem, by applying and evolutionary and systems dynamics approach. System Dynamics presents a great opportunity to understand the evolution of these different trends because this technique allows the researcher to place the analysis in time and to represent , when present, phenomena's of "increasing returns"; which makes the timing of the so called "small events" (Arthur 1994) or historical events determinant for the final or evolutionary equilibria the system will reach.

By using a combination of institutional economics theory (mainly principal-agent) and engineering design theory (mainly functional requirements engineering), our aim is to build a systems dynamics model complemented by Role Playing Games that can capture the institutional context and is able to indicate what contracting practices are likely to occur and which ones are likely to succeed in view of the meeting the public values and demands. Several international case studies will be used to build and validate our model. The research questions, the theoretical background –mainly related to the evolution of institutions-, the research approach proposed and the analysis realized making use a first conceptual simplified version of this model will be presented in the paper from section 2 to 5. Section 6 present a discussion of

the remaining challenges and questions that need to be solved in order to arrive to the expected simulation models. Finally in section 7, the most important conclusions of this paper re presented.

2. Research Questions

The research project "Cross-national benchmark of Roads Infrastructures: Performance Indicators and Innovative Contract Arrangements" aims to answer the following question: How to achieve the results expected from innovative contracting –mainly improvements in efficiency and innovation-, while keeping the room for strategic behaviour (of contractors) and the effects of it at the minimum possible?

The main result expected from the research is thus an overview of lessons each of the countries can draw on their own position and on how the other performs and to a evolutionary and dynamic benchmarking framework that could serve as a tool for countries to evaluate if elements from practices elsewhere can be incorporated in their own regulatory regimes, contractual arrangements and practices at home

The most important sub questions are: a) What theories are relevant in order to analyze the features of the different countries concerning innovative contracting policies in Road Administration and the practices resulting thereof?, b) What are the contracting practices in the different countries and how did they evolve?, d) What are the main similarities and differences between the practices of these countries concerning the contracting and administration of roads?

The most important propositions are:

- The countries more successful in the use of innovative contracting practices were the ones that implemented them in the more "coherent" way (proper timing, taking into account synergy between different policies and overall coherency of the system), or contrarily
- The ones that followed an "ad-hoc" approach, by applying each policy individually, not paying explicitly attention to the coherency and synergy between policies, but rather applying extra measures per each new policy implemented (i.e. the use of technical measurements together with the use of Key Performance Indicators in order to reduce the room for strategic behaviour).
- Changes have mainly as a reason the financial deficit experienced by the different road agencies
- The innovative contracting practices increase the "room for strategic behaviour", which is used or not in dependence of institutional context
- There is a tension between flexibility and public values
- The project portfolio of road agencies is becoming a more varied one. It is not a complete change from traditional to new practices but is rather resulting in a combination of many different contractual forms in the whole spectrum from traditional to new; varying per project characteristics.

As can be seen in the propositions, central in the research is the issue of understanding the evolution of the different national procurement strategies. It is for this reason that the following section focus on reviewing the different economic theories that give support to our analysis of institutional evolution. The contribution from other theories will be presented later in this paper.

3. Institutions and their evolution (Conceptual Background: Economic Theory)

Infrastructures are complex multi-actor systems and therefore "institutions" play a key role in them. The present research project focuses on the economic and technical angle concerning innovative contracting practices in Road Administration and therefore the analysis of institutions will also be focused on their influence on the economic behaviour of the agents involved in the problem.

Though standard economics is highly abstract and virtually ignored and continues to ignore the analysis of institutions; paying no attention to the influence of the institutional environment on the behaviour of economic actors (Dequech 2003; Groenewegen 2005); there is a growing interest in the study of institutions from other economic streams of though. Though there are different schools of thought, all together this body of theory could be called Institutional Economics. The differences between these schools of thought will be explored later in this chapter.

Institutional Economics is expected to play a central role in the research project because of two reasons. First, the research object itself, "innovative contracts" is a particular kind of institution. A second reason is the comparative nature of the project. Only when transactions costs - which are the costs that differ depending on the kind of institutions or governance structures- are taken into account, it is meaningful to compare the institutional systems and/or contracting structures of different countries. When transaction costs are neglected, the differences in contracting practices and governance structures are also not expected to have explanatory value, because in principle the performance and the costs of all of them should eventually lead to the same optimal results. As expressed by Groenewegen (2005) one shortcoming of standard economics is that it has no adequate explanation for the existence of different organizational forms.

