UNIVERSITÀ DEGLI STUDI DI PALERMO
Modelli per il miglioramento della performance nel settore pubblico
Dipartimento di Scienze Politiche e delle Relazioni Internazionali (DEMS)
SECS-P/ 07

URBAN TRANSPORTATION GOVERNANCE AND WICKED PROBLEMS:

A SYSTEMIC AND PERFORMANCE ORIENTED APPROACH

IL DOTTORE
GUIDO NOTO

IL COORDINATORE
PROF. CARMINE BIANCHI

IL TUTOR
DR. FEDERICO COSENZ

CICLO XXVI

ANNO CONSEGUIMENTO TITOLO 2015

Acknowledgments

The writing of this dissertation would have not been possible without the help of several people that supported me during this period.

First of all, I would like to express my gratitude to the PhD Coordinator Prof. Carmine Bianchi. His experience and wisdom introduced me to the research activity and guided me in these years.

My sincere gratitude equally goes to my tutor Dr Federico Cosenz, who served as a trustful guide throughout my PhD experience.

I am deeply thankful to Prof. Pablo Bereciartua for the time spent in long conversations that inspired my work and life.

My gratitude also goes to Prof. Enzo Bivona for the invaluable support during the three years spent in the department

This thesis project involved many institutions and agencies in Palermo and Buenos Aires. In particular I would like to thank Carmelo Quattrocchi and Marcello Bartolone, (top managers at AMAT), Ignazio Messina (manager of Strategic Planning and Control at Municipality of Palermo), Roberto Lanza (manager of Transportation Service at Sicilian Region), Maximiliano Fioravanti (former Director of the Ministry of Public Works of Argentina).

A special thanks goes to my family. Words cannot express how grateful I am to my mother and my father. My older sister Lidia and my cousin Manfredi that deserve a special mention for their affection in spite of their sharp criticism.

Finally, thanks to all my friends and to all the people I met around the world that teach me, in their uniqueness, something new.

List of contents

List of Figures and Tables

Chapter 1: Background Studies

Chapter 2: Research Methodology

Chapter 3: Palermo's case study

Chapter 4 : Buenos Aires' Case Study

Chapter 5: Two Cases Studies Compared

Appendix A

Appendix B

Abstract

Background

Public actors and, in general, public service providers - such as municipalities, provinces and agencies - play a major role in achieving a satisfying quality of life for citizens.

The social context in which these institutions operate is intrinsically complex. This complexity arises from the different expectations of the community (pluralism). It also arises from the plurality of actors involved in policy-making (institutional complexity) and from the interplays of several factors, such as those related to technical, economic and environmental dimensions (scientific uncertainty) (Head & Alford, 2013).

The above characteristics determine what literature defines as ‘wicked’ problems (Rittel & Webber, 1973). The term ‘wicked’ does not means ‘evil’, but refers to issues that are hard to define and manage, due to the high complexity of the environment which they affect (Australian Public Service Commission, 2007; Head & Alford, 2013). These issues often lead to counterintuitive behaviours in terms of time (trade-off between short- and long-term) and space (trade-off between different institutions or functional areas within an organization) when actions are taken to resolve them. Institutional complexity, pluralism and scientific uncertainty typically characterize the provision of public services, for this reason, many issues that Public Administrations (PA) have to deal with, can be considered wicked.

Over the last thirty years, New Public Management (NPM) reforms (Hood, 1991) have drastically changed the role and the way Public Sector institutions are managed. NPM reforms, in particular, were aimed at addressing the shortcomings of the traditional paradigm of Public Administration based on Weber’s model of ideal bureaucracy (Hood, 1991;

O’Flynn, 2007). Performance and market orientation, and decentralization of power to local authorities are two of the main pillars which support the NPM reform (Hood, 1991). However, the resulting structural devolution and quasi-privatization created multi-level governance structures in which public services are subjected to pressures and constraints arising from different institutional levels, with diverse goals and service expectations. These pressures and constraints, which often push toward conflicting goals between the institutions involved, are mainly due to ownership relationships, asymmetric exchange of resources (Lioukas et al., 1997) and contracts (Head & Alford, 2013). The result is a fragmentation of both the governance structure and the stakeholders aims that service providers must comply with when pursuing a desired performance in terms of outcomes (e.g. quality of life) for the community they are supplying.

Christensen and Laegreid (2007) maintain that the emerging multi-level governance structure is hampering the capability of both the political and administrative bodies to effectively intervening on the levers of control related to the public service provision. Fragmentation enhances the institutional complexity in the public sector and, therefore, the presence of wicked problems in the decision-making sphere (Steane et al., 2015).

At an urban level, among the services that the public sector is called upon to provide, transportation plays a central role (Meyer & Miller, 2000; Hall, 2000; Miller & Hoel, 2002; Caragliu et al., 2011; Lombardi et al., 2012; Albino et al., 2015). The significance of people’s mobility in cities is related to direct, indirect and induced effects on the economy, as well as on the development of the urban area (World Bank, 2002; Weisbrod, 2009). The direct effects concern both time and cost of travelling for citizens and capital purchases for transportation sectors. Indirect and induced effects are mainly related to sales, productivity and support for jobs in the transportation sector as well as on other sectors (Weisbrod, 2009).

Interdependencies among transportation, land use, community development, and environmental systems together with a diverse set of stakeholders interests and interagency relationships (Weiner, 1999) makes transportation problems become increasingly wicked (Willson et al., 2003).

Research objective and questions

This research aims at contributing to the research stream focused on the structuring and managing of urban transportation systems in a wicked environment whose complexity is generated by institutional fragmentation.

Given the diverse goals and expectations accruing from the multi-level governance structure depicted above, the research will address the following questions:

RQ 1: how do different governance levels influence public transportation performance in complex institutional settings? Particularly, can we identify and monitor barriers and determinants of good performance in transportation systems where a great number of actors is involved?

In recent years, coordination and inter-institutional joint-action have been identified by literature as possible approaches for dealing with governance fragmentation and the wicked problems arising from it (Pollit, 2003; Christensen & Laegreid, 2007; Benington & Moore, 2011; Head & Alford, 2013). These solutions created network structures where traditional Performance Management (PM) systems results excessively static in terms of time and space and, therefore, do not help in understanding the process of accumulation and depletion of resources and the effect of their employment on outcomes.

RQ 2: How to adapt a performance management perspective aimed at supporting institutional systems to achieve a better coordination among those players involved in decision-making processes? How to frame the governance of urban transportation systems in such a way that it allows us to build a shared understanding of problems and to align distinct organizations in the pursuit of common objectives? Is a strategic dialogue achievable through the application of new feedback relationships between the different governance levels?

Methodology

The adoption of a systemic and dynamic approach for the analysis of the wicked problems of social contexts like urban transportation systems, is suggested by literature (Rittel & Webber, 1973; Hjorth & Bagheri, 2006; Head & Alford, 2013).

System Dynamics/Thinking is an approach that enables us to frame complex systems (Sterman, 2000) and to adopt a systemic view when trying to tackle wicked problems (Hjorth & Bagheri, 2006; Head & Alford, 2013; Auping et al., 2015; Bianchi, 2015). In order to explore urban transportation service performance, System Dynamics will be used through a Performance Management perspective (Bianchi, 2010).

The present work will also be supported by the analysis of two different case studies. Since each transportation system has distinctive characteristics - derived from different legal and managerial systems, geography and population development - two case studies of two urban areas (Palermo in Italy and Buenos Aires in Argentina) were developed. The aim of the case studies is to show the potential benefits of a systemic and performance-oriented approach for tackling wicked issues arising from fragmented governance structures. Particularly, the case studies will start taking on the service providers perspective, shifting then the boundaries of the analysis in order to include the other governance levels influencing the service performance.

Results

In multi-level governance structures, such as the ones discussed in the cases provided, the lack of communication and coordination often generates unilateral and asymmetric exchange of resources (Lioukas et al., 1993). Through the definition of a set of performance indicators outcome oriented, the policy-solutions hereby proposed will explore the possibility to build new feedback processes across the governance levels. These feedbacks will link the results achieved by the service provider with the system strategic resources when these are owned or controlled by other actors. The resulting models represent useful tools that service providers may adopt to enhance communication with other governance levels, or tools that top-governance level may use so as to design resources allocation policies.

In order to answer the research questions set out above this work has been structured as follows. An opening chapter will provide an introduction to the evolution of urban transportation systems, with a particular focus on the role that Public Administrations have been called upon to assume over recent decades; a second chapter will present the research methodology used in this study, at the same time highlighting the advantages for its adoption; the case studies will be discussed in the third and fourth chapters, so as to show how a systemic and performance-oriented approach can be used in different contexts and for different governance-related issues. A fifth chapter will then look at the two case studies previously analysed in a comparative perspective. The concluding chapter will sum up the contribution made by the present work, and outline the future challenges and perspectives this study could address.

Chapter 1: Background Studies

1.1 The Rise of Multi-level Governance Structures in Public Sectors: a 'Wicked' Context

1.1.1 Wicked Problems

"*Policy problems cannot be definitively described*". With this sentence Rittel and Webber (1973, pp. 155) introduced the concept of 'wicked problems' within the Public Administration field. The term 'wicked' does not means 'evil', but refers to issues hard to define and manage due to the high complexity of the environment which they affect (Australian Public Service Commission, 2007; Head & Alford, 2013). These issues are persistent and often lead to counterintuitive behaviours despite considerable effort to solve them (Van Bueren et al., 2003).

In order to better identify 'wicked' problems, Rittel and Webber (1973) outlined their characteristics:

1. There is no definitive formulation: In complex contexts there are no criteria for framing problems since they exist in open systems. The process of formulating a wicked problem is the problem itself. This happens because the information we need to understand wicked problems depends on the way in which we intent to solve them and by our biases in dealing with it.
2. They have no stopping rule: the problem of solving a wicked problem is equivalent with the process of understanding it. According to the first proposition, in open systems, such as the ones in which these issues exist, there are no ends to the causal chains that link the steps achieved in the process of understanding them.

3. Solutions are not true-or-false, but good or bad: the process of evaluation of the solutions provided to tackle wicked problems is influenced by the interests, the value-set and the ideological predilections of who is judging. Social facts cannot be classified as true or false in absolute terms; therefore their assessment may be better expressed as “good or bad”, “better or worse”, “satisfying” or “good enough”.
4. It is not possible to test a solution: if we implement a solution for a wicked problem, it will generates a wave of consequences that will not allow us to isolate the solution itself. For example, in complex systems short term solutions may appear to work, but just later on we can measure their real impact. Simulations may represent a useful tool to understand the expected impact of solutions for wicked problems. This can compress or expand time and space, allowing learners, for example, to simulate decades in the life of a business or a century of climate change in a few minutes (Sterman, 2014). When real experimentation is too slow, too costly, unethical or just plain impossible, that is, for most of the social issues we face nowadays, simulation becomes the main tool we can use in order to discover how complex systems work and where high leverage points may lie (Sterman, 2014).
5. There is no opportunity to learn by trial-and-error: when dealing with wicked problems, every implemented solution is consequential and irreversible. If we build a new road for solving a congestion problem spending a relevant amount of money, we cannot easily disinvest if its performance is not satisfactory, and its effects will impact for several years on the life of the people involved. Therefore, in context in which actions taken are irreversible and the half-lives of the consequences are long, every trial counts.

6. They do not have an enumerable set of potential solutions: generally, in the pursuit of a wicked problem, a host of potential solution arises, and another host is never though up. When problems are ill-defined, the set of potential solutions relies on realistic judgement and on the amount of credibility and feasibility of the actions proposed.
7. Every problem is essentially unique: there are no classes of wicked problems. Although some wicked problems may look similar, we can never be sure that the particularities of a problem do not override its commonalities with other problems already dealt with.
8. Every problem can be considered to be a symptom of another problem: problems consist in the gap between 'what is' and 'what should be'. In order to solve problems we should first understand the cause of the discrepancy. Removing the cause identified poses another problem of which the original plan was the symptom. The new problem can, in turn, be considered the symptom of still another 'higher level' problem, and so on. This is what happen in wicked contexts. Trying to cure symptoms may complicates the resolution of the root problem because 'every trial counts' (see proposition 5). An example could be given by fragmented governances when symptoms are experienced by single players that tackle them at their own level without exploring the real problem behind those symptoms.
9. The existence of a discrepancy representing a wicked problem can be explained in numerous ways. The choice of explanation determines the nature of the problem's resolution: in dealing with wicked issues we cannot rely on linear mode of reasoning and to put an hypothesis to a crucial test because of their uniqueness (see proposition 7) and lacking of opportunity for rigorous experimentation (see

proposition 5). People tend to choose explanation arbitrarily – the ones that are plausible and fit their intentions best.

10. Decision makers have no right to be wrong: in the sense that there is no tolerance of experiments that fail. Decision-makers are made responsible for the consequences of the actions they generates. Moreover, their solutions proposed are confounded by a further set of dilemmas raised by the growing pluralism of the publics.

Because of the characteristics outlined above we can counterpose wicked problems to 'tame' ones. These lasts can be easily defined and formulated because they are characterized by low level of complexity and are capable of standard or routine solutions (Head & Alford, 2013). Of course, tame and wicked problems are just the extremes of a wide spectrum of problem types. Therefore we can argue that there are several degrees of 'wickedness'. These change on the base of multiple dimensions (Head & Alford, 2013). Among these dimensions Head and Alford (2013) identifies:

- Scientific uncertainty: fragmentation and gaps in reliable knowledge about problems,
- Institutional complexity: governance fragmentation and interconnectedness,
- Social pluralism: diverging interests and values of stakeholders.

Such features generally characterize policy problems. Even planners that operates in private contexts, such as corporations, need to recognizes certain level of wickedness in their planning activity. However, the context in which wicked emerges with more strength is the public one. Uncertainty, institutional fragmentation and pluralism of interests are common – and cannot be ignored - to many Public Administrations and other public service providers, such as agencies and utilities.

While uncertainty and social pluralism are intrinsic in the public domain, institutional complexity arose due to the several reforms that characterized PAs over the last thirty years.

Particularly, the interventions addressed at reforming Public Administrations in 1980s and 1990s determined structural changes in managing and organizing public institutions. One of the results of these changes is a governance fragmentation (Christensen & Laegreid, 2007; Pollit, 2003) that increases both complexity and pluralism in the environment in which Public Administrations operate and, as a result, the wickedness of the problems they are dealing with.

Administrative fragmentation and external constrains often result in a lack of strategic dialogue between different governance levels, as well as in a competition in setting policy priorities between political and administrative bodies (Christensen & Laegreid, 2007). Pressures and constraints coming from different institutional levels carrying a multiplicity of goals and expectations - though under the same institutional mission - might indeed complicate effective policy-makers' interventions.

These reasons have been often used to blame multi-level governance as an institutional setting contributing to inefficiency, opaqueness and institutional inertia. However, multiple levels also provide access for new actors to decision-making, and may possibly contribute to checks and balances for policy-making and implementation, and to the mobilization of stakeholders and their resources and commitment (Van Bueren et al., 2003). This may happen only if there is an adequate interaction an coordination among the player involved in the decision-making processes.

Wicked problems are indeed issues that require interaction and negotiation between actors involved in order to come to a mutual understanding of the nature of the problem and how this may be tackled (Van Bueren et al., 2003; Ferlie et al., 2011). Strategies for addressing wicked problems should take the institutional constellation of interdependent relationships and resource dependencies between stakeholders as given, and build a mutual understanding of problems that can guide joint effort to cope with wickedness (Ferlie et al., 2011).

In the last twenty years, both theory (Kettl, 2006; Mandell & Keast, 2007; Weber & Khademian, 2008; Ferlie et al., 2011; Head & Alford, 2013) and practice (Joint-up and Whole-of Government reforms) concerned with wicked problems and multi-level governance have been focused on the need to improve coordination of actions and collaboration between internal and external stakeholders. An inter-institutional governance approach, including new forms of coordination and power-distribution between the main actors involved, has been introduced in order to tackle the wickedness coming from governance fragmentation (Christensen & Laegreid, 2007) and to neutralize or limit its negative implications on both policy- and decision-making.

In the following paragraph the public management reform processes that occurred in the last 40 years will be explored and discussed with the aim of understanding the determinants of governance fragmentation in relation to wicked problems.

1.1.2 Public Management Reforms

Public Administration (PA) practices have always attempted to respond to the challenges and the shortcoming of what came before (Bryson et al., 2014).

Until the 1980s PA were adopting hierarchical forms of organization and control so as to respond to a particular set of conditions – industrialization, urbanization, the rise of the modern corporation, faith in science, belief in progress and concern over major market failures (Bryson et al., 2014). These forms were aligned with the typical bureaucratic administration model conceptualized by Weber in the firsts decades of 1900s.

In order to avoid a political or individual influence across the administrations, bureaucracy models are mainly concerned on input monitoring and process compliance rather than results achievement. This have the effect of limiting the administration ability to develop a decision-making process policy-oriented. Another feature of the traditional approach is represented by the tendency to foster specialization that tends make each single department a cultural fortress, creating ‘vertical silos’ (Christensen & Laegreid, 2007; Head & Alford, 2013).