In the study of institutions we can distinguish different theoretical bodies and research schools. First, we can make a distinction between the Old Institutional Economics (authors such as Veblen, Mitchell, Commons, Ayres, Gordon and others) and the New Institutional Economics (authors such as Williamsom, North, Langlois and others). Within these two, there are more specific research schools like the so called Comparative Institutional Economics (CIA) with writers as Aoki and Evolutionary Economics or the Economics of Increasing Returns with authors such as Arthur.

Rutherford (1994) points out that the dispute between the Old and the New Institutional Economics centres on five main issues: a) Formalism vs. antiformalism, the role of formal theoretical modeling as opposed to less formal methods, including historical and "literary approaches", b) Individualism vs. holism: the emphasis to be placed on individual behaviour leading to social institutions as opposed to the effect of social institutions in moulding individual behaviour, c) Rationality vs. rule following, the validity of rationalist explanations as opposed to those that place limits on the applicability of rationalist conceptions, d) Evolution vs. design: the extent to which institutions are the result of spontaneous or invisible-hand processes (resulting from the maximization behaviour of each individual) as opposed to deliberate design, and e) Efficiency vs. reform, the basis on which normative judgments can be made, and the appropriate role of government intervention in the economy.

Given the purpose of this paper, we will explore in this section, only the difference regarding the way these different research schools conceptualise evolution.

3.1. How do institutions change?

Central for understanding the roots of the differences between the contracting practices of different countries is to analyze how these different systems have evolved. As Greif (1998) points out, among the most fundamental questions of institutional economics are: "Why do societies evolve along distinct institutional trajectories? And, why do societies often fail to adopt the institutional structure of more successful ones?

Standard or Neoclassical economics is quite static on its point of view. For standard economics just one single and most efficient equilibrium point is possible and therefore, independent of the history or initial conditions of the system, all economical systems should evolve until they reach the ideal and most efficient equilibrium point. This equilibrium point is inspired on the Walrasian model and the American model is considered its nearest approximation. The idea of a single equilibrium point is coherent with the assumption of scarcity of resources and the law of decreasing returns.

New Institutional Economics (NIE) is richer in its analysis and through the inclusion of the concept of transaction costs opens up the possibility of different arrangements or governance structures being the most efficient dependent on asset specifity, frequency and uncertainty in the transaction (Williamson 2000). Nevertheless, it keeps many of the static and formal assumptions of neoclassical economics. Even though different arrangements are considered plausible (E.g. hierarchy, market or hybrid), it keeps aiming at finding the most efficient governance structure for a specific transaction. The main reason for this similarity in conceptions is that NIE continues to assume the law of decreasing returns and a rational maximizer individual –with bounded rationality in the worst of the cases-, not directly influenced by exogenous or pre-existing institutions.

Though both Old and New institutionalism recognize that institutions may be deliberately designed and enforced or may involve in unplanned or "spontaneous" processes, the authors in NIE conceive the evolution of institutions more as a spontaneous and invisible-hand processes , unintended results of human action but not of human design. Meanwhile, the authors in the Old Institutional Economics (OIE) question this view and opt for a more design oriented one. Menger's central questions give us a clear impression of this tension: How can it be that institutions which serve the common welfare and are extremely significant for its development come into being without common will directed toward establishing them?" ([1883] 1985 p.146)

Moreover, in what refers to the importance of history, OIE seems to give a higher weight to it than NIE and becomes in this way seems to become more evolutionary. Veblen (1898) from the OIE tradition conceptualizes the evolution of institutions as one of a "genetic account of an unfolding process". He aims at a treatment of institutional evolution as a process of "cumulative causation". For him, being this cumulative process more based on habituation to material conditions and constraints -rule following- than on rationalistic calculation.

Rutherford (1994) highlights two important points rising from Veblen's notion of "cumulative causation". The first is the statement that institutional evolution should be conceived in a more wider sense than simply the adjustment to a series of exogenously given shocks. In this sense, NIE seems to fall short because does not deal with the internal dynamic of the system but only with the rational (or intendedly rational) responses of economic agents to exogenously given changes in population, technology, trading opportunities , or ideology. The second is that a discussion of cumulative causation involves a clear idea of path dependency.