New Public Management (NPM) was the major public sector reform approaches that many western nations adopted during the period between the early 1980s and the mid-1990s (den Heyer, 2011) so as to respond to a concern with government failures and a belief in the efficiency of markets (Bryson et al., 2014). This reform was indeed aimed at solving the shortcomings with regard to efficiency and effectiveness, which are intrinsic in the traditional bureaucratic approach described above (Hood, 1991).

Hood (1991) identifies seven main doctrinal components around which NPM was built:

- Hands-on professional management: giving more ‘freedom’ to top managers;
- Explicit standards and measures of performance: goals orientation and definition of indicators;
- Greater emphasis on output controls: resource allocation linked to measured performance;
- Shift to disaggregation of units: creation of ‘manageable’ units inside the PA;
- Shift to greater competition: move to term contracts;
- Stress on private sector style of management: greater flexibility for hiring and rewards;
- Stress on greater discipline and parsimony in resource use.

These doctrines sat alongside four reinforcing megatrends (Hood, 1991; O’Flynn, 2007): slowing down or reversing government growth; privatisation and quasi-privatisation;

automation in the production and distribution of public services; an international agenda focused on public policy and management issues. Synthetically, we can conceive NPM reform as a push away from large, centralized government agencies toward devolution and privatization (Bryson et al., 2014).

The practical application of NPM suffered from a range of weaknesses attributable to implementation issues and fundamental tensions (O'Flynn, 2007). Although NPM succeeded at superseding the bureaucratic model in various ways, competitive government models tend to create isolation and competition among programmes and departments inside the public sector which strengthen the 'silos' structure already in place (Cristensen & Laegreid, 2007) and may spur destructive behaviour (O'Flynn & Alford, 2005; O'Flynn, 2007). If we consider that these programmes and departments may have subterranean connections in respect to certain problems, their isolation enhances the overall wickedness.

In NPM, public service organizations are dominated by producer interests. As a result, public service organizations tend to be neither efficient in terms of saving public money nor responsive to consumer needs (Stocker, 2006). In order to resolve such a distortion the solution adopted was to fragment monopolistic public service structures and to develop incentives and tools to influence the way that they operate.

These consideration lead us to maintain that NPM was ill- suited to deal with wicked problems because it did foster public agencies fragmentation and isolation that was already in place with traditional public administration paradigm (Head & Alford, 2013). The main issues which characterize the 'pillarization' of the public sector which followed the NPM reform, can be summarized as (Pollit, 2003): contradiction and tension between different policies which decrease their effectiveness; duplication and contradiction of action programmes which negatively affect the use of resources; lack of synergy among stakeholders; fragmented services provided to citizens.

The pitfalls of NPM are also related to new material conditions and challenges that have emerged in recent years (Bryson et al., 2014). These are mainly related to an increase of the environmental complexity in which PAs operates.

In such a new context, Moore (1995) identified the need to shift away from the competitive paradigm, focused on results and efficiency, toward the achievement of a broader goal, namely: ‘Public Value’ creation.

Public Value is a multidimensional construct created by government through services, laws regulation and other actions (Kelly et al. 2002), therefore, it primarily results from government performance (Moore, 1995; Bryson et al., 2014).

Public Value management may be considered as the emerging management paradigm for PA (Stocker, 2006; Bryson et al., 2014). This is based on the proposition that a wide range of stakeholders is legitimized and should be included and involved in the PA activity (Stocker, 2006; O’Flynn 2007).

Public Value creation is determined by the delivery of services – which represents the first vehicle for creating value -, the achievement of outcomes - that includes the wider and dynamic impact that results from the actions taken - and the generation of trust (O’Flynn, 2005, 2007). The outcome focus that characterizes the emerging paradigm has been remarked by several theorist (Moore, 1995; Stocker, 2006; O’Flynn, 2007; Bryson et al. 2014). Outcomes achievement in the public context does not depend exclusively by the action of single organizations, but it requires more collaborative effort (Brousseine, 2003; Stoker, 2006). In a highly fragmented PA, the need for collaboration is even stronger. Fragmented governance structure has been found disruptive (O’Flynn & Alford, 2005; O’Flynn, 2007; Steane et al., 2015) because fragmentation increases institutional complexity and, therefore, the presence of wicked problems (Christensen & Laegreid, 2007; Head & Alford, 2013; Steane et al., 2015). The presence of collaborative relationships represents the linchpin for understanding and addressing wicked problems where multiple parties - with differential knowledge, interests or values - are involved (Head & Alford, 2013). This is due to three main elements that collaboration determines (Head & Alford, 2013): a better understanding of the nature of the problems; the development of agreed solutions; an easier implementation of the solutions identified.

Due to this, since 1997, many Countries – among which we find UK, Australia and New Zealand as first movers - have been attempting to increase their ability to deal with problems related to governance fragmentation through a new wave of reforms called 'Joined-up Government' (or 'Whole of Government'), whose aim is the enhancement of coordination between different governance levels for improving public sector performance (Pollit, 2003; Christensen & Laegreid, 2007). Joined-Up Government (JUG) '*is an umbrella term describing various ways of aligning formally distinct organizations in pursuit of the objectives of the government of the day'* (Ling, 2002, pp. 616). JUG aspires at achieving horizontal and vertical coordination so as to eliminate situations in which different policies undermine each other, to make a better use of scarce resources, to improve synergies among stakeholders in a particular policy area and to offer citizens less fragmented access to services (Pollit, 2003; Christensen & Laegreid, 2007).

The idea behind this wave of reform is to design and implement more flexible and pervasive governmental systems in order to foster a more pragmatic and intelligent collaboration among different players (Bianchi, 2015). To do that, JUG trend proposes an inter-institutional governance approach, including new forms of coordination and power-distribution between the main actors involved, so as to tackle the 'wickedness' coming from governance's fragmentation (Christensen & Laegreid, 2007; Karré et al. 2013; Steane et al., 2015), and to neutralize or reduce its negative consequences on system service performance (Pollit, 2003).

JUG operates at two different levels for creating coordination (Carey et al., 2015): the first is the institutional one - acting on ‘institutional’ factors, such as relationships, the interdependencies between different actors, and the rules that guide action; the second point of intervention is at the level of structure and process - interventions at this level seek to alter the structure of the network, thereby influencing the nature and processes of interaction between actors.

The present work, and the case studies that will be further explored, focus on coordination at an institutional level. That means, coordination solutions and policies designed in the cases will consider governance structures as given and will aim at improving the system by acting on rules and relationships between the players.

1.1.3 About Performance Management application in the Public Sector

Performance Management (PM) is here broadly defined as the process by which an organization manages its performance in line with its institutional mission, strategy and desired purposes (Bititci *et al.*, 1997; Neely, 1999; Otley, 1999). The general purpose of PM systems is to describe the link of resources with activities and outputs, and to link outputs to outcome (Bouckaert & Halligan, 2006).

NPM can be acknowledged as the reform that introduced the use of Performance Management tools in the public sector (Bouckaert & Van Dooren, 2003; Modell, 2009; Marcon & Russo, 2014).

The main reasons that justified the introduction of PM in the public sector can be synthetized in (Marcon & Russo, 2014):

- a need to introduce strict forms of managerial and financial control;
- the emulation of private sector’s practices;

- a greater focus transparency in Public Administration;
- the need to enhance the effectiveness;
- the implementation of result-based evaluations;
- the will to enhance a veritable professional accountability.

The advantages of Performance Management applied to the public sector are of obvious systemic importance in considering the accountability requirement of linking the activities performed by public managers to the performance achieved (Marcon & Russo, 2014).

Even though a new management paradigm is emerging in the public organizations sector, the adoption of PM frameworks may still be considered necessary. However, it emerges the need to improve them in relation to both the new structures which characterize PAs and the new expectation of the community – in a broad sense - with regards to public services. The implementation of post-NPM reforms indeed implies the use of an outcome oriented view of performance to frame and assess new objectives of public organizations (Bianchi, 2015). A new PM approach should also consider the effects of actions and programmes both in the short and in the long run. Moreover, the viewpoint of PM systems should be wider in spatial term, not only focusing on single units or institutions, but on an inter-institutional perspective (Bianchi, 2012, 2015).

Bianchi (2010, 2012) identifies three complementary views of PM: objective, instrumental and subjective one. The *objective view* takes into account the relationship between an organization and its environment. Once the ‘product-client’ of a system/organization has been identified, it is possible to design the processes and the activities needed to generate it. Surely, the products generated by these processes may be addressed to internal (e.g. back office units) or external clients. Specially in the public sector, understanding the impact of internal clients is a necessary step so as to improve the overall performance and to foster accountability within the organization/network.

According to an *instrumental view* of performance, PM frameworks are usually characterized by three main elements:

- Strategic resources: physical or information resources held by the system that can be employed in order to achieve some desired result.
- Performance indicators: intermediate results that measures the state of a system by comparing it with a target value or a benchmark.
- End-results: the results the Administration gets thanks to the management cycle (production process).

In fragmented governance structured it may happen that strategic resources and end-results are under the control of different actors. This add an element of complexity when designing PM systems.

The *subjective view* provide a synthesis of the previous two because it relates both the activities to undertake and the related objectives, and performance targets to achieve. This view focuses on the importance of strategic goals/objective settings. Distortions that may raise with improper goal settings (i.e. unfocused goals, confusions between means and ends, etc.) risk to affect the overall system performance. This is particularly true in PAs when different organizations pursue different and maybe conflicting goals.

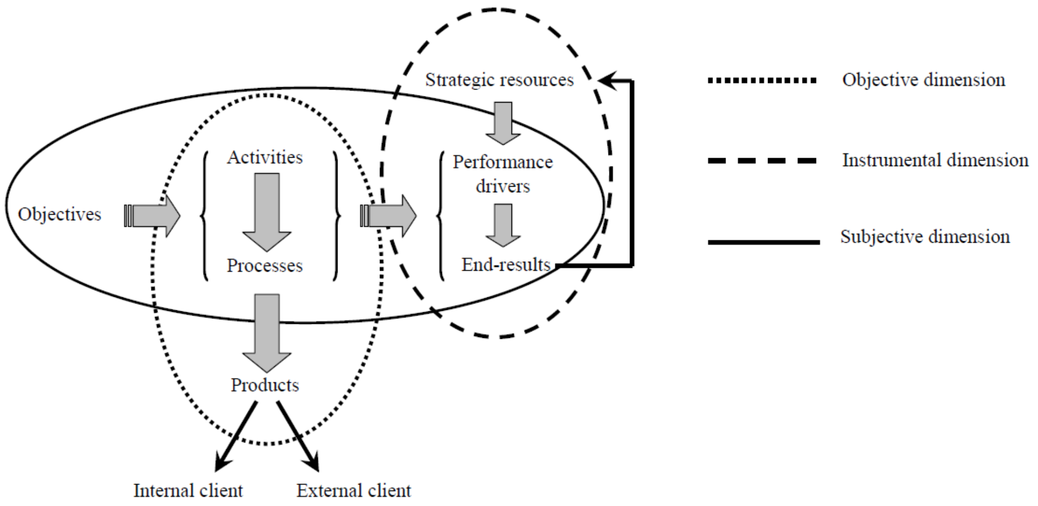


Figure 1.1: Three views for designing a performance management system (Bianchi, 2010)

When analysing performances, the perspectives through which an organization, or - in case of multi-level governance – a network, can be observed are three (Bianchi, 2012): internal, external and time. Under the internal profile, performance emerges from the consistency between different sub-systems, departments or areas of an organization – i.e. the coherence between strategic guide and operations. Under the external profile, organizational performance can be articulated in different dimensions (Eccles, 1991; Coda, 2010; Litman, 2014). Particularly Coda (2010) identifies financial, competitive and social ones. An unbalance between these dimensions – i.e. prevalence of financial performance in respect to the competitive or social one - may determine an unsustainable growth rate. Lastly, time perspective concerns the prejudice that short-term policies may cause in the long-term results.

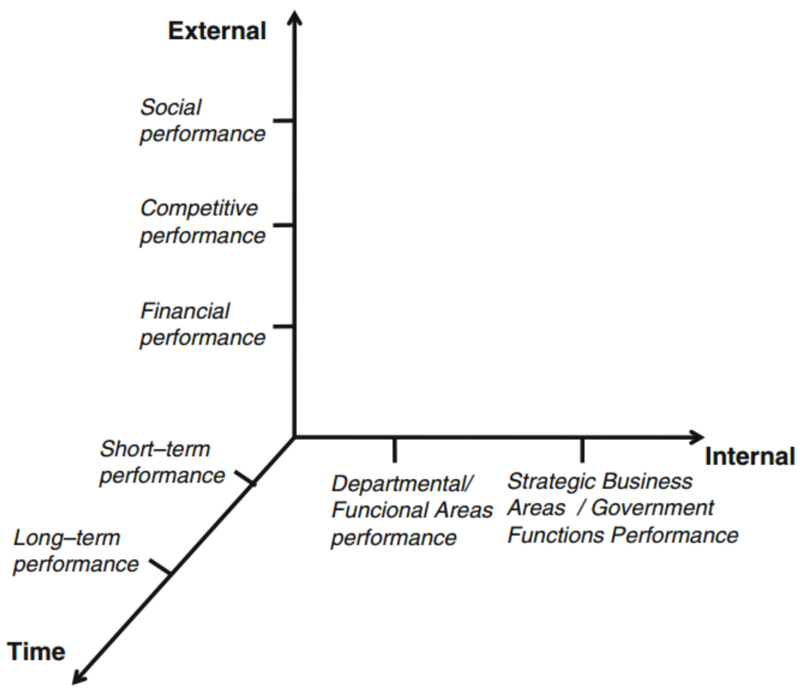


Figura 1.2: Framing organizational performance (Bianchi , 2012)

Traditionally, PM frameworks to PA has been mainly focused on the financial dimension of performance. These tools have been mainly used on an annual base in order to justify the use of resources (den Heyer, 2011) creating inefficiencies and unbalances between different institutions.

Some authors (Sloper et al., 1999; Linard & Dvorsky, 2001; Bisbe and Malagueño, 2012; Bianchi, 2012) have also raised others critical issues related to the development and use of traditional PM approaches. Bisbe and Malagueño (2012) put in evidence the lack of a perspective that may capture the dynamic complexity of managerial decision-making. PM techniques tend to ignore a number of relevant factors influencing both planning and measuring organizational performance and, therefore, they may limit decision-makers' strategic learning processes (Sloper et al., 1999; Linard & Dvorsky, 2001). Such factors are primarily associated to delays, non-linearity, intangibles, and to the unintended consequences on human perceptions and behaviours caused by a superficial or mechanistic approach in setting performance targets. Bianchi et al. (2015) found that traditional Performance Management approaches result to be static in terms of space - they tend to stress excessively some functional areas of organizations while ignoring others - and time - they do not allow one to properly assess both determinants and consequences of performance with reference to the trade-offs existing between short and long-term effects. Due to that, these tools do not help in understanding the process of accumulation and depletion of strategic resources and the performance drivers' effect on outcome indicators (Morecroft, 1999; Warren, 2005).

These pitfalls lead to behavioural distortions, or 'performance paradoxes', such as 'myopia' - when managers focus their efforts on short term targets at the expense of longer term objectives -, measure fixation - when outcomes are difficult to measure there is a natural tendency to use performance indicators based on measurable outputs -, unclearness about what is actually measured, 'symbolic behaviour' - monitoring appears to be in place but is in fact not -, etc. (Marcon & Russo, 2014). However, this does not mean that PM approaches are harmful for PAs. These distortion may be overcome through the adoption of a dynamic and systemic perspective (Bianchi et al., 2010; Bianchi, 2012; Bianchi et al., 2015; Noto & Bianchi, 2015).

A systemic perspective may allow PM experts to switch from output performance measures to outcome ones, making Performance Management an approach useful to drive decision-makers in both designing competitive strategies and measuring the results achieved.

A fragmented governance, in which several stakeholders are involved in a service provision process, enhances the issues related to static nature of PM approaches. In an environment characterized by different expectations, setting strategic goal as well as allocating resources may be particularly challenging unless an understanding of what is needed to be achieved by the stakeholders is shared.

The network mechanism arose for dealing with wickedness in the public sector strengthen the need for revising traditional PM systems (Putansu, 2015). PM should adopt a perspective able to consider the network of actors and their collaborative practices when measuring and monitoring performance. A more sophisticated approach to PM should focus on the end-results of the network logic, because this would allow more flexibility in relation to the processes by which outcomes are achieved (Head and Alford, 2013). It should also recognize the complex feedback loops permeating actions and policy programs and the delays implicit when dealing with wicked issues, through greater focus on intermediate results evaluation (Head and Alford, 2013).

1.2 The evolution of urban transportation systems: from public provisions to new organizational forms

Urban areas economic and social health depends to a large extent on the performance of its transportation system (Meyer & Miller, 2000). Mobility in metropolitan areas is considered to be a public issue because of the huge impact of the externalities it produces. However, these externalities are not directly visible for each passenger when choosing between private or public mode of transportation. Due to that public actors have to intervene in order to make public transportation more attractive, reducing the negative impact of an excessive use of private transportation which is very unlikely to coincide with any acceptable concept of the public good (Della Porta & Gitto, 2013). Due to that, public transportation can be considered as a factor that contribute to the creation of Public Value. Particularly, transportation has a direct influence on quality of life, social integration and cohesion, productivity and competitiveness of firms operating in a territory (Barbero et al., 2011). However, since urban transportation systems are complex (Wang et al. 2008) and present an high degree of wickedness, the risk of running into counterintuitive behaviours when actions are taken to improve them is high. The wickedness of urban mobility issues depends by the three factors mentioned in the first paragraph. Particularly:

- **Pluralism** concerns the different needs and expectations of the community in relation to transportation systems in terms of infrastructures and service supplied. For example, different targets of people may own different needs in relation to mobility, such as different businesses perceive infrastructures adequacy in different ways.
- **Institutional fragmentation** characterizes service provision when more than one player is involved in it. This could be the case of an urban area in which the bus service is run by several private companies that run the service under the standard requirements of different public authorities. In such a context it is hard to monitor performance and to check whether public or private investments provide the expected return in terms of 'value' for the reference community.
- **Scientific uncertainty** permeate transportation systems in many aspects among which we may identify environmental impacts, users' behaviour, etc.

The local public transport sector has not escaped the waves of reforms that characterized public management. We can identify two phases in the evolution of local public transportation which are coherent with the public management trend already explored.

A first phase – NPM oriented - was characterized by a common path of changes oriented toward a growing usage of some form of competition (van del Velde, 1999). This determined the emergence of new service organizational settlements more output-oriented and more independent from political control (Della Porta & Gitto, 2013). Market orientation and performance management have been replacing traditional mechanism of transportation regulation that were mainly focused on the social function of the service (Della Porta & Gitto, 2013). Competition and privatization have been implemented so as to reduce cost and to pursue efficiency. NPM reforms established a result-oriented culture that revolutionized the service provision. However, these new regulations have been failing in allowing transportation systems to pursue outcome results such as traffic congestion problems or pollution (Goodwin, 1997; Della Porta & Gitto, 2013). Market mechanisms stress the system on cost saving and efficiency pursuing ignoring public value creation process. In fact, this measures were aimed at strengthening financial sustainability of providers with the ambition of sustaining, in the long term, other dimensions of performance such as economic and social ones. However, not achieving public outcomes resulted in the raise of long term problems affecting the financial sustainability itself. This is due to the fact that urban transportation systems are complex, with multiple variables and feedback loops between subsystems and influencing factors (Wang et al. 2008).

Van de Velde (1999) framed public transportation arrangements emerged in this period into two main categories: authority initiative and market initiative. This distinction refers to the organization of the supply of public transportation services and relates to the legal framework in which these services are provided. In authority initiated regimes, transport authorities have the legal monopoly of service; this means that autonomous market entry is legally impossible. In market initiated regimes, the supply of transport services is based upon the principle of autonomous market entry resulting from a market process that may considers a certain regulation at the entrance. In figure 1.3 it is shown a diagram that allows us to analyse the different governance structures of urban transportation.

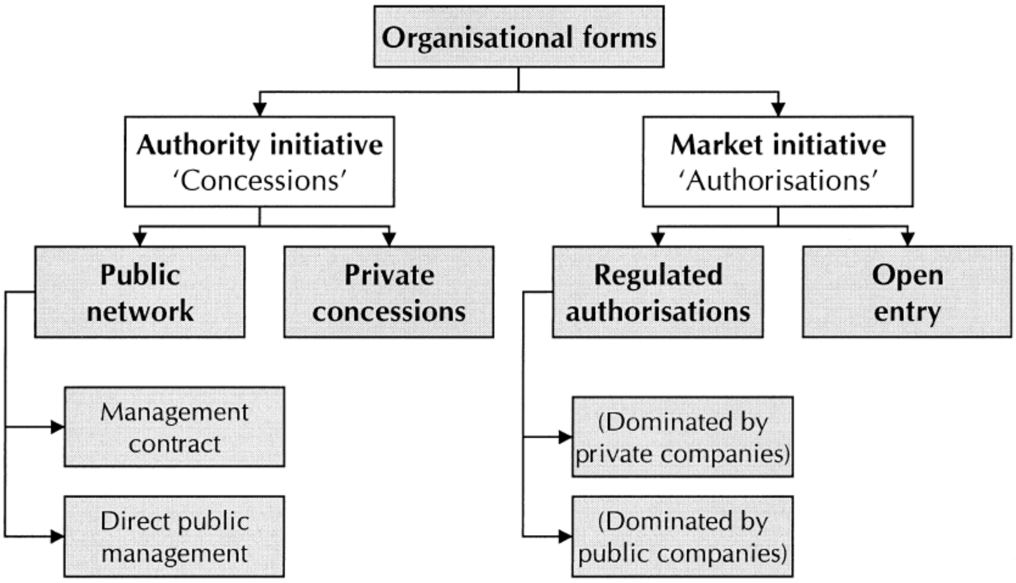


Figure 1.3: Organisational forms in public transport (van de Velde, 1999)

In authority initiatives, service results from the decisions of the authority/ies. In these systems the service can be provided by 'concessioning' to private company or from public ownership arrangements. In concessioning, the authority selects a private company that is responsible for setting-up and operating the public transport service. Public ownership regimes may be based on one authority that owns vehicles and infrastructure, and runs directly the service - by itself or through a public owned company. Alternatively, the authority can make the assets available to a private operator which is in charge of managing the whole service (van de Velde, 1999). In such initiatives, the authority plays the role of the entrepreneur, however it leaves a limited room for initiative to the service provider selected.

In market initiatives services are meant to appear out of autonomous market processes. We may find ‘open entry regimes’ that rely on the hypothesis of perfect competition, contestable markets of monopolistic competition. In these cases the authority is not absent, but it will take action in order to guarantee the safety and continuity of the service. Other forms of organizing market initiatives are the ‘authorisation regimes’. In this case, in order to entry in the market and provide the transportation service, companies have to apply for an authorisation. On the one hand these regimes shift the burden of continuously service improvement to the market; on the other hand regulations and protection against competition may create a situation in which firms are no longer disciplined by market force.

In market initiatives the authority do not play anymore the role of the entrepreneur but it may play three different roles (van de Velde, 1999):

- Watchdog (regulatory authority): controlling on predatory behaviours by autonomous companies, safety of operations, coordination of supply, etc.;
- Subsidiser: granting fare rebates to specific target groups of users and/or subsidise transport companies. The aim of these subsidies is the redistribution of wealth so as to reach a different market equilibrium than what would prevail otherwise. However, as we will see further on analyzing the Argentinian case, the use of subsidies may generate serious distortions and inefficiencies.
- Supplier: in this case the authority goes back to its role of entrepreneur by complementing the system service with additional services that are deemed to be socially desirable (i.e. providing routes that are not profitable but that may help in overcome the segregation of some districts).

Of course this classification in authority and market initiatives do not exclude the possibility to have combinations between them. In both kind of arrangements (authority or market) we find a delicate trade-off between pressures on financial outputs objectives of service providers and the general interest related to the socio-environmental outcomes improvement. In fact, even when the service is run by public-owned enterprises, these have to take care of their economic and financial conditions together with pursuing the public interest (Cavalieri, 2010; Della Porta & Gitto, 2013).

The different governance structures outcoming from the NPM reforms and portrayed in figure 1.3, shares a common characteristic that is the presence of multiple decision levels.

This, and the relative conflicting interests between stakeholders, enhances the complexity intrinsic in improving public local transportation (Della Porta & Gitto, 2013). Due to this complexity, the transformation of urban transportation services from an input to a result-oriented perspective cannot be solved by only focusing on the companies providing the service (Stanley & Smith, 2013), but it should consider the whole system through an inter-institutional perspective.

These emerging criticalities gave room for a second phase of transformation that concerns a shift from output to outcome (Della Porta & Gitto, 2013) and a value creation orientation.

Although many governments are going toward this direction, it is not possible yet to identify an unambiguous reform process with clear features and steps to follow. This is also due to the differences in the stage of NPM implementation across western countries and the different organizational forms adopted in public transport systems around the world.

However, many authors agree on the need for a better coordination and networking between the stakeholders involved in the service provision processes (Pucher, 1996; Hull, 2005; Sager, 2004; Stanley & Smith, 2013; Della Porta & Gitto, 2013). The post-NPM reforms are indeed culturally oriented toward public governance. They focus on cultivating a strong sense of values, team-building, the involvement of participating organizations, trust, value-based management, collaboration, and improving the training and self-development of public servants (Ling, 2002; Christensen & Laegreid, 2013).

1.2.1 Performance Management and Measures of Urban Transportation

Even though a new transformation of the local transportation sector is taking place worldwide, this does not mean that the tools introduced by NPM need to be indiscriminately discarded.

Performance measurement and management systems are still essential to the achievement of strategic goals (Eboli & Mazzulla, 2012; Poister et al., 2013). In a study conducted on 88 cases of transit agencies in the US, Poister et al. (2013) discovered that an extensive use of performance management practices contributes to increase effectiveness in small and medium-sized public transportation systems. This is proofed to be true because PM practices help both the establishment of clear goals and the generation of useful information that help decision-makers to manage programs more effectively (Poister et al., 2013). Therefore, when problems arise, the feedback provided by performance indicators and results can help both top and line managers in taking corrective actions on a timely basis, which is essential to keep on pursuing the desired goals (Poister et al., 2013).

PM systems can be divided into hierarchically ordered types of activities, here called levels, which differ on the basis of scope and horizon (Van de Velde, 1999; Bianchi, 2004; Bouckaert & Halligan, 2006). PM levels were classified by Van de Velde (1999) using the following:

- Strategic level (what do we want to achieve?): this first level is concerned with the formulation of those general goals that the organization aims at pursuing. The main features of the service – e.g. who the main target groups are, which one is the area of supply, how is the positioning of the service in relation to that of substitutes, etc. – are established at this level.

- Tactical level (what product can help us to achieve the aims?): this level focuses on a decision-making process directed at the acquisition of those means necessary for reaching the general aims fixed at the previous level, and on how to use these means most efficiently. The actual design of the service takes place at this level, e.g. definition of routes and frequency, fares, image of the service, etc.
- Operational level (how do we produce that product?): at this level the necessary steps are taken so as to make sure that the service is delivered efficiently, by translating tactical aspects into day-to-day practice, e.g. management of vehicles, drivers, infrastructures, etc.

It is clear that these levels are not necessarily harmonious and compatible (Bouckaert & Halligan, 2006). Well-functioning operational levels do not always guarantee a well-functioning and good performing strategy/policy. PM systems should take this into account by looking at strategic, tactical and operational performance management (Bianchi, 2004; Bouckaert & Halligan, 2006).

Therefore, in order to apply performance management to the whole transportation system of an urban area, these three levels should exchange information with each other. Thus, the operational level's performance must be reported to the decision-makers working at the tactical level, so that they might intervene if necessary. Conversely, the performance achieved at the tactical level represents useful information for other levels, in order to adjust current strategies to the system.

The figure below illustrates how this feedback system between strategic, tactical and operational (STO) levels works.

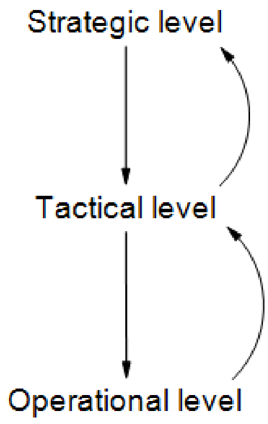


Figure 1.4: Strategic, tactical and operational levels' feedback system

The multi-level governance implicit in the urban transportation organizational forms described in the previous paragraph, often represents an obstacle for the interaction between different PM levels. In turn, this may impinge on the strategic level's ability to establish general aims that will avoid being static and unclear.

This study focuses particularly on proposing new solutions for improving performance at the tactical level. The proposed solutions will be well-suited to be integrated and support coordination with the other levels.

Tactical level is responsible for the service's design. Therefore service quality, which is the main outcome giving us of the goodness of the service and its design, is central to this study.

Given the multi-faceted nature of the transportation service, previous literature has identified several performance indicators that may measure its quality (Eboli and Mazzulla, 2012; Cascajo and Monzon, 2014). In particular, Eboli and Mazzulla (2012) provided a review of such indicators, by identifying some characteristics that would prove useful to decision-makers when evaluating service quality. These are:

- Service availability: this variable is related to the path and coverage of the transportation system, the number of stops, their relative distance and location. It mainly concerns the service's extensiveness and frequency.

- Service reliability: Turnquist and Blume (1980) define transit service reliability as "*the ability of the transit system to adhere to schedule or maintain regular headways and a consistent travel time*". Therefore frequency and timeliness represent useful variables to be monitored (Cascajo and Monzon, 2014).
- Fares: the service aspect regarding fares includes characteristics of the monetary cost of the journey, as well as the availability of volume discounts (e.g. for monthly passes).
- Comfort and cleanliness: these aspects characterize the experience of users in adopting public transportation modes.
- Safety and security: the two terms respectively indicate the chances of being involved in an accident, and of becoming victim of a crime, while making use the service.
- Information: passengers need to know how to use the transport service, where the access is located, where to get off in the proximity of their destination, whether any transfers are required, and when transit services are scheduled to depart and arrive.
- Customer care: includes elements needed to make the journey easier and more pleasant, such as drivers' courtesy, helpfulness of ticket agents, personnel's appearance, and elements linked to the easiness of tickets' purchase and of fares' payment, like the presence and condition of ticket issuing and validation machines, and the effectiveness of ticket selling network.
- Environmental impacts: this is the service aspect regarding the impact of mobility systems on the environment, including effects in terms of emissions, noise, visual pollution, vibration, dust and dirt, odour, waste, but also effects of vibrations on roads and estimations of natural resources' consumption in terms of energy or

space. In this respect, vehicle’s age together with the type of vehicles (gasoline, methane, electric) give us a reference to monitor environmental impacts.

Similar characteristics have also been identified by Cascajo and Monzon (2014). Particularly, they tested several performance indicators related to the areas identified above and found that most of them were successful in improving quality of service, customer satisfaction, and system productivity.

The features listed above may weigh differently in determining result achievement, depending mainly on the qualities of the urban context where the service is run.

Even though this study focuses particularly on the tactical level of performance, framing a PM system that takes into consideration all the three performance levels is essential in order to tackle wickedness and enhance coordination among stakeholders. In order to connect all three performance management levels – strategic, tactical and operational – is it necessary for these measures to provide for a feedback system reporting achieved results to the strategic resources owned by the system, even though through different actors. This is made possible only through the adoption of a dynamic perspective.

Chapter 2: Research Methodology

A systemic (or 'holistic') view is recommended by the literature (Ackoff, 1974; Head & Alford, 2013; Rittel & Webber, 1973) in order to tackle wicked problems because it allows us to think broadly about social problems and their possible solutions, considering major stakeholders' interests and expectations. The need to think systemically emerges from the complexity of the social environment. In complex situations, while focusing on single components or relationships within a system does not necessarily help to improve the whole system (Hjorth & Bagheri, 2006), it can also generate imbalances which, in the medium-long term, may negatively affect the performance of the same system component/relationship.

A method which allows us to take a broader perspective on wicked issues is System Dynamics (SD). SD is indeed able to link a system's structure to its performance and vice-versa, often for the purpose of changing structure relationship so as to improve performance (Richmond, 1994; Hjorth & Bagheri, 2006).

2.1 System Dynamics

System Dynamics is an approach developed during the 1950's primarily by J.W. Forrester. It may be defined as a perspective and set of conceptual tools that enable us to understand the structure and dynamics of complex, non-linear, multi-loop feedback systems (Forrester, 1961; Meadows, 1980; Sterman, 2000).

Forrester brought together concepts from several sources such as control-engineering, cybernetic and organizational theory (Meadows, 1980; Vennix, 1990). This technique, which was originally applied to industrial company problems (e.g. inventory management, falling market share, instability of labour force, etc.), has been successfully applied to a wide variety of social systems (Meadows, 1980).

System Dynamics is suitable for analysing the dynamic tendencies of complex systems – i.e. what kind of behavioural patterns they generate over time. The main assumption of the SD paradigm is that these patterns arise from the causal structure of the system analysed. Causal structures are determined by physical or social constraints, goals, rewards and pressures that make a system's agents behaving in a certain way (Meadows, 1980).

SD methodology uses causal structures in order to frame the system under analysis. The perspective through which a system dynamicist looks at the system and its behaviour is endogenous. This means that modellers tend to shift the boundaries of their SD models in order to include the structures that cause a certain behaviour within the system. This perspective allows the modeller to build closed chains of causal relationship, also known as 'feedback loops'. System Dynamics models are made up of several feedback loops linked together.

SD offers two kinds of representation: causal loop diagrams (CLD) and stock and flow diagrams (SFD). The first is qualitative and aims at focusing on the causal relationship among the variables. The other is quantitative and aims at emphasizing the physical structure of the system being analyzed.

The figure below shows an example of feedback loop through a CLD representation.

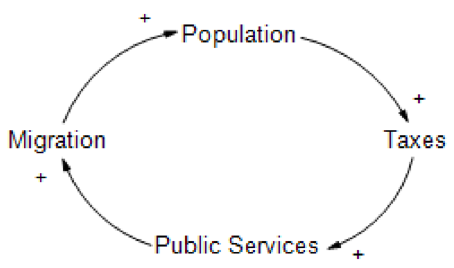


Figure 2.1: A feedback loop

The structure represented in figure 2.1 explains how the population of a certain area has a positive[1] influence on the amount of taxes the PA may collect. A greater amount of taxes generates resources that can be invested in the public services provided. Better public services make the area more attractive and this causes people living outside that area to move their businesses and residency into the area. The population will then grow due to this incoming migration flow. When every relationship in the loop is positive (therefore marked with the + sign) or the number of negative relationships is even, we have a so called ‘reinforcing’ loop. This kind of loop tends to produce exponential growth behaviours.