This concept claims that history matters because the choices made earlier does constraints the choices available in the future, what happens next depends critically on the present conditions, which is also the outcome of the pre-existing situation. Therefore, it also claims that small differences in initial conditions can make for widely differing outcomes.

These differences between NIE and OIE are only a general reading of the authors in these schools. A deeper view of their works let us see that the dichotomies between traditions are also present within authors in the same tradition. Therefore, it could be more helpful to explore the

theories of specific authors or the approaches of specific research schools instead of continuing with the comparison of the NIE vs. the OIE view in general.

3.2. Comparative Institutional Analysis vrs. Evolutionary Economics

Two approaches will be discussed in this section, one coming from the Comparative Institutional Analysis (CIA) research program, particularly based in the works of Aoki (1995; 2000; 2002) and one coming from the area of evolutionary economics, particularly based in the works of Brian Arthur (1989; 1990; 1990; 1994) on increasing returns and path dependence.

3.2.1. SINGLE EQUILIBRIUM VS. MULTIPLE EQUILIBRIA

Both approaches recognize the possibility for the evolution of multiple equilibria. Aoki states "I have suggested that the convergence of the various economic systems that exist worldwide, and a *complete convergence* toward the Walrasian model in particular, would be difficult because of the variance in *historical conditions* among economies and the need for *structural consistency* between regulations and other institutions" (1995 p.5). Arthur makes also reference to this when explaining what he found on the problems more interesting to him (normally problems involving competition among objects whose "market success" was cumulative or self-reinforcing): "There was typically more than one long-run equilibrium outcome. The one arrived at was not predictable in advance; it tended to get locked in: it was not necessarily the most efficient; and its "selection" tended to be subject to historical events"(1994 p. xiv) .

As already shown in their statements, similarities but also differences are found in the way they explain the processes from which these different equilibria result.

3.2.2. DESIGN OR SPONTANEOUS PROCESSES

Both authors seem to visualize these processes as spontaneous and invisible-hand, resulting from the choices of individuals aiming at maximize their gains but with bounded rationality. Bounded rationality means that individuals face constraints in their information processing capabilities as well as on their maximization calculation capabilities. This change towards bounded rationality is indeed what opens the possibility to more evolutionary explanations.

3.2.3. INSTITUTIONAL COMPLEMENTARITY AND PATH DEPENDENCE

They both are concerned with the "inertia" of the evolving system. Nevertheless Aoki explain this inertia and resistance to change in terms of Institutional Complementarity[1], while Arthur conceptualize this inertia or trend difficult to change as resulting from positive feedbacks in the system for which the initial conditions and "small events" in the beginning matter. He describes two characteristics for increasing return system; the first, inflexibililty, which refers to the possibility of lock-ins and the second, nonergodicity. About this second property he says "historical "small events" are not averaged away and "forgotten" by the dynamics. History may decide the outcome". It seems clear that the conceptualization of Arthur accentuates the importance of history and "path dependence".

[1] Institutional complementarity means that the operations of one institution are reinforced by the existence of other institutions. The regulatory structure generally reinforces the system when it is internally consistent with other systemic elements. Each element of the institutional structure is mutually reinforcing. Thus an institutional structure will be resistant to environmental changes once it is formed. Attempts to change one institutional element independent of other elements will have only a limited effect Arthur, W. B. (1994). Increasing Returns and Path Dependence in the Economy, The University of Michigan Press.

3.2.4. CONSTANT INERTIA OR TIME DEPENDENT INERTIA

They also differ in the way they conceptualize this inertia. For Aoki this inertia of the system is to some extent constant, while for Arthur the inertia of the system increases after certain point, making a trend almost impossible to be changed. This difference can be seen in the following statements. Aoki says "Historical conditions *extant* (currently or actually existent) at the outset of the transition constrain the possible outcomes of the reform process, but they do not fully determine their later development" (1995). Arthur view instead says that " heterogeneities, small indivisibilities, or change meetings –what he calls "small events"- become magnified by positive feedbacks to "tip" they system into the actual outcome "selected" (1994 p.27).