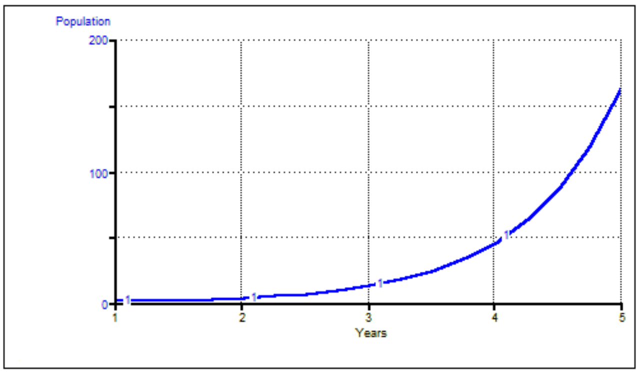


Figure 2.2: Exponenatial growth behaviour

On the other hand, what are known as ‘balancing’ feedback loops, are characterized by an odd number of negative relationships, and tend to counteract any disturbance and move the system toward an equilibrium point (Meadows, 1980).

[1] Positive (or direct) here means that when one variable changes (e.g. increases) it determines a change in the same direction (e.g. increases) to the connected variable; negative (or indirect) means that when one variable changes (e.g. increases) it determines a change in the opposite direction (e.g. decreases) to the connected variable.

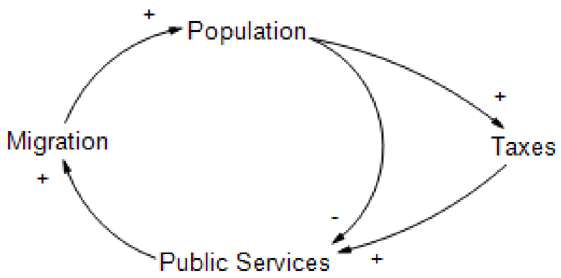


Figure 2.3: Balancing loop

The inner loop in figure 2.3 is a balancing loop. As we may imagine, although an increase in population determines more potential taxes, in the long run it also means more people to serve and as a result public service inadequate to the needs of the new population. This loop tends to counteract the exponential growth behaviour shown previously. The following graph shows the typical 'exponential decay' behaviour of balancing loops.

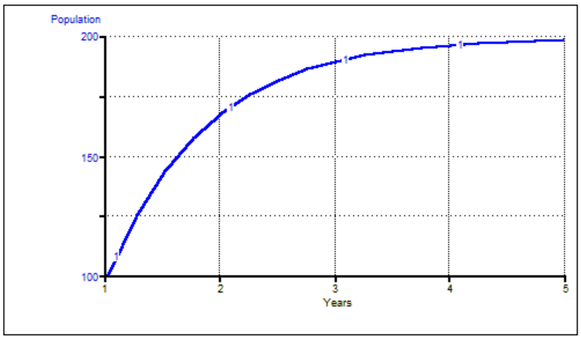


Figure 2.4: Exponential decay behaviour

While the concept of a causal loop diagram is very immediate and easy to understand, the stock and flow diagram requires a brief description of the elements included:

- **Stocks** (square variables): accumulation of material/information resources at a given moment in time;
- **Flows** (arrows with valves): flows of materials/information to or from a stock over a period of time;

- **Auxiliary variables** (round variables): elements that help the calculation, mostly indicators, parameters or constants.

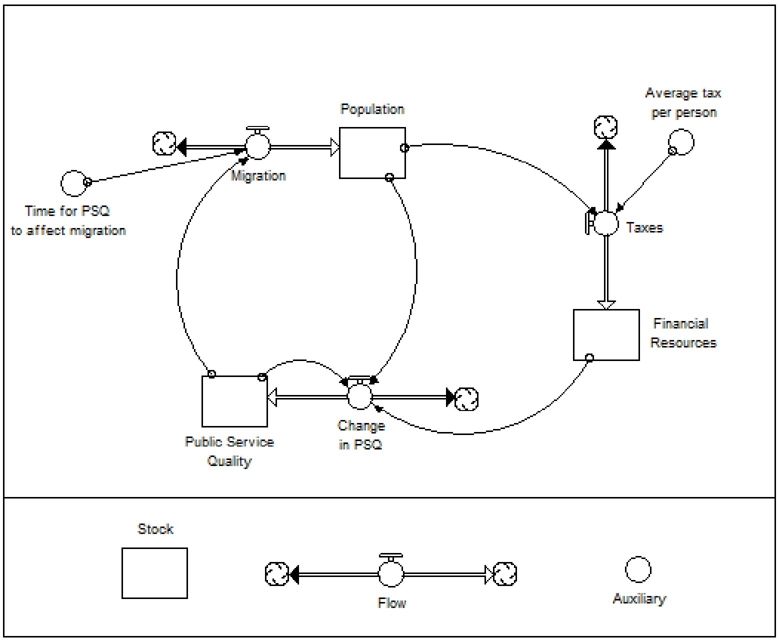


Figure 2.5: An SDF diagram

In the figure above the CLD structure displayed in figure 2.3 has been re-built in SFD terms. The image also provides a legend describing the symbols that represent stocks, flows and auxiliaries.

The interaction between multiple loops determines the overall system behavior. The following graph shows a simulation of the simple model described above.

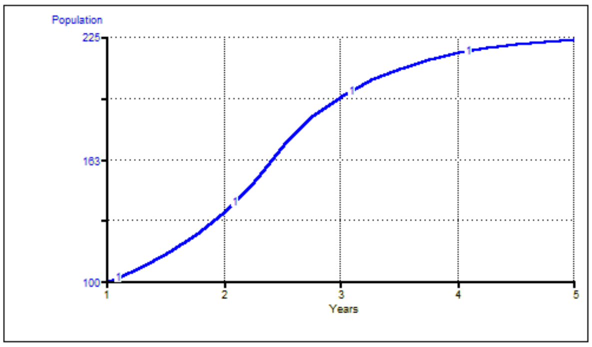


Figure 2.6: S-shaped pattern

As we can see, the initial exponential growth behavior, driven by the reinforcing loop, was then substituted by an exponential decay pattern after the second year. This generated an S-shaped behaviour caused by the shift in loop dominance over time.

What emerges from this simple system and its behaviour is the importance of the delays and nonlinearities. A nonlinear relationship affects the 'strength' of the feedback loop[2] in which it is included, determining at a system level a switch in pattern (from exponential growth to exponential decay). In the same way, time delays (e.g. the time for Public Service Quality to affect migration) can be crucial elements influencing the dynamic behaviour of a system. In the example previously discussed the time that Public Service Quality takes to affect migration determines the moment at which the behaviour experiences a shifting loop dominance.

2.1.1 Strengths and Weaknesses of System Dynamics

"All models are wrong" writes Sterman (2002) about the validity of SD models. With this sentence, which is also the title of his article, he means that our knowledge of complex systems is limited and therefore we have to simplify our models so we can represent the complexity within them. Since SD models cannot be 'right', their validity comes from their usefulness (Meadows, 1980; Sterman, 2002). This means that a model can be considered valid only as long as it is able to depict the dynamics of the phenomena under analysis. Such a concept of validity is coherent with the fact that System Dynamics models are not directed at problems of precise prediction, but are interested in general dynamic tendencies.

Even though Barlas (1996) identifies some formal qualitative aspects for model validation, there is no precise quantitative index for summarizing this process (Meadows, 1980). This is

[2] The ability to drive the overall system behaviour.

mainly due to the feedback structure which makes parameter estimation and sensitivity analysis problematic.

Despite these validation issues, the features that make SD particularly attractive for applying it to public policies and wicked issues are the ability to frame complex systems, and the possibility of simulating and understanding the main determinants of counterintuitive behaviours.

SD is not the only methodology that allows us to carry out systemic analysis. There are others 'soft OR' methods that offer similar improvements in mapping systems' structures (Pidd, 1996; Akkermans & van Oorschot, 2005). Among these, Pidd (1996) identifies 'Soft System Methodology' (SSM) and 'Cognitive Mapping'.

Both Cognitive Mapping and SSM share with SD the aim of dealing with complexity through a systemic approach (Checkland, 1988; Eden, 2004) and have been considered useful for tackling 'wicked' problems (Eden, 2004; Head & Alford, 2013; Hjort & Bagheri, 2006; Lane & Oliva, 1998). Even though each of these three approaches could be equally well employed in mapping complex structures (Akkermans & van Oorschot, 2005), SD modelling has a distinctive feature: simulation. Simulation in fact allows us to test the implicit assumptions about dynamic behaviours coming from the mapped structures (Akkermans & van Oorschot, 2005).

The value of simulation as a scientific method lies mainly in three features (Axelrod, 1997): prediction (or forecasting), existence proof, and discovery (of new structures). However, in social sciences such as management, this value also lies in its educational and training features. Sterman (2014) considers simulation the main tool we may use in order to discover how complex systems work when real experimentation is too slow, too costly, unethical or just plain impossible; that is, for most of the social issues, such as urban transportation.

However, it is important to mention that SD is not the only method allowing us to simulate a systems' behaviour. Another simulation technique that emerged in the social sciences in recent years is Agent Based Modelling (ABM).

Both SD and ABM use computer simulation techniques for investigating social systems characterized by non-linear causal relations, with a focus on both understanding and qualitative prediction of a system's behaviour (Schieritz & Milling, 2003). Due to this, the two techniques have a broad overlapping area in management research. Even though SD and ABM can be used to describe the same phenomena, there are some differences between these techniques that may result in different simulation outputs. These differences mainly concern (Schieritz & Milling, 2003): the level of analysis that is 'macro' in SD and 'micro' in ABM (forest vs trees); the top-down perspective of SD differs from the bottom-up one adopted by ABM modelers; the basic building block of modelling which is the 'feedback loop' for SD and the 'agent' for ABM; and the concept of time, continuous in SD and discrete in ABM. While on the one hand it might be more challenging to conduct a structural analysis through ABM due to its poor definition (Jennings et al., 1998; Schieritz & Milling, 2003), on the other hand ABM allows us to include other characteristics of the social system (such as spatial explicitness) that may overcomplicate a SD model. Based on both the objective of a research (structure and/or behaviour) and the level of the analysis a researcher wants to achieve (agent or system), one simulation method can be more consistent than the other.

Given the characteristics hereby analysed, SD results to be an adequate method to study governance issues in a wicked context. This consideration arises from the fact that SD allows us to conduct structural analysis of a system considering its multiple institutional levels. Furthermore, the focus of SD models on the understanding of general dynamic tendencies gives us room to lay out this study following a pragmatic approach of research. As previously discussed, wicked problems cannot be understood or solved by scientific knowledge (Head &

Alford, 2013). Therefore, purely positivistic or realistic paradigms are not entirely adequate for an analysis aimed at understanding and tackling wickedness.

Furthermore, SD is also valuable for this study inasmuch it may be framed adopting Performance Management Theory fundamentals (Bianchi, 2012). On the one hand this allows for the use in the current study of the same language present in previous studies about performance in public management; on the other it helps traditional PM approaches to overcome those pitfalls that were mentioned in the first chapter of this work.

2.2. A Dynamic Performance Management (DPM) perspective

System Dynamics, in addition to provide the holistic perspective claimed in the previous paragraphs, may help PM framework at solving the shortcoming identified by literature: lack of a dynamic perspective orientated at tackle complexity, being excessively static in terms of time and space.

The firsts contributions of SD applied to PM research can be found in 1984. The pioneers of this scientific field have been John Morecroft (1984, 1985, 1999) and Kim Warren (1999, 2000, 2004, 2005). Their approach originates from the Resource-based View (RBV) of the organization focusing on the build-up and defense of competitive advantages. In order to overcome the lack of a dynamic perspective, the authors proposed a Dynamic RBV (DRBV) of the firm achievable through the support of simulation models. These models are focused on both building-up and depletion processes of core assets including workers, equipment, population, workload, perceived service quality, and financial resources. Each strategic resources can, to some extent, be controlled in isolation of the others; however, where there is not balanced growth or coherence in the assets, then organizations will be unable to grow to achieve their own potential, or might grow in a non-sustainable way (Bianchi et al., 2015). In other words, these studies remarked that the management of strategic resources, and more specifically the maintenance of an appropriate balance between such assets, is the key to sustainable development (Morecroft, 1999; Warren, 2008).

An interesting development of Morecroft and Warren studies can be found in Winch & Bianchi (2006), Bianchi (2010, 2012), Bianchi et al. (2010), Cosenz & Noto (2014). Moving from the same findings of Morecroft and Warren, they recommend a complementary approach focusing on the identification of end-results and the related performance indicators which aim to drive the strategic resource allocation. Such an approach – named Dynamic PM (DPM) – aims to explore how end-results provide an endogenous source to the accumulation and depletion processes affecting strategic resources within a system. Results can be modelled as in- or out-flows, which change over a given time span the corresponding stocks of strategic resources, as a result of actions implemented by decision-makers.

Both SD and PM combination approaches – Dynamic RBV and Dynamic PM - represent strategic resources as ‘stocks’. An example could be given by the ‘number of vehicles’ in a transportation system: it is a variable that can be measured in unit and that can be observed at a given moment in time.

However, while a dynamic resource-based view concentrates the analysis on these variables, and the relative models are designed based on the building up and decline of key core assets, a dynamic performance management view approaches the system analysis by identifying both end-results and performance indicators (Bianchi et al., 2015).

End-results are typically represented as ‘flows’. A flow is what changes the stock over a period of time. Back to the number of vehicles’ example, one of its flow is the ‘vehicle purchasing rate’. This, that can be measured as unit per time, says to us how much ‘number of vehicles’ has changed during the time period considered.

End-results depend from intermediate results (performance drivers or indicators) that are causally determined by the employment of strategic resources. These indicators are usually measured in relative terms by comparing the actual state of a variable with a target value or a benchmark. The gap this comparison creates, represents the intermediate result the management should monitor in order to achieve the end-results. When dealing with social issues such as transportation, indicators should not focus only on economic measures but should also include aspect relative to other dimensions of performance (Eccles, 1991; Coda, 2010) in respect to the holistic perspective mentioned above.

The model structure is then obtained by linking the relevant stocks and flows which determine a certain behaviour of the system over time (Cosenz, 2010). The feedback loops built by following this approach, imply that the flows affecting strategic resources are measured over a time lag. This makes clear how the delays involved in the resources accumulation process represent a central issue in managing performance in a dynamic and complex environment such as the one studied here.

This approach provides a systemic view of a production/provision process since each performance indicator shows how the employment of the linked strategic resources affects all the other interdependent resources within the system (Bianchi et al., 2015). Due to this interdependence, each strategic resource has indeed the power to foster or not others in the same system. For example, financial resources affect the number of vehicles available to the service through new investments; the number of vehicles available impacts on the distance travelled during year, and this last determines the amount of public resources assigned. Public funds increase net income which, over time, influences the financial resources value positively.

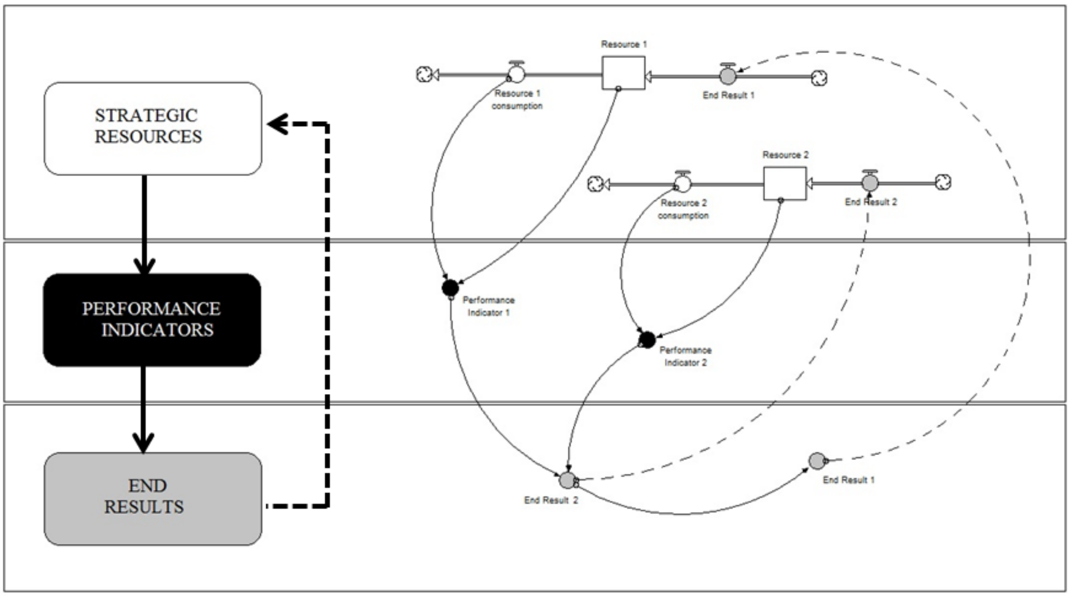


Figure 2.7: A Dynamic Performance Management view (from Bianchi et al., 2015)

Figure 2.7 illustrates the dynamic performance management framework. The analysis starts from the bottom of the diagram which concerns end-results identification. These are causally related to performance indicators variables, which are represented as auxiliary variables (in black). These indicators represent the intermediate results that explain how the final ones are achieved. Performance indicators depend (causal relationship) on the usage of the strategic resources (square variables). Strategic resources accumulate value when the end-results are achieved and decrease value when they are employed in a new production/provision cycle.

Particularly relevant for this study, and related to the DPM approach, are the 'external' and 'internal' perspectives defined by Bianchi (2010) that suggest the adoption of an inter-institutional level of analysis to better frame the value dynamics of public organizations, seen as 'loosely-coupled' institutions. While at the single-institution level performance is assessed primarily in relation to the effects produced by decision-makers on their own organization, at the inter-institutional level, performance is assessed in relation to the effects produced by decision-makers on the wider system, which comprehend multiple institutions, i.e. the urban area (Bianchi, 2010, 2012). The inter-institutional system's performance does not correspond to the mere sum of the performance of each single institution, but can be defined as "*the net relationships and synergies among the different institutions linked to each other*" (Bianchi, 2012, pp. 147).

In order to assess performance at an inter-institutional level Bianchi (2010, 2012) suggest as a first step of analysis to firstly focus on performance at a single-institution level. This allows the analyst to understand how the organization is likely to positively contribute to the generation of public value. Public value creation will then provide the conditions for the generation of new value to the benefit of each institution participating the system (Bianchi, 2012).

Such a shift from a micro to a wider system perspective allows us to broad the boundaries of the analysis without losing the focus on the performance assessment.

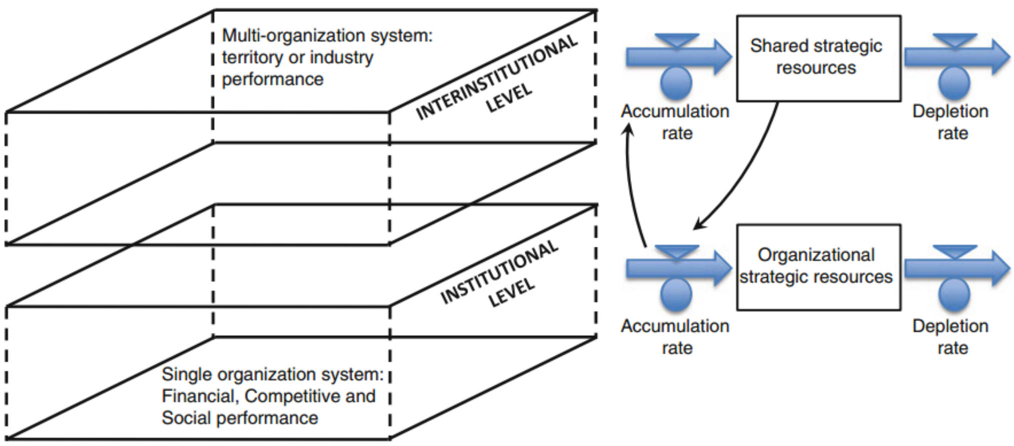


Figure 2.8: The institutional and inter-institutional levels for analysing multi-level governance framework (Bianchi, 2012)

Figure 2.8 shows how a DPM approach is likely to include different governance levels when applied to a case. Strategic resources affecting the service performance can be owned by several stakeholders. In order to insure a proper endowment of such resources and to keep a proper balance between the different strategic resources it is necessary that the governance levels coordinates their action.

DPM is the approach chosen for tackle this research work. It characteristics permit us to set out the study in terms of performance management, overcoming those limits that do not allow traditional tools to deal with complexity and wickedness. Furthermore, DPM takes into account the inter-institutional environment in which a public transportation service is provided.

Chapter 3: Palermo's Case Study

3.1 The Case Background

In Italy public transportation development in the last 40 years can be divided in different eras (Della Porta and Gitto, 2013).

The first one, named 'municipal capitalism age', started at the beginning of 1900 and was characterized by a strong focus on the urban dimension and the social function of the urban transportation service. This phase, which was historically determined by the weaknesses of Italian economy of that time, consisted in the in-house provision of the service by the government, through the employment of municipalized firms.

A second phase, interesting the years between 1980 and 2012, and called regionalism, may be divided in two stages. The first one was aimed at integrating the urban service with the extra-urban one. In those years the concept of Public Local Transportation, that is a transportation service focused on the territory and not on the single municipality within its boundaries, emerged. A National Fund of Transport was introduced (Law 151/1981) so as to cover the expenditure of agencies that were free to rely on subsidies, since the public transportation service was not considered financially sustainable. However, this ultimately provoked an increase in the expenditure, creating a huge deficit in the public transport sector.

In order to overcome such pitfalls, a NPM oriented reform was introduced in 1997 by the government. Italian NPM has been mainly characterized by a political orientation toward power decentralization to local governments and privatization of public companies (Anselmi, 1995; Rebora, 1999). Nowadays, local utilities in Italy are often run by joint stock companies controlled by public agencies such as Regional and Municipal Administrations. This creates a multi-level governance structure in which public services are provided by these subsidiaries through service contracts. The pressures and the constraints arising from different institutional levels, with diverse goals and service expectation, could render a top management intervention more complicated. Eventually, such a governance implies an administrative fragmentation that is depriving both the political and administrative bodies of levers of control and information, raising questions of accountability and capacity (Christensen & Laegreid, 2007).

From 1997, and particularly after the reforms of 2005 and 2011, this situation has been made even more complicated by the introduction of the European Union 'Stability and Growth Pact' (SGP). This is a rule-based framework for the coordination of national fiscal policies in the European Union. It was established to safeguard sound public finances, based on the principle that economic policies are a matter of shared concern for all Member States (Lo Bue, 2014). The adoption of this framework by the Italian Government determined serious limits to the expenses that local agencies can undertake in order to balance their budgets. Therefore, even these joint stock companies are under pressure from the local authorities to balance their budget with decreasing resources, and the same level of quality standard of the service expected (for example, Palermo's transportation utility service contract was reduced by 20% from 2011 to 2012). Furthermore, the Italian 'Stability Pact' 2014 established new constraints for local authorities' subsidiaries.

3.2 The Governance Structure of Palermo's Transportation System

The case here presented is based on the urban transportation service in Palermo. The service is run by AMAT S.p.A.. This, since 2005, is a joint stock company in which the Municipality of Palermo holds the 100% of shares. On the one hand, being formally private, the company is accountable for its economic and financial performance; on the other hand AMAT faces several constraints coming from both the service contracts stipulated with the Municipality—who imposes significant personnel policies —and from the influence of the Sicilian Region—*i.e.*, the Region allocates the 50% of the total funds the utility receives and decide the minimum ticket price this may ask to the citizens.

This fragmented structure made AMAT experiencing a dynamic problem consisting in a decreasing net income which results, over time, non-sustainable in each performance dimension.

Figure 2 synthesizes the multi-level governance structure in which the utility operates.

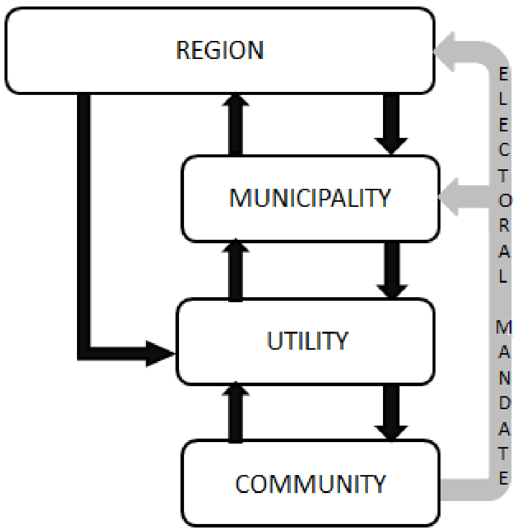


Figure 3.1: The governance structure

In Italy, Regions constitute the second level of Public Administrations. Sicilian Region influences the utility activities directly (by deciding the ticket price) and indirectly (by transferring funds to the municipality that have to be devoted to urban transportation). The Municipality of Palermo, on its side, corresponds a fixed amount of funds to AMAT every year. On the other hand, holding the 100% of the utility shares, the economic performance of AMAT influences results and strategies of the Municipality itself. At the bottom of the governance structure presented in Figure 3.1, we find the community, namely, citizens and visitors of Palermo and its territory. AMAT provides the service to them and if it does not match their expectations this will badly influence both the utility performance in terms of ticket sold, and the others governance levels (because of the lower level of public value generated) when elections time comes.

The governance structure described above falls into the ‘authority initiative’ category of organizational form. The public sphere plays the role of the supplier through a public network of actors. AMAT has indeed the legal monopoly of initiative in the sense that autonomous market entry is legally impossible and that all production or market entry is the result of a conscious one-sided authority initiative to produce or request the production of services (Van de Velde, 1999).

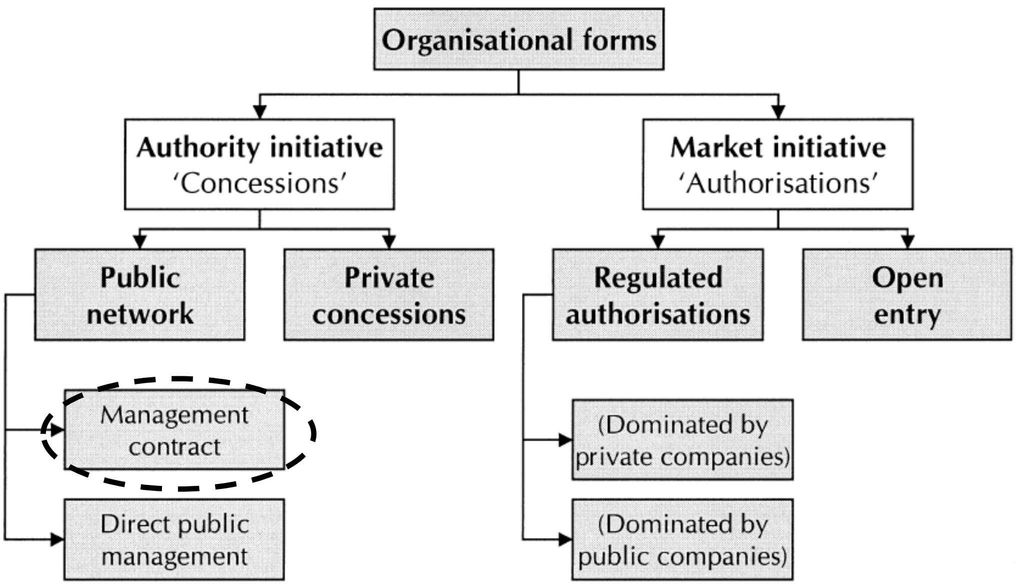


Figure 3.21: Palermo's organizational form of public transportation

When building a model upon this case we need to take into account the governance structure displayed in figure 3.1 since it influences and sometimes generates, important causal relationships responsible for the whole-system’s behaviour (Bianchi et al., 2010; Bivona & Montemaggiore, 2010; Winch, 2010).

The model was built with the aim of simulating AMAT performance. Being this last the service provider, a model able at simulating its performance behaviour would allow us to understand the system structure. It would be possible to analyse where and how the wicked problems that the service faces originates. However, this does not mean that the inter-institutional structure of the governance were not considered. Connections among governance levels would be made explicit through causal relationships and, once the performance indicators will be identified, it will be clear who and how influence each of those. As a result, an SD model and a set of performance indicators were built that allowed us to run the analysis.

The main assumption behind the case study refers to a population that does not change. This choice was made since this variable has been pretty much stable during the period considered[3].

The data needed to develop the case and build the model have been collected thanks to several meetings with four AMAT top managers (economic and financial director, human resources director, maintenance department director, transport service director), and an interview with the 'Transportation of people department' director at Sicilian Region. These meetings helped in building a qualitative structure of Palermo's model (namely a Causal Loop Diagram). Once the system was structured, thanks to a deep document analysis (balance sheets from 2008 to 2012, service contracts with Municipality of Palermo and Region of Sicily) a quantitative SD model was built (Stock and Flow (SF) model).

SF structure was needed in order to distinguish among strategic resources and end-results and to identify the relative performance indicators. Also SF diagram allowed the simulation of the analysis results. As the model building process is iterative, the formulation of the SF model helped in testing and adjusting the first CLD sketch. The variable chosen as reference

[3] Source ISTAT.

mode for this case study is AMAT net income. This represents the main result which the management monitors and aims to achieve, and it is computed as the residual of all revenues and gains over all expenses and losses for the period (Stickney et al., 2009).

3.3 Palermo's Model

3.3.1 A Causal Loop Diagram

Through the CLD it is possible to identify the system feedback loops responsible for the system performance behaviour. Each link constitutes a hypothesis based on the key actors meetings. In the diagram below it is displayed the CLD with the identification of the main loops.

Figure 3.3 shows three main reinforcing loops related to the dynamics generating revenues, and two balancing loops concerning the origins of costs. Additionally, two more reinforcing loops show the feedbacks from the community to the service quality standard, while another balancing loop refers to debts.

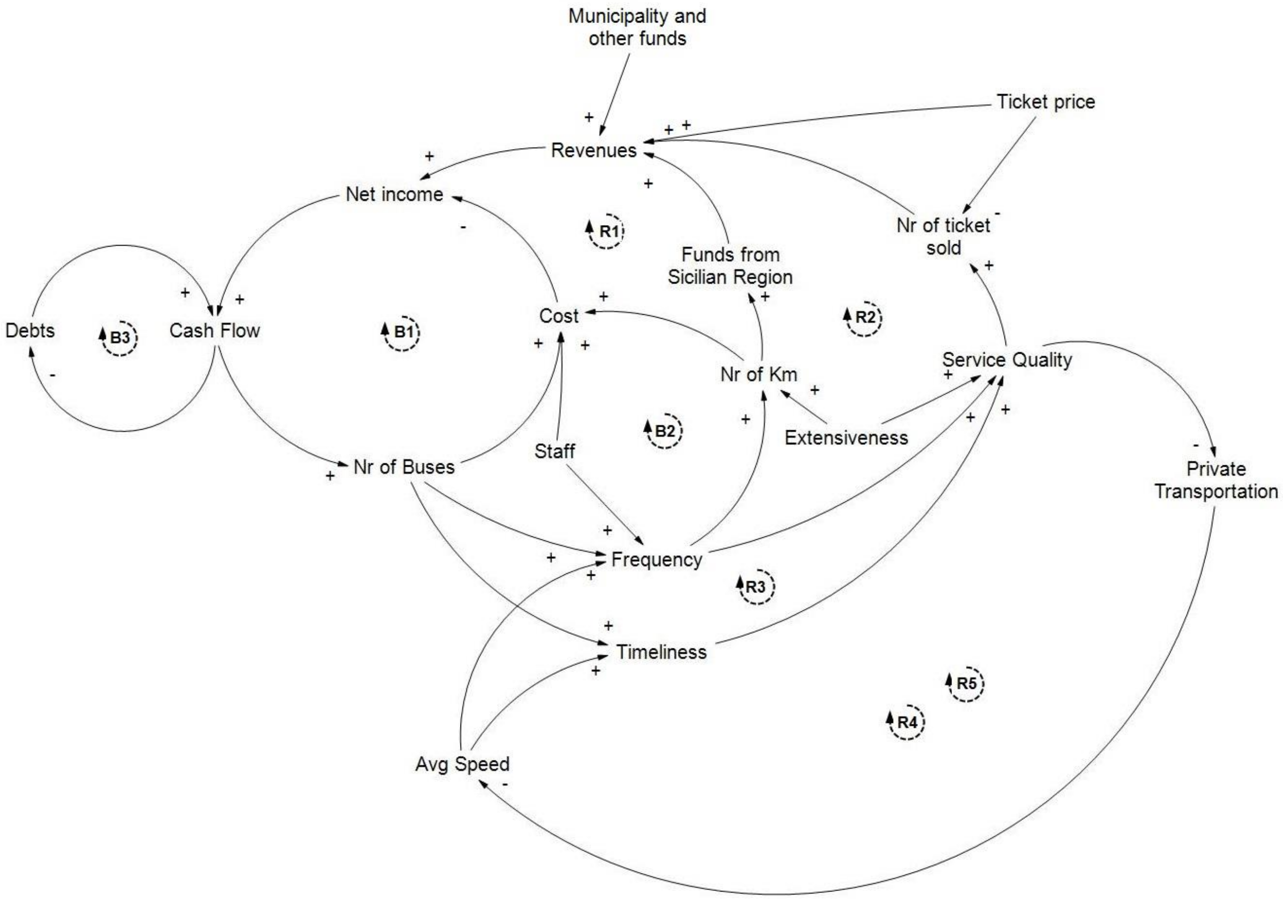


Figure 3.3: Palermo's case CLD

In Figure 3, Rs and Bs identify the systems' loops. R stands for 'reinforcing' and B for 'balancing'.

R1 loop shows how net income is connected to cash flow; a positive cash flow gives the company the possibility to invest in new buses. The presence of new buses makes the company able to provide the service with more frequency. This directly impacts on the number of km travelled every year which, based on the service contract with the Sicilian Region, determines the amount of funds the same Region would allocate to AMAT for its service. These funds are one of the main determinants of company's revenues, base of calculus for net income.