3.2.5. DECREASING VS. INCREASING RETURNS

As expected, the root of this difference can be found in their assumptions of decreasing returns vs. increasing returns. Aoki firmly states that "the reason for the evolution of multiple, sub-optimal organizational conventions is not increasing returns as focused recently in economics, but complementarity among strategic choices of agents (strategic complementarity)" (1995). He defines strategic complementarity as the process of selecting the strategy that corresponds to the prevailing social strategy. Meanwhile Arthur does believe that increasing returns (or positive feedbacks) are the reason for the evolution of different and hardly or non-predictable equilibria.

There are also differences in the way the resulting equilibria are conceptualized. Though Aoki aims to go to a more evolutionary view that other authors in the NIE, he also try to stick to the main assumptions of Neoclassical economics, as is the one that there is one resulting equilibrium which is also the most efficient one. This tension can be clearly seen in his work. He says "there is not absolute guarantee that the structure achieved will be the optimal one"(1995 p.11). He even seems to indicate that sub-optimal equilibria (reached through rational individual decision) are possible, but he also states that really not efficient options are not possible equilibria. Thus he stills consider that the resulting equilibria will be always efficient and at worse, sub-optimal. Arthur is less confident in this respect and thinks that even though individual choices are rational, there is no guarantee that the option selected (between two technologies for example) is, from any long-term collective point of view, the better of the available options.

An important question remains: Even though the inertia in the system, how does change take place? The CIA approach continues to consider external factors as the cause of change. Aoki says "Though the institutional structure is inertia-driven, the structure and environment of the economic game underlying it will be affected by the development of production and information processing technologies as well as by the globalization of financial transactions" (1995).

In synthesis we could say that Arthur goes further than Aoki in terms of evolutionary explanations and challenges important assumptions of Neo-classical economic by assuming increasing returns instead of Decreasing returns and the importance of Initial conditions. Nevertheless in that way he also opens the possibility to explain the creation of multiple equilibria in a more dynamic and to some extent more consistent way.

Moreover, thorough the emphasis he put on "small events" at the beginning that tip the development in a particular direction and the inclusion of the time dimension, though the formalization of the theory becomes certainly more difficult, it also becomes much more dynamic.

Arthur himself says in the preface of this book "Increasing Returns and Path Dependence in Economics": "the increasing-returns world in economics is a world where dynamics, not static, are natural; a world of evolution rather than equilibrium; a world of probability and chance events" (1994 p.xx).

3.3. Making use of System Dynamics

The theory of Arthur keeps a close relationship to the thinking behind Systems Dynamics theory. Both theories cite Prigogine and his advances in biology and source of inspiration of their standpoint about the evolution of systems.

It is also important to underline that when the views of Aoki and Arthur are analyzed in System Dynamics (SD) terms, some of the dichotomies seem to vanish. Both terms "complementarity" and "reinforcement" from Aoki, and "increasing returns" from Arthur, make reference to what SD calls "positive or reinforcing feedback loops". Also when Aoki refers to institutional reform and advice successive systemic changes in place of a Big Bang approach, he adds that "Rather, finding the **source of strategically important and politically feasible changes** may open up opportunities to induce **successive systemic changes** by relaying on "complementarity" between various institutions". This view is very much in line with the idea that SD propose of finding "leverage points" when changes in the system performance are wanted.

For these two reasons, the similarity between SD and Arthur's approach and the potential of SD as a tool to find a middle ground between these two theories, we think that if the evolution of the contracting practices is to be modelled, System Dynamic methodology offers a promising potential.

It is now clear why System Dynamics should play an important role in the research project and why it has been chosen as the right modelling and analysis technique. Now we can proceed to the following section, where the research design is presented.

4. Research approach proposed

In order to answer the research question and to validate the propositions already mentioned, the research has been designed as a multiple case study research with embedded units of analysis. The main unit will be the national procurement strategy (or the strategy of the road authority in charge of national roads and highways) with all its components (i.e. contractor selection methods, project delivery, project finance and performance contracting between others). The embedded unit will be projects, preferably Public Private Partnerships (PPP) projects in which these new contracting practices are being used.

Possible case studies will be one Scandinavian case (Finland and/or Norway), one Hispanic (Spain and/or Chile) and one or two Anglo-Saxon cases (England and Australia).The methods to be used in order to draw conclusions from the evidence gathered in the case studies will be mainly System Dynamics and Role-Playing Games. These two methods will be used in a complementary fashion. This means that Role Play Simulations will be carried out taking into account values given by the SD model, and at the same time, the results from the Role-Playing Game Simulation will be feed into the SD model. The Role-Playing simulations will particularly deal with the soft variables in the model, such as "Strategic behaviour", which are the product of human random decisions.

The steps realized and still to be done, in order to arrive to these simulation models are the following:

1) System Analysis. A first set of causal diagrams has been built as result of a meta-analysis. A significant number of articles in the field has been reviewed and this together with interviews with experts has resulted in a first draft causal and generic model which includes a)Institutional and evolutionary economics concepts, b) Project delivery methods, c) Project financing methods and d)Performance contracting. The results from this first step are presented in the following section.

2) Conceptual model application to the different case studies. This will be done in two steps. First the generic causal model will be applied to each country, reflecting the different stages in the reform process and considering as main policy only contracting practices that count for 30% or more of the projects. Second, the model will be applied to the embedded unities or specific innovative projects. This will give us a view at the future and we could use the parameters of this model to run a prediction on evolutionary stages; as well as new mechanisms in the system will be discovered in comparison to the initial system studied in step 1. It is in this model or specific case that more attention will be paid to the use of Key Performance Indicators and design space or freedom. These aspects are very difficult to study for the whole country.

3) A Role-Playing Game simulation will be developed also per case study. This will contain the general plot of actors, formal and informal institutions linking actors and constraining their behaviour and a clear logic from actors decisions to overall outcomes, which will be the ones used as input of the SD model.

4) Development of a SD simulation model. Parallel to the development of a Role-Playing game simulation, the development of SD simulations model has also to take place. It is important to mention here that we are aiming not at a single SD model that shows all the different phases the country has gone through because with each change in policy the structure of the system itself also changes and therefore a single model is almost impossible to be done. Instead we are aiming at different SD model that show; a)The system before the reforms (with the specific values of each variable per country); b) Country specific models that will help us to predict the possible effects of the application of new policies (the values of it will come from the data of the innovative project) and finally, after the conceptual models have been validated and applied to each case study, will be possible to generalize and build b) 3 or 4 models that show the different combinations of policies or strategies that are now in place in different countries . These models could be eventually used by different policy makers by making them specific per country when placing the national values per parameter and perhaps varying the strength of the causal relationships

5. System Analysis

In order to answer the questions previously mentioned and after a preliminary research – including interviews and literature review- a system analysis was carried out and a first conceptual model of the procurement system was built. The model consists of a set of system diagrams that explain the evolution of the four main trends in road contracting. In this paper, only the two final diagrams will be shown. The complete set of diagrams was presented in (Altamirano and Haraldsson 2005) and (Altamirano and Herder 2006). A brief version of this dynamic view will be presented in section 5.2.

5.1. Principal Agent Theory and Engineering Design Theory

Before presenting system diagrams with the analysis of the evolution of the different practices, we will present here the most important causal relationships in the model. These relationships together with their theoretical basis are presented in Table 1. The relationships not mentioned in this table come from the literature of road administration or from interviews with experts.