B1 loop represents the dynamic by which an increase in number of buses - determined by cash availability and, therefore, incomes - increases, over time, the cost of maintenance which will be added to the total cost the company yearly incurs. Total cost is the negative component of the net income.

B2 loop represents the higher cost the company incurs in when number of km travelled per year grows. In fact, when number of km travelled increases, due to a bigger frequency related to an increase in the number of buses available, total cost of gasoline increases.

B3 loop shows the company's debt policy. Simply, whenever the cash flow goes below zero, AMAT management is willing in increase its debt. While every time the cash flow is positive, AMAT management is willing to use part of it to reduce its debt.

R2 and R3 loops represent the dynamics relative to service quality. These loops were built based on the hypothesis that service quality mainly depends on the extensiveness of service, its frequency and its timeliness. An improvement of service in these directions would determine an improvement in quality as perceived by citizens and customers. As the perceived quality of service increases, customers' satisfaction will grow and revenues coming from ticket sale will increase. This will positively affect net income that, determining the cash level, may allow the manager to invest in new buses in order to ensure a better service quality.

Concluding, R4 and R5 loops show how an increase in service quality may cause, over time, a reduction in private transportation and so in traffic congestion which will allow buses to run faster and more frequently.

A last comment on the CLD regards the boundaries of the system, that is to say, the variables considered exogenous (namely, variable not influenced by any other factor within the system). This study considers exogenous the extensiveness (number of bus routes), ticket price, the revenues coming from the municipality service contract and a variable directly impacting on the cash flow: other funds.

The number of lines is determined unilaterally by the Municipality, while the ticket price is decided by the Sicilian Region.

The reason why the municipality service contract has been considered exogenous resides in the fact that this contract is characterized by a fixed amount of money that does not change in base of any parameters.

Other funds represent not-planned funds coming from 'external' actors such as the European Union (this is what happened in 2011, where € 20 million funds were attributed to AMAT by the Municipality in order to buy new buses).

A particular remark is due in explaining the decision making process regarding personnel area.

As the reader may notice, the staff variable is not affected by any others. This could sound curious since, being 'Labor' one of the component of any production function, total staff should receive at least a feedback from the activity size. What surprise in this case study it is that, due to the Municipality influence and to the Italian Stability Pact (Articles 550-569 of the Italian Law n.147/2013), the top management is not able to modify human resource availability when needed.

3.3.2 Stock and Flow Model

The conversion from a CLD to a SF model is a necessary step to do for conducting the performance analysis and for simulating the results of the structural analysis conducted above. The SF model structure allows us to read the causal relationships of the system by adopting a Dynamic Performance Management perspective.

As already stated, in order to define performance indicators, a DPM approach starts from the identification of the system's end-results. The main end-result here identified is the net income. This depends on the total cost and the total revenues.

Revenues come from ticket sales, municipality service contract and regional funds. The municipality service contract is not depending on any variable, but it has been negotiated as a fixed amount of money the Municipality of Palermo correspond to AMAT each year for the transportation service. Regional funds depends on the total funds Sicilian Region assigns to local transportation each year and on the number of km travelled by the company.

Ticket sales revenues are determined as the number of tickets sold times the ticket price. This last variable has a minimum value fixed by Sicilian Region. The number of tickets sold depends on customer satisfaction and, therefore, on service quality. Through the meetings with AMAT managers emerged how the most significant service quality determinants are: service extensiveness, service frequency and service timeliness.

Service frequency and extensiveness, together with the average route length determines the distance travelled and so the regional funds assigned.

While service extensiveness – that has been measured as number of lines – depends on political choices, service frequency and timeliness are affected by both number of buses and number of drivers available for the service. Frequency and timeliness also depends on the average speed of buses which is affected by traffic congestion. This last mainly depends on the rate of private transportation modes usage that is influenced by the service quality itself.

Frequency indicator has been measured as the number of trips done during the year divided by the number of trips done during the first year considered by this analysis. Timeliness has been measured as the number of trips planned against the number of trips lost for each year.

As already stated and explained, personnel policy has been taken as exogenous in this model. The number of vehicles available – which also affects service frequency and timeliness - depends on the amount of investments made. The fleet characteristics, and in particular average bus age impact on the maintenance cost that, together with the other costs (personnel, gasoline, depreciation, etc.) determines the total cost, negative component of the net income.

The investments AMAT makes depend on the financial resource availability which are influenced both by the business management results and the debt policy.

In figure 3.4 it is shown a simplified version of the SF model regarding Palermo's case[4].

[4] The full map and list of equations of the model can be found in Appendix A.

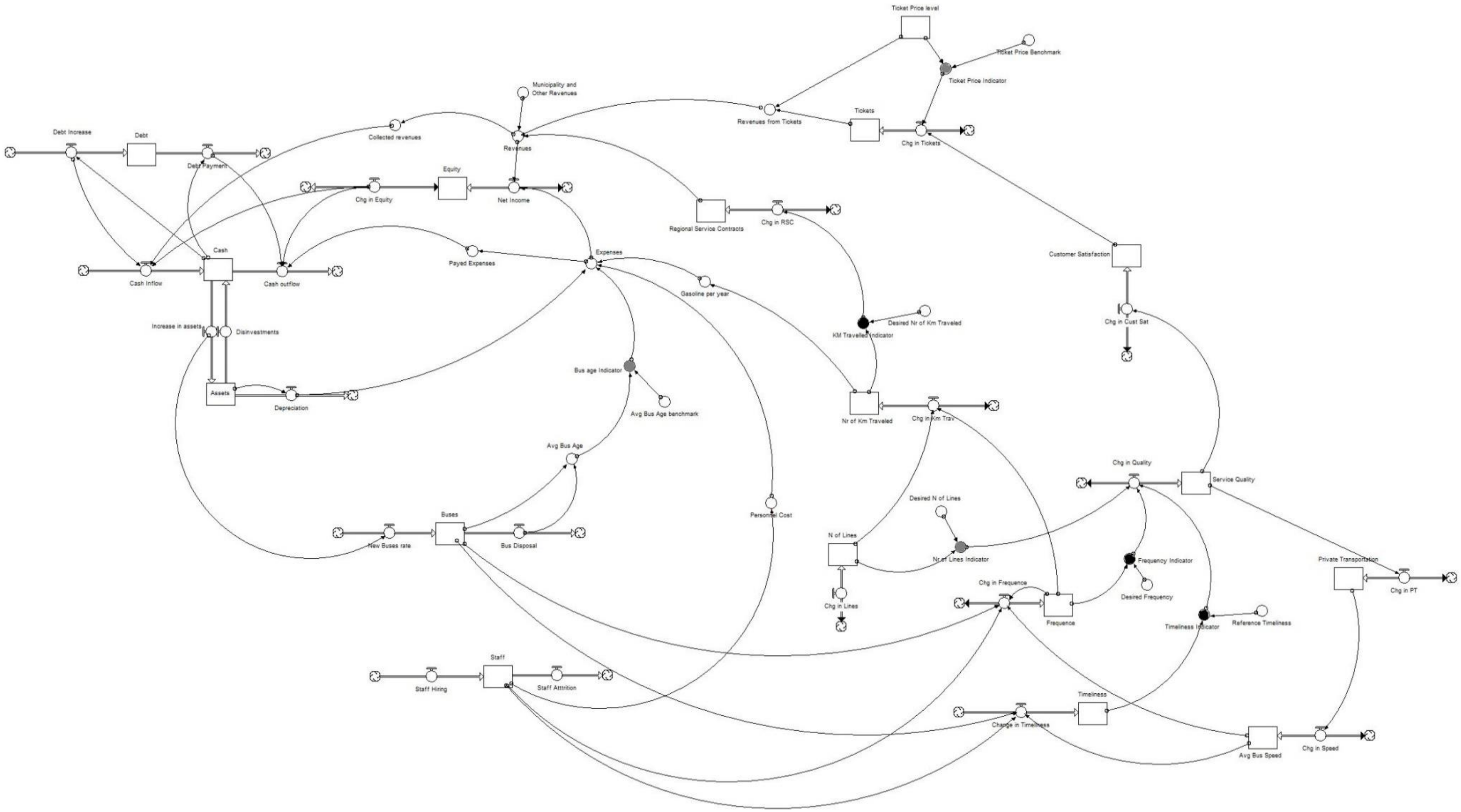


Figure 3.4: Palermo's case SFD (simplified version; the full version of the model comprehensive of equation is available in the Appendix)

The simulations results are portrayed in Figure 3.5.

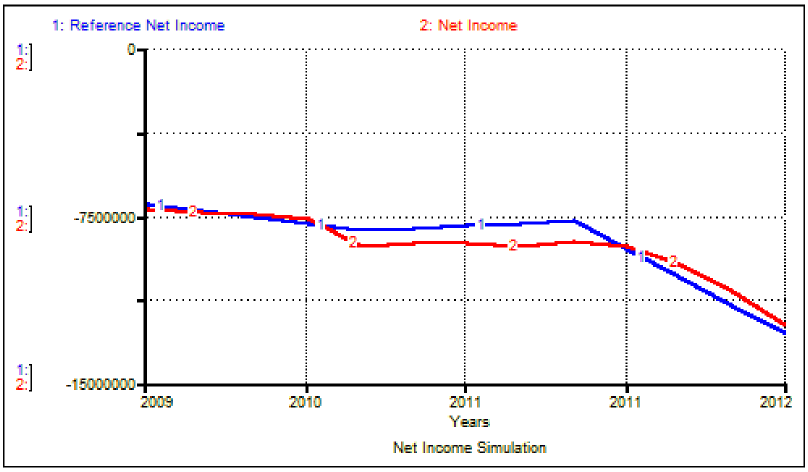


Figure 3.5: Simulation results

Line 1 (Reference Net Income) represents the historical data taken from the official balance sheets (2009–2012). Line 2 (Net Income) represents the result of the model simulation. As we may notice, the system has encountered a dynamic problem which consist in a non-economic sustainability.

Replicating the system behavior with a low deviation from the historical data is important but it is not enough to demonstrate the reliability of the model (Barlas, 1996). Therefore, some other tests (structure verification test, extreme condition test and sensitivity analysis) have been conducted in order to validate the model. Also, once the model was built, further discussions on its structure were conducted with AMAT managers in order to get feedback and further insights on the case study.

The diagram in figure 3.4 also shows the performance indicators (colored circles) defined by the adoption of a DPM approach. This are listed and discussed as follows:

Indicator 1 - Distance Travelled: This indicator was built by comparing distance travelled (measured in number of km) by the company's buses during the year, with the distance requested by the Municipality and the Region in order to perform the service contracts duties. Given the company resources, this is an effectiveness indicator that shows AMAT's ability to perform a specific service requirement. Distance travelled depends on extensiveness (number of lines) and frequency of service. Given the resources in terms of buses and drivers, it is AMAT having a major role in ensuring a satisfying frequency of lines to offer to customers.

Indicator 2 - Buses' Age: Buses' age indicator impacts directly on cost of maintenance. Buses younger than five year cause an ordinary cost of maintenance (i.e., filters, oil, etc.); non-ordinary costs (i.e., engine repair) are at the expenses of bus suppliers. Buses older than five years determine a bigger cost for AMAT since it is in charge of both ordinary and non-ordinary costs. This intermediate result is affected by the investment rate (bus purchase rate). The investment rate appears mainly determined at a municipal level (through the allocation of specific funds).

Indicator 3 - Ticket Price: Ticket price, as microeconomic literature may support, has a direct impact on the demand of service. The minimum ticket price is determined by Sicilian Region. The company is allowed to apply a lower price only if the municipality guarantees to pay out the difference between the two prices multiplied by the number of tickets sold during the year. This means the company cannot modify the ticket price in relation to demand variations.

Indicator 4 - Nr of Lines: The extensiveness of service was measured as the number of lines the company offers. Today AMAT service runs through ninety lines. From the top management interview emerged how this number is mainly affected by the political sphere.

Politicians impose the presence of many non-remunerative lines in order to ensure the public service to citizens.

Indicator 5 – Frequency: This indicator is measured as a ratio between the actual service's frequency and the initial one (in 2009). Frequency ratio is an indicator of effectiveness, and measures the ability of the company at optimizing its resources (buses and drivers) in order to ensure as much frequency as possible.

Indicator 6 – Timeliness: This indicator is the ratio that measures the rate of trips done over the total trips planned. The main variables that affect this indicators are: lack of drivers, lack of bus available and traffic congestion.

3.4 Discussion and Policy Options

What emerges from the indicators analysis is that many players may be considered responsible of the service performance. When one indicator is depending on a resource owned or controlled by other players than AMAT, that resource do not get any feedback from the system performance (see ticket price or number of lines). The more 'endogenized' is the resources in the system (that is to say, the stronger are the feedbacks a resource gets from the system), the more the system's player can effectively intervene on the connected performance driver (Noto & Bianchi, 2015).

In this case, three out of six indicators (buses' age, ticket price and number of lines) are mainly depending on other governance levels. This situation, which is pretty common in organizations providing public services, makes the different governance players managing the resources under their control solely to pursue their individual aims. The set of indicators provided would inform these actors about how the system works and therefore encourage them to adopt a systemic view. This would facilitate the alignment of aims between the various stakeholders, which is the first step for pursuing the coordination claimed by the Joint-up government reform (Noto & Bianchi, 2015).

In order to foster coordination, it is therefore necessary to reform the system structure so that the exogenous strategic resources (such as ticket price) can get feedbacks from the system itself; like that, new loops will be added to the system 'endogenizing' new processes relevant for the service provision (Noto & Bianchi, 2015). This structural change is based on communication and information exchange between stakeholders owning strategic resources.

3.4.1 Policy options

The performance indicators analysis gives a clear understanding of how fragmentation and multi-level governance impact on the service performance. Creating a feedback from system performance to the system resources may resolve the effects of fragmentation of actions among the governance players involved. Therefore two policies that creates such loops has been tested through the model.

The first policy concern the 'endogenization' of ticket price value decisions. Figure 3.6 shows the new loop (B4).

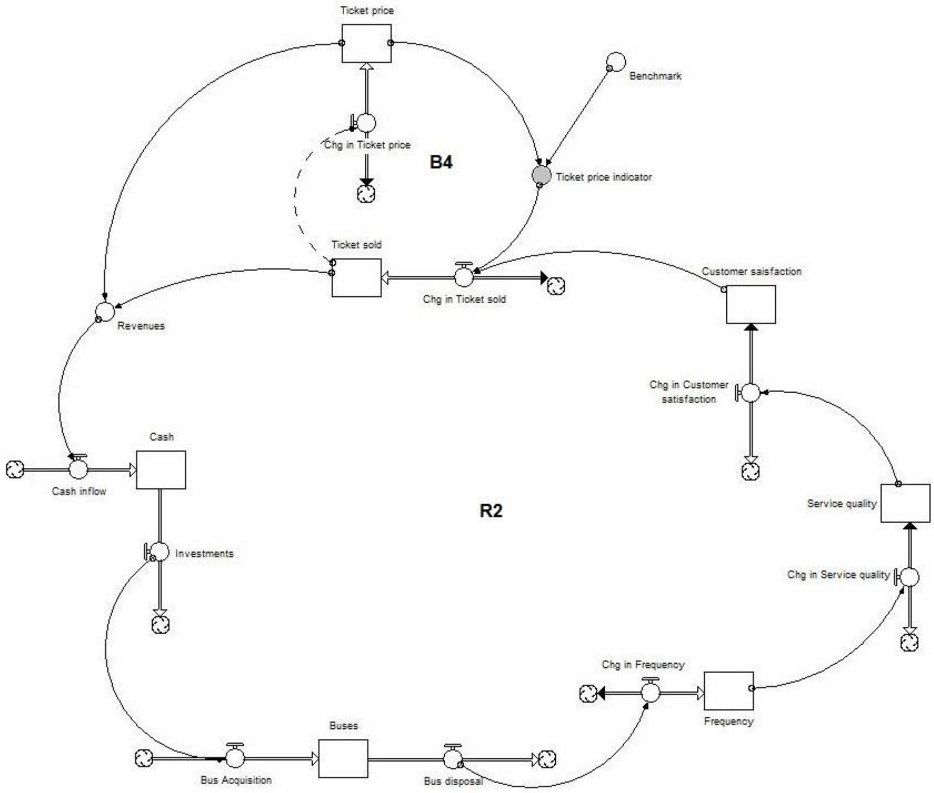
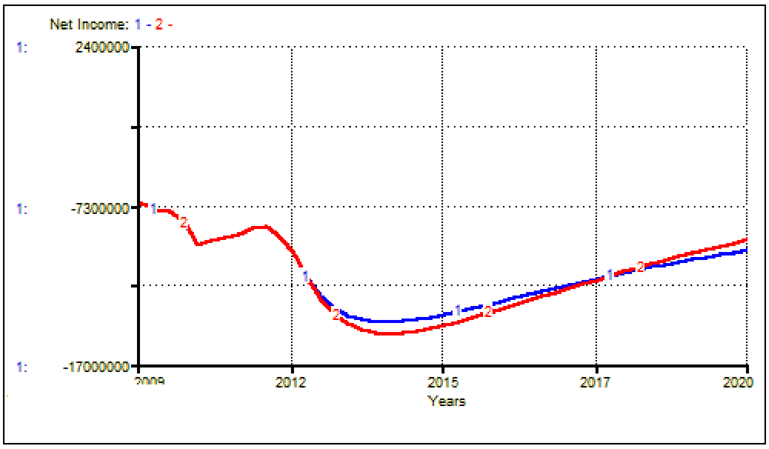


Figure 3.6: Policy option 1 - ticket price indicator

R2 is one of the loops representing the dynamics relative to citizen/customer satisfaction. This loop is based on the hypothesis that customer satisfaction depends on the frequency of service. A service improvement in these directions would lead to an improvement in quality as perceived by citizens and customers. As the perceived quality of service increases, customers' satisfaction grows and ticket sale revenues will also increase. This will positively affect net income. 'Tickets sold' is a strategic resource influenced not only by customer satisfaction but also by the ticket price level. Ticket price value is a strategic resource controlled by the Sicilian Region. This governance level does not get any feedback from the company performance (in terms of tickets sold) in order to decide how much to ask to citizens for a ticket. Adding a new causal link (dashed in the above figure) and a new flow ('Chg in Ticket price') to the existent structure would give to the Sicilian Region the possibility to intervene on this variable more consciously and to take into consideration the effects on the whole system. With this new link we then create a new feedback loop (B4) which strengthens the coordination between the governance levels involved, now able to jointly intervene on the 'ticket price' indicator.