Causal Relationship	Theory	Theoretical explanation
Output/effort based criteria →(-) Design space	Design Theory	The more operation and detailed are formulated the client requirements (for tendering) the smaller the design space left to the contractors bidding
Flexibility → (+) Innovation	Design Theory	The more design space given to contractor, the more opportunities he has to innovate (in the design solutions he will propose)
In-house expertise →(-) Information Asymmetry	Agency Theory	Information asymmetry occurs when one party to a transaction has more or better information than the other party and is therefore equivalent to what Agency Theory calls "private information"(Lambert 2001) of the agent. If the government agency has less expertise and technical know-how, the "private information" of the agent increases.
Information Asymmetry →(+) Room for opportunistic behaviour	Agency Theory	Taking into account that the agent has an incentive to misreport the "signal" he saw in order to receive a more "favourable" compensation contract, if there is more information asymmetry and he has more "private information" he will have more opportunities to misreport without being noticed.
Outcome/Final Quality Criteria → (+) Information asymmetry→(+) Room for strategic behaviour	Agency Theory	This is the result of various theoretical propositions: a) The sensitivity of the signal (performance measure) measures how much the expected value of the signal moves in response to a change in the agent's effort, b)Effort is costly to the agent and therefore he aims to minimize it, Assuming that the higher the level of performance indicator used, the more noise is introduced in the signal and this become more driven by other factors (i.e. external factor, etc) than agent's effort; then information about agent's effort become private information. Therefore outcome/final quality criteria are expected to give more opportunities to the agent to maximise his utility without increasing the real outcome and own effort level.
Combined/Integrated contracts → (+) Room for strategic behaviour	Agency Theory	Given that not all performance measures are equally sensitive to a particular action, some can be more easily manipulated than others. When the agent is responsible for multiple tasks, he can vary how much attention he spends on one task versus another and in this way manipulate the compensation he receives.
Long term of contract → (+) Room for strategic behaviour	Agency Theory	Multi-period models make the management of principal-agent relationship even more complex. As is the case when the agent is responsible for multiple tasks, the private information of the agent becomes larger. When he can decide on investment levels for different periods, he can also distribute investments in the most productive way for him, which is not necessarily the one more convenient for the infrastructure condition and future performance.

Table 1. List of most important causal relationships. Source: (Altamirano and Herder 2006)

5.2. The conceptualization of the evolution process

The dynamic view that resulted from the system analysis carried out can be formulated in brief as follows:

The environment of the public sector has changed significantly in the last decades. A new paradigm has emerged in public administration causing a global trend of liberalization and

privatisation of public utilities, including road infrastructure. This trend together with the stagnation of national economies has created a funding problem.

In reaction to this funding problem some countries have started to experiment with indirectly financed projects (financed by private parties, so as concessions and toll roads). Besides the problem in funding, another effect of this process of liberalization and privatisation, has been the loss of in-house expertise, which weakens the effectiveness of direct supervision methods.

Thus, once more a solution to this new problem is needed. Key Performance Indicators (KPI) are beginning to be incorporated in contracts. These indicators are more outcome that output or effort oriented (see Figure 1). The positive effects of this measures is that small public agencies can manage the road network efficiently focusing only on the key strategic issues; and that more flexibility and therefore design space is granted to contractors; increasing the room or the probabilities for innovation (i.e. materials and processes).

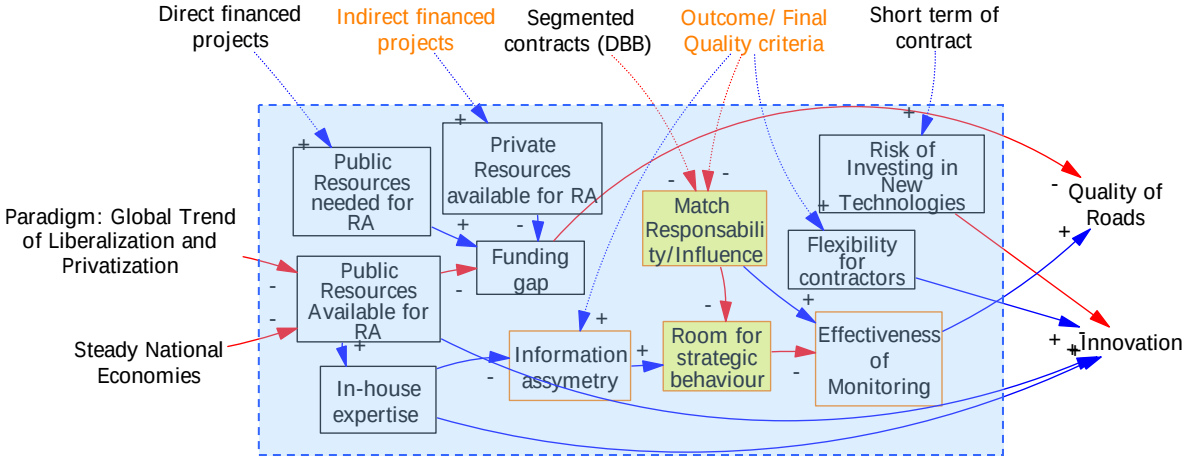

Figure 1 System Diagram of the Second Trend in Procurement Strategies

Nevertheless, this solution also creates new problems. The match between responsibility and influence has become in risk creating more room for strategic behaviour. A focus on outcomes/results (i.e. number of accidents in the road) could mean that contractors are being held responsible for things out of their area of control or influence.