In order to test such a policy, the model was simulated (figure 3.7) in the mid-term future (from 2009 to 2020) with (line 2) and without the proposed solution (line 1). In both cases the net income experiences a growing path. This is due to the fact that, even when no policies are applied, the net income trend of the firsts years after the historical data were collected is characterized by a transient behavior and then tend to settle at about – 7 mln €. In figure 3.7 is it possible to observe how applying this new feedback policy the net income, after a worse result in the short term, shows a better result in the mid-term.

The second graph of figure 3.7 displays the behavior of the Ticket Price indicator. The declining trend that this indicator was experiencing before the policy application has been divert thanks to the new feedback process.



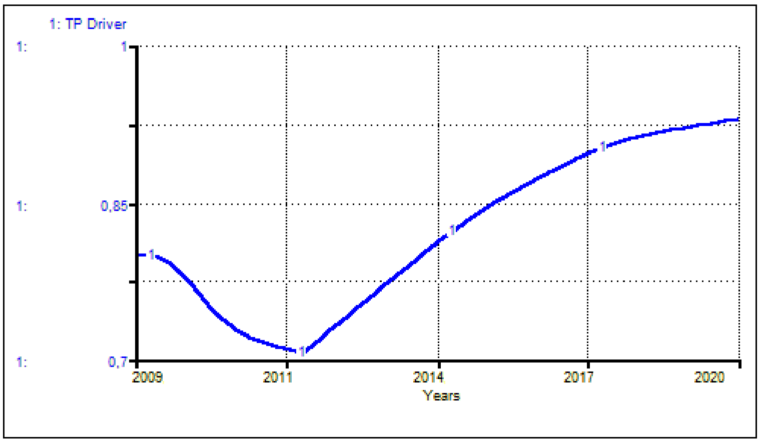


Figura 3.7: Policy option 1 - results

By looking at the policy effects we notice that, even though they show a better result than if no policies would be applied, this solution is not satisfactory since the net income is still negative at the end of the considered period. Also, if we observe the pattern of the service quality (figure 3.8), which can be considered a good measure of value created, we see that it still remains below the reference value (1.00) and does not present a decisive growing path after the policy application.

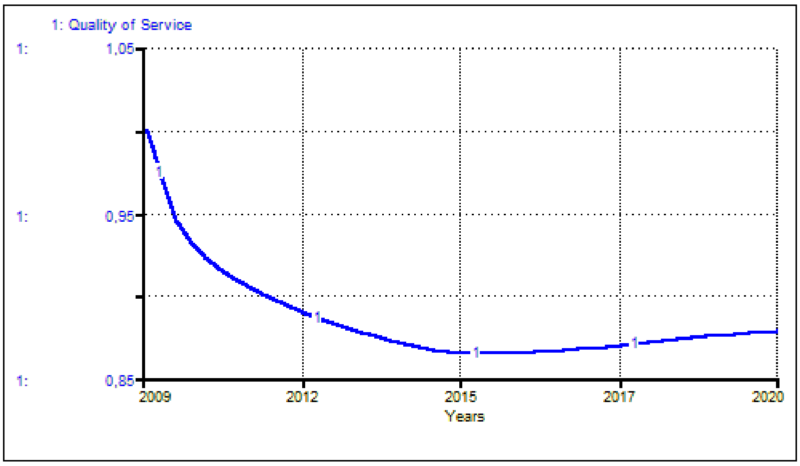


Figure 3.8: Policy option 1 - value creation

The second policy designed and tested concerns the feedback that the buses age indicator may give to the Municipality in order to receive more funds to be invested in new vehicles.

Like that, whenever the average bus age is higher than the benchmark one, the Municipality will correspond more funds to the service provider so as to buy new buses. In order to strengthen this policy we can also decide to increase the percentage of bus acquisition on total investment from the initial 30% to 70% if the revenue from the Municipality of Palermo are bigger than a certain amount (i.e. € 28 mln).

The diagram displayed in figure 3.9 shows the cost loop (B1) already described and the new reinforcing loop (R6) that relates the system performance (buses age indicator) to an exogenous resource (Municipality Service Contract). Whenever the buses age indicator scores below its reference benchmark (10 years), the Municipality receives this information and allocates more funds to the provider for investing in new assets. More funds from the Municipality increase the total revenues and so the net income. A bigger net income will be translated, over a collection time, in a bigger cash-inflow that allows AMAT to increase its investments in new vehicles. An increase in the bus fleet due to new buses incoming lowers the average buses ages toward its goal and has an impact on the cost of maintenance per bus unit.

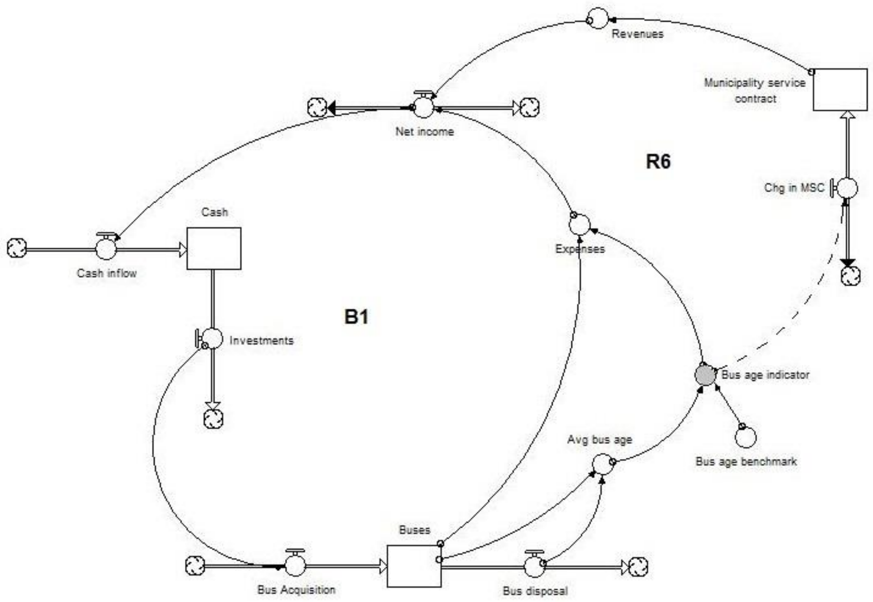


Figure 3.9: Policy option 2 - bus age indicator

Adding a new causal link (dashed in the above figure) and a new flow (‘Chg in MSC’) to the existent structure would give the Municipality of Palermo the possibility to intervene on this variable more consciously taking into consideration the effects on the whole system. Applying such a policy results in a better performance and a net income that within 8 years become positive. The first graph displayed in figure 3.10 shows the net income without any policy application (line1) and the same variable simulated with the implementation of the new R6 loop. The second graph shows how the buses age performance indicator develops by applying this policy. Even in this case we may observe a decisive change of trend in the performance indicator behavior from when the policy has been applied.

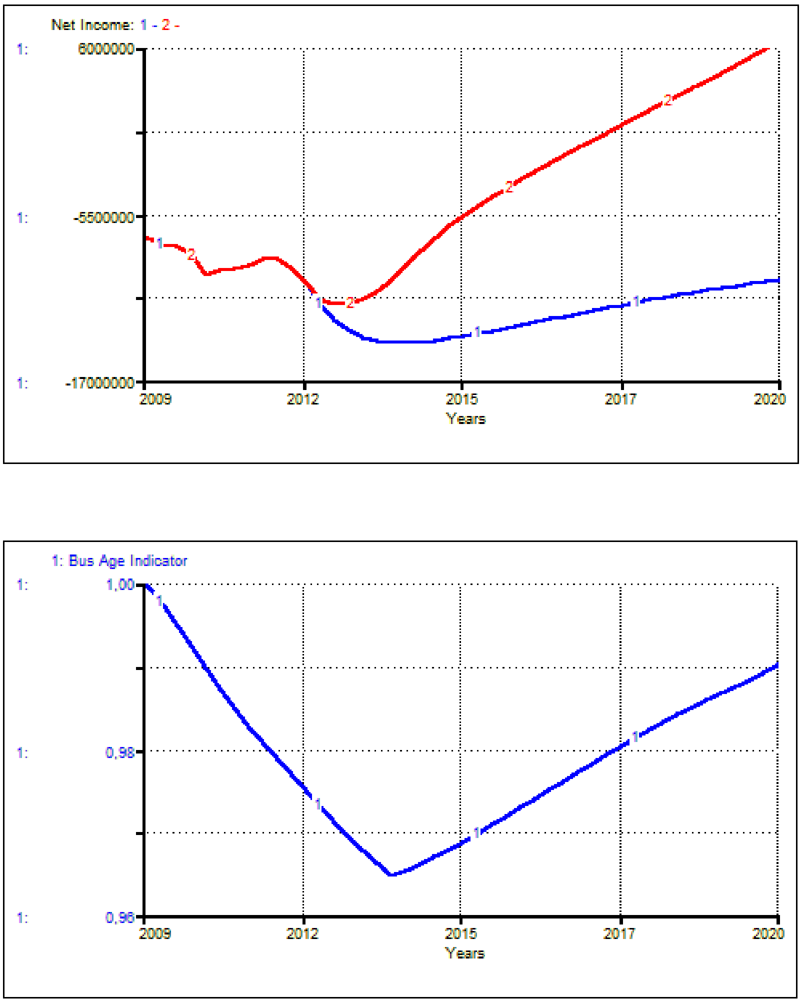


Figure 3.10: Policy option 2 - results

This solution also resulted to have a stronger impact on the creation of public value. As we may notice in following graph the service quality starts a rapid and determined growth from 2013 (first year of policy application).

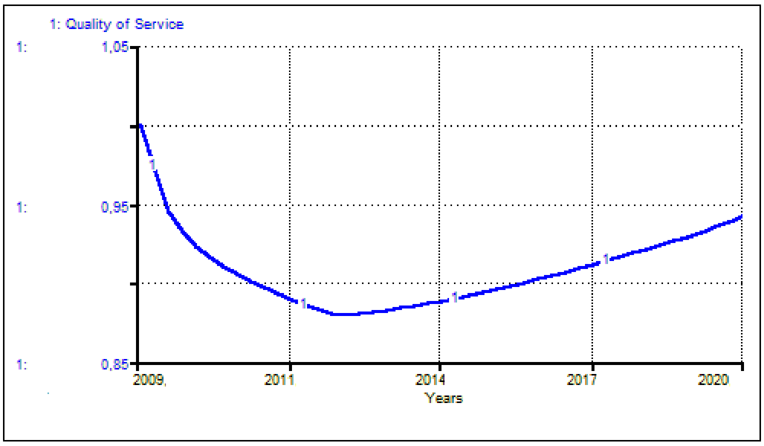


Figure 3.11: Policy option 2 - value creation

Chapter 4: Buenos Aires' Case Study

4.1 The Case Background

Transportation sector represents one of the major priorities for Argentinian government. This consideration emerges from the data about the direct public investment, where transportation holds the 70% of the total public expenditure (Barbero et al., 2011).

The Argentinian urban transportation system has been object of much interest in the last fifteen years. During the '90s the sector underwent major reforms, which were addressed at solving problems related to low service quality, low infrastructure investment rate, and financial weakness displayed by the sector. For these reasons the system was reformed through privatization and deregulation, in accordance with the NPM reform that was happening all over the world during those years.

The financial crisis that shook Argentina in 2001 drastically changed the role of the state in this sector, and more generally in the whole economy. Between 2002 and 2009, public direct investment in Argentinian economy experienced a tenfold increase. The sector that was the most influenced by this rise of public investment was the transportation one, which went from an expenditure of 0.15% of GDP in 2002, to that of 0.70% of GDP in 2009 (Barbero et al. 2011). At this time the fares for urban transportation service were locked and the national government started to invest a growing amount of public money so as to help users to get easier access to the service, while supporting private concessioners that were unable to deal with the financial crisis.

After these two waves of reforms, three main elements characterize today urban transportation in Argentina (Barbero et al., 2011): a strong policy of public investment in the system; a rapid growth in demand generating traffic congestion problems; a constant growth in the amount of subsidies given to service suppliers.

4.2 The Governance Structure of Buenos Aires’ Transportation System

Public transportation in Argentina may be defined as a hybrid system (Barbero et al., 2011). In fact, the service is run by private entities, but the decision-making process happens at a state level. By looking at it through an NPM perspective we notice how decisions, funds for investments, and expenditures are matters of concern for the national level (i.e., the reform has not been directed toward the decentralization of power to local administrations). At the same time, a service run by private companies demonstrates the implementation of a far-reaching reforming program towards market mechanisms in comparison to Italy.

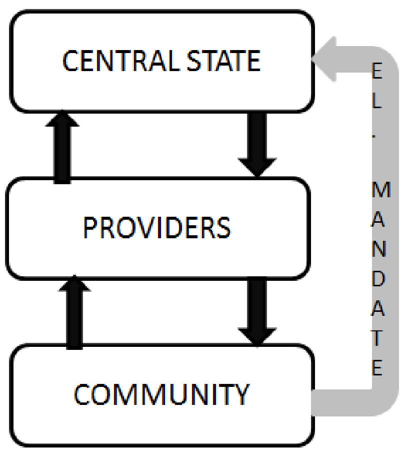


Figura 4.1: The governance structure

In the figure above is displayed the governance model of the Argentinian transportation system. Comparing to the Italian case, we may notice that the top governance level (national government) interacts directly with the service providers, bypassing the level of local authorities (i.e. municipalities or provinces). The central state provides funds and a regulatory framework for the providers to operate. The latter deliver the service to the community, and give feedbacks to the central government in terms of tickets sold and quality requirements. Finally, the community responds to the service quality by choosing whether to use the service, and giving a feedback to the political level when the election time comes.

This organizational form, which is formally based on market initiatives, is nevertheless strongly influenced by the role of central authority. Even though private companies run the service through their own assets, the centralization of the decision-making process at state level puts urban transportation under the supervision of a centralized and professionalized bureaucracy. Therefore, although we cannot talk about a form of legal monopoly, we can consider this organizational form as a combination between a "concessions to privates" regime (authority initiative) and a "regulated authorization" regime (market initiative).

In this organizational form, the main role that the government plays is a subsidising one, granting fare rebates to the users.

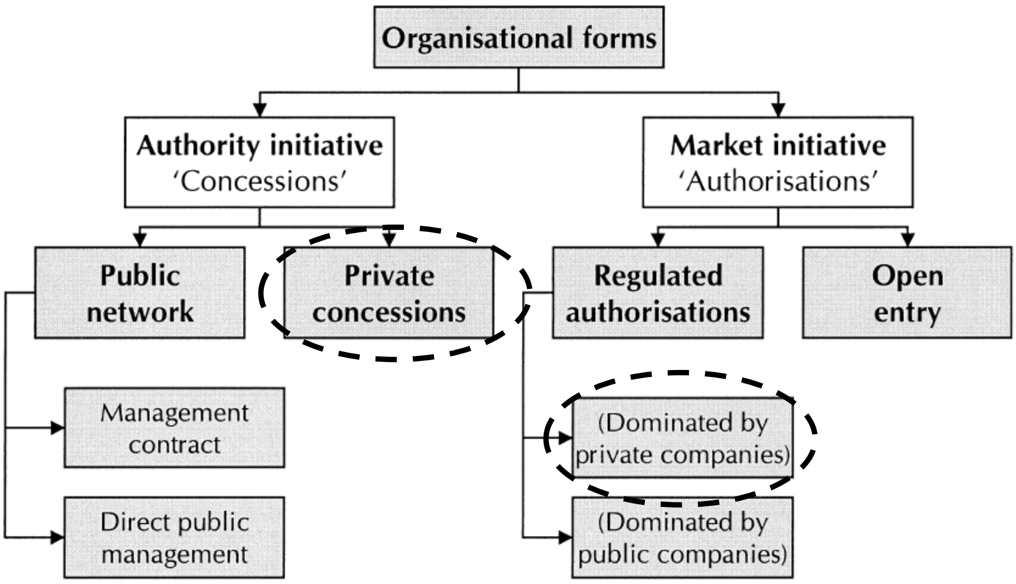


Figure 4.2: Buenos Aires' organizational mode of public transportation

As previously mentioned, starting from 2001 the central government enhanced its contribution in terms of public expenditure in the transportation sector. Much of public funds (43%) have been allocated to the FFSIT fund (Fondo Fiduciario del Sistema de Infraestructura del Transporte) for the subsidiary policy that allows concessioners to keep fares locked. Another relevant share of these funds (22%) has been allocated to the urban mobility within the capital city (Barbero et al., 2011).