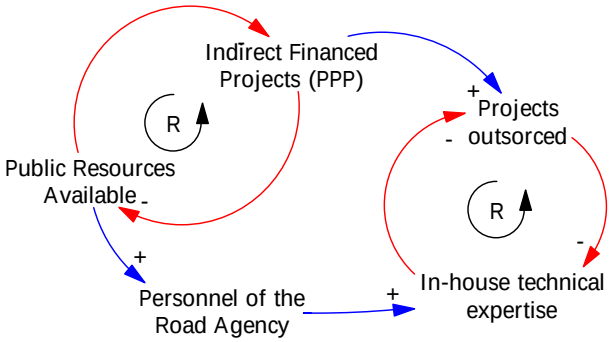

Figure 2 Detailed view of reinforcing loops in the system

It is important to highlight that even though these have not been pictures in the system diagrams –for the sake of simplicity- many reinforcing loops are taking place in this reform process. An example is presented in Figure 2. As it can be seen, there are two reinforcing loops in the system that together accelerate the reform process. The first can be explained in the following way: the less the public resources available for the road agencies –as product of the

new Public Administration paradigm and economic stagnation- the more the need and the higher the number of projects that will be probably financed by private parties. At the same time, the more the indirectly financed projects, the more success stories for PPP projects will arise and the preference towards this kind of projects will be reinforced, doing less and less acceptable the use of public funds for road infrastructures projects and therefore actually causing a reduction in the public resources available for the road agencies.

This reduction in the public resources assigned to the road agencies cause also a downsizing of the agency and therefore the loss of personnel with technical expertise. The less the technical expertise in-house, the higher the number of new projects that will be outsourced, which at the same time makes technical expertise less necessary and therefore accelerates the process of emigration of personal with this expertise towards the private companies. Finally, it also happens that the more indirectly financed projects, the more the number of projects that will be outsourced, because usually PPP projects involves and require a private company not only for the financing but also for the realization of it. In this way the result is two reinforcing loops, out of which the first accelerates the second even further, through its two factors, public resources available and indirect financed projects.

The evolution process continues in this same way, a new policy or solution is implemented and with this a new problem arises, making new policies necessary. Until we finally arrive to a scenario with four new policies, all part of the national procurement strategy; 1) Indirect financed projects, 2) Combined contracts, 3) Outcome/Final Quality criteria and 4) Long term contratcts (see Figure 3).

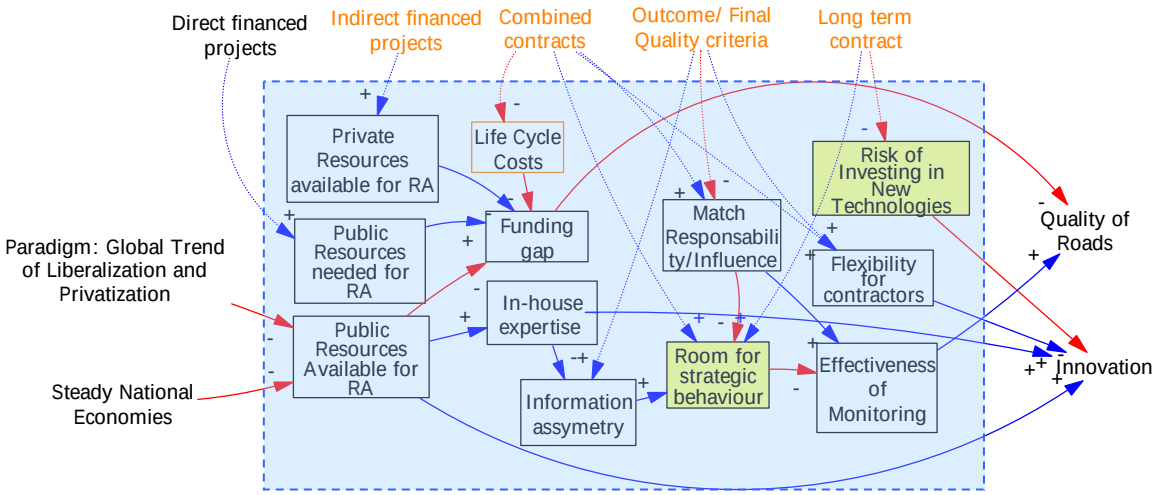

Figure 3 System Diagram of the Fourth Trend in Procurement Strategies

This first analytical exercise already shows that the reform process in the Road Administration sector has been a gradual process of multiple instable equilibria, and initiated originally by changes in external factors and paradigms in public administration. Changes in the environment created a new set of problems. Solution to these problems, created new ones and successively in that in the way, the countries have been forced to implement these different trends, though sometimes in different orders.

6. Preliminary Results and Discussion

The first system analysis of the evolution of the different trends allows us conclude that.

In general, one needs to be careful about the results expected from the application of these practices. The attractive efficiency wins and savings from some countries seem to have been the result of proper timing and application order of the different strategies, probably combined with favourable external factors and extra policies that counter balance the possible perverse effects of some of these policies. The system analysis also seems to indicate that the different trends are interdependent and to some extent some are the logical reaction to problems caused by the "solution" given in the previous trend. Synergy is expected for example towards achieving innovation. If policies increasing the flexibility or design space or contractors are implemented together with policies that reduce the risk for the contractor to invest in new technologies, their combined effect in innovation is expected to be larger than when applied individually.

Finally, the tension between technical aspects and public values was clearly captured in the system diagrams: increasing flexibility has had an impact in the room for strategic behaviour (Altamirano and Herder 2006). Flexibility has been increased aiming at improving innovation, the service levels and therefore aiming at achieving public values more efficiently. Nevertheless, the policies implemented to increase flexibility seem also to increase the room for strategic behaviour, which –when used by the contractors- can translate in quality decline and therefore could actually threat the fulfilment of public values in the long term.

Nevertheless, in order to draw more concrete conclusions about the pro's and con's of applying these new contracting practices, about the preconditions for success and of course to answer the overarching research question of this study: How to achieve the results expected from innovative contracting –mainly improvements in efficiency and innovation-, while keeping the room for strategic behaviour (of contractors) and the effects of it at the minimum possible? We need to go further and after applying these conceptual models to specific case studies, also translate them in concrete System Dynamic simulation models that could predict the results of different combinations of policies, the possible conflicts between practices and show the best ways to solve the trade-off between flexibility and public values.

This translation poses big challenges and important questions, some of these are:

a) Should we build one single generic model with many decision rules or indeed the proposed set of different models. How can we deal with the changes in the structure of the system itself that result from the implementation of new policies?
b) Can we model the problem at this level of aggregation, with variables such as in-house expertise and room for strategic behaviour; and still obtain significant accurate values for the results in performance of these new practices?. Or do we need to model the underlying physical flows and stocks?
c) Do we need to model the infrastructure itself or can we model only the operation of it?
d) How do we model "room for strategic behaviour"? Can we model it making use of System Dynamics of it is really necessary to use Role-Playing Games?
e) Is the combination of System Dynamics with Role-Playing Simulation a methodologically valid and promising one?

The discussion of this paper with experts and other researchers using System Dynamics for similar problems aim to reflect on these questions and find good ways to solve these modeling dilemmas.

7. Conclusions

After presenting an overview of the research questions being proposed, the conceptual background that will be used to study the evolution of the procurement strategies, the research approach being proposed and the preliminary results of the system analysis carried out; it can be concluded that System Dynamics is indeed a methodology with great potential for the modelling of evolutionary processes where multiple equilibria are possible, where historical events and initial conditions do make a difference and where the time domain needs to be included.

Nevertheless, the use of System Dynamics for explaining these evolutionary processes - given the nature of many of these problems in which institutional contexts and many stakeholders play an important role- poses still important challenges regarding the way these "soft" variables –like strategic behaviour- resulting from the choices of diverse economic agents can be modelled and how the structural changes resulting from new policies, can be integrated in a single deterministic model. A combination of SD models with Role-Playing Games is proposed in order to overcome the first difficulty but results from this combination are still to be seen.

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