The FFSIT fund was created in 2001 with the aim of supporting the transportation system. FFSIT gets funds from four different sources: National Treasure funding (Aportes del Tesoro Nacional), gasoline taxes, debt issuing from the National Bank (BNA), interests, and fines (Castro & Szenkman, 2012). It has been estimated that about 70% of the providers' revenue comes from those funds.

The policy behind the creation of this fund is 'supply-subsides' based: moneys are transferred to private providers so as to compensate for the fares' locking. In this way the government provides indirect help to the service users. However, some researchers (Barbero et al., 2011; Castro & Szenkman, 2012) highlighted the risk of distortions deriving from this policy's application, arguing that it may represent a disincentive for providers to improve service quality.

This is what actually happened, between 2003 and 2013: although subsidies to service providers grew by more than 400%, the quality of the service did not improve or, in some cases, decreased[5] (Castro & Szenkman, 2012).

In figure 4.3 it is shown the historical path of the subsides provided to the transportation sector in Argentina from 2005 to 2011. As we may observe, this variable shows an exponential growth behaviour.

[5] http://www.cnrt.gov.ar/content/estadisticas/automotor accessed on 28/04/2015

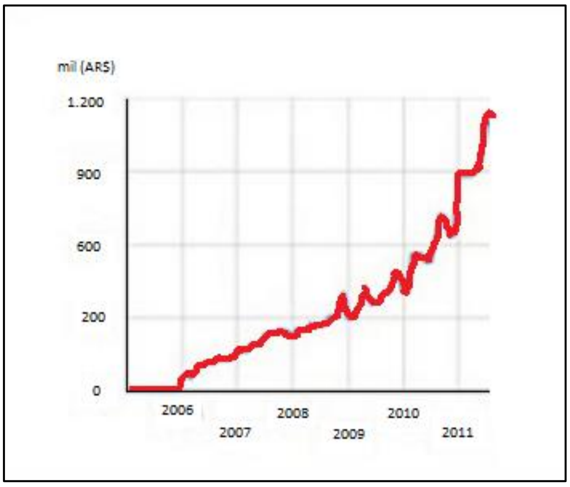


Figure 4.3: Historical trend of subsidies (http://interactivos.lanacion.com.ar/manual-data/estudio_de_casos_14.html)

This dynamic problem – raising subsidies and declining quality - has been conceptualized thanks to a SD model structured through a DPM approach. The model is focused on a particular route operated by a private company (Linea 60 - Micro Ómnibus Norte SA). This route connects the five municipalities composing the northern metropolitan region of Buenos Aires with the capital city: Escobar, Tigre, San Fernando, San Isidro and Vicente Lopez. The region counts about 1.2 million inhabitants. This provider has been chosen since its size in terms of number of buses, and the number of people to serve, are similar to that of the Italian provider analysed in the previous chapter. However, because of the difficulties connected to obtaining the data – i.e. it was not possible to have access to the company’s data –, some assumptions have been made (i.e. cost model). The model was built based on interviews with experts (the former Director of infrastructure of the City of Buenos Aires, the former Director of the Ministry of Public Works of Argentina and an independent researcher) and a deep document analysis (contracts, reports[6]).

[6] http://www.transporte.gov.ar/content/subsidios/ and Lopez M, Wadell J (2007) Investigación de transporte urbano público de Buenos Aires, INTRUPBA. Secretaria de Transporte de la Naciòn Argentina.

.

4.3 Buenos Aires’ model

4.3.1 A Causal Loop Diagram

The model aims to explore the dynamics experienced by the Buenos Aires’ urban transportation system between 2000 and 2013. In the following figure a causal loop diagram represents the main structure of the model.

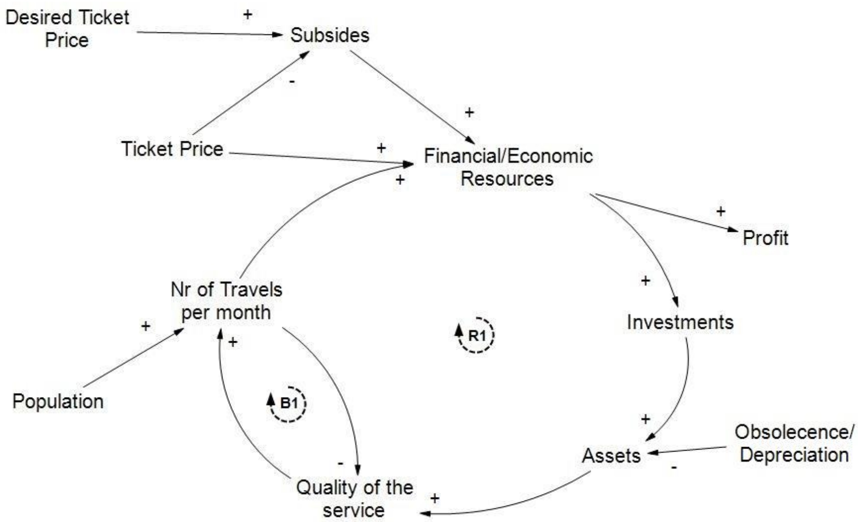


Figure 4.4: Buenos Aires case CLD

The increase in subsidies is related to the decision, taken by the government in the firsts years of the century, of blocking the ticket price for urban transportation services in order to make transportation more accessible. In fact, the Government ensures that ticket prices are blocked by guaranteeing specific funds to the service providers to cover any shortfall.

The amount of subsidies each company gets is determined by the gap between the actual ticket price and the price the service providers would otherwise apply times the number of ticket sold.

As we may notice the model structure can simply be represented by two loops. A reinforcing loop (R1) explains how a certain dotation of financial resources (that depends on the amount of subsidies and on the ticket sold) allows the company to invest more in new assets - which may range from new buses to modernizing the service, such as installing air conditioning. New assets impact on the service quality that decides users to adopt this mode of transportation. The number of trips, multiplied by the average ticket price, determines new financial resources the company may use to continue investing in the service. The number of trips, however, also have a negative influence on the service quality when the routes reaches the maximum carrying capacity of the asset dotation (B1). In fact, if the number of passengers surpasses the maximum carrying capacity of the transportation mode, this will negatively impact on the travel safety, comfort and on the travel time that will increase.

4.3.2 Stock and Flow model

A Stock and Flow model has been built in order to run a performance analysis and to simulate the result so as to get insight into how the system works and what criticalities result in the experienced counterintuitive behaviour – namely, a rise in subsidies and a decline in the service quality.

The end-results that have been identified in order to apply a DPM approach to the case are: ‘change in service quality’ and ‘new investments’ which is the flow feeding the assets level.

Service quality is determined by the number of assets the company devotes to this route. Assets comprehend a wide range of productive factors that go from tangible ones (i.e. buses, parking areas, etc.) to intangible ones (i.e. reputation, brand, customer base, etc.). These are increased by new investments and decreased by obsolescence and depreciation. In this case study, the initial number of assets is assumed to corresponds to an estimated value of the 342 buses that the company uses on this route. In order to get an equilibrium the investments need to be sufficiently high so as to compensate the obsolescence/depreciation and the constraints in capacity.

The amount of resources invested depends on the financial resources available. The stock of resources available can be devoted either to increasing assets or can be put aside as dividends for the company' shareholders.

Assuming that revenues and costs are collected/payed immediately, financial resources depends on incomes minus costs (these lasts were assumed as the 95% of incomes[7]). Incomes are generated by the business cycle through multiplying the number of trips time the ticket price (as showed in the figure below), and by the amount of subsides the company receives.

The number of trips depends by both the number of users, and the service quality. This last receives a feedback from the amount of trips itself (B1). In fact, given a fixed number of assets, the greater the number of trips, the lower the service quality - since a greater number of people travels in each bus.

Figure 4.4 displays the two main loops of the model described above[8].

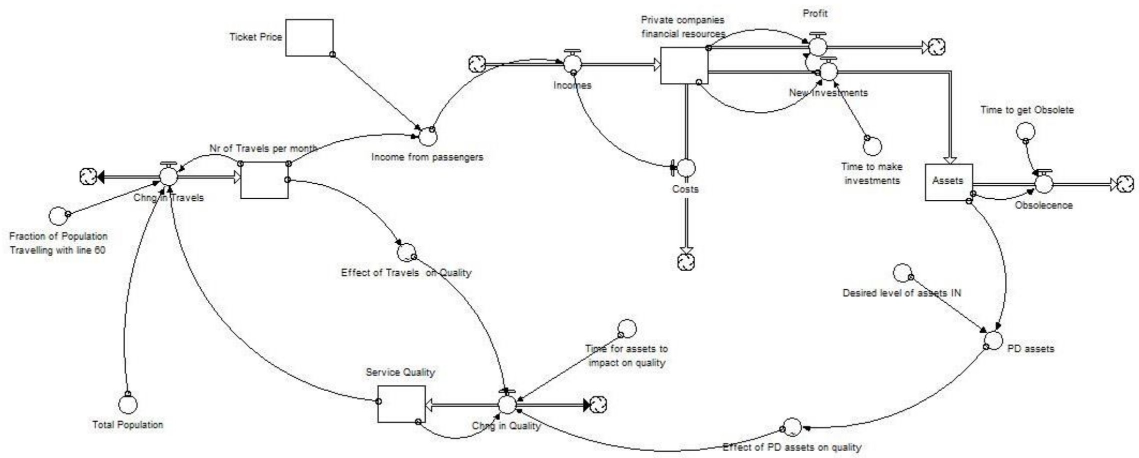


Figure 4.5: Business management loops

[7] Data extrapolated from http://www.indec.mecon.ar/Economico2005/definitivos/inc_definitivos_empresa.asp Instituto Nacional de Estadistica y Censos – accessed on 28/04/2015.
[8] The full model map and equations are available in Appendix B.

As already stated, incomes also depend on the amount of monthly subsidies the company receives. These subsidies are determined by the gap between the actual ticket price and the desired price times the number of trips in that period.

The desired ticket price is initially determined as the actual ticket price, but it increases in accordance with trends in inflation. Therefore, due to inflation adjustments, it changes annually.

The subsides come from public funds, in particular from FFSIT fund. In the model presented below it is assumed that these are equal to the required subsidies.

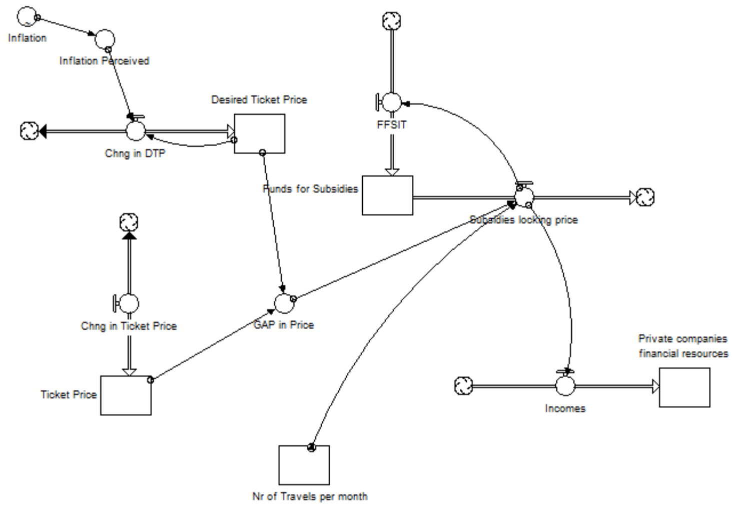


Figure 4.6: Subsidies decision making process

The number of trips per months - that represents one of the factors of the ‘subsidies locking price’ equation - does not changes exclusively due to the influence of service quality but it also depends from the average number of trips per month. This has been assumed as a percentage of the total population that live in that urban area.

In order to estimate the total population and its changes, an ageing chain has been developed[9]. The population considered regards the inhabitants of the five municipalities through which the route 60 passes.

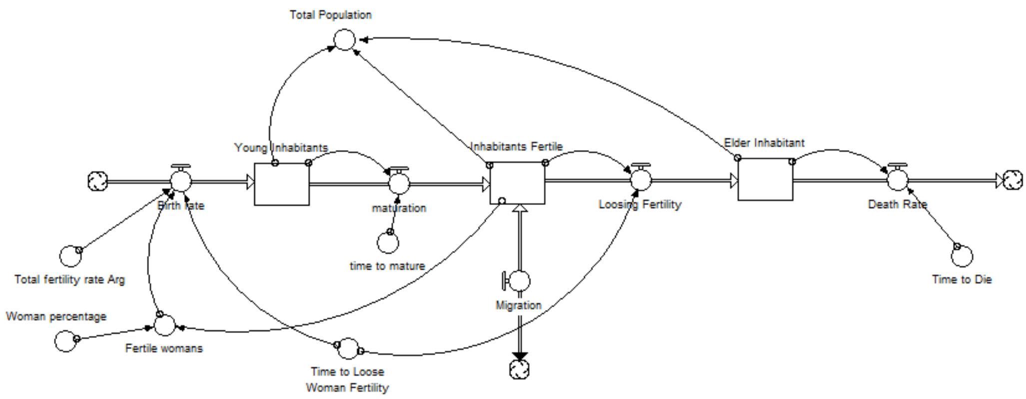


Figure 4.7: Ageing Chain Northern Metropolitan Region

The assumptions of this ageing chain concerns the adoption of the national fertility rate and the migration rate. The migration rate (for which precise data was not available) has been calculated as the difference between the actual population at the end of the period considered and the simulated population without considering any migration flow.

The number of trips per month is then calculated as the total population of the five municipalities multiplied by a percentage corresponding to the usage rate of the route. This variable does not change merely because of the changes in population but is also influenced by the service quality.

The model here explained produces the simulations shown below:

[9] Direccion Provincial Estatistica, 2010

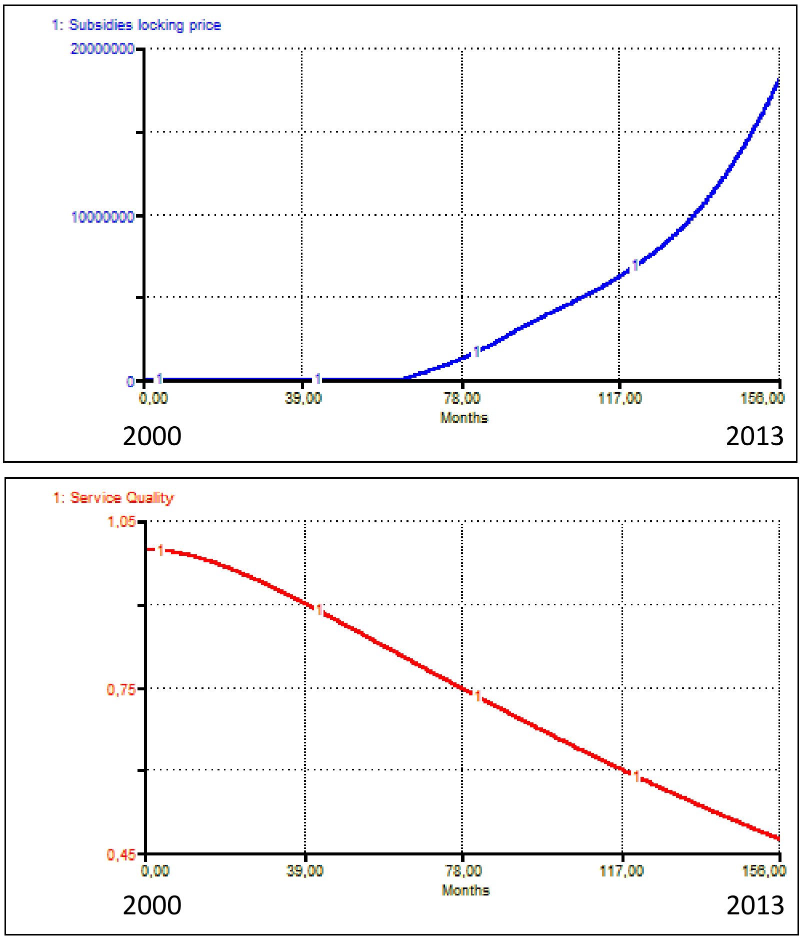


Figure 4.8: Simulation results

As we may notice, even if, according to the available data[10], the subsidies grew from 0 up to 18 million AR$ per month (about 50.000 AR$ per bus per month), in less than 13 years, the quality of service has experienced a constant decline (Castro & Szenkman, 2013). We can conclude that this simple model is able at reproducing the counterintuitive behaviour explained above.

By looking back at figure 3, we may observe how the quality of the service is influenced by the number of trips and the assets value. If the number of trips increases due to an increase in population (as it happens in the model), it will reduce the service quality level. In order to

[10] http://interactivos.lanacion.com.ar/manual-data/estudio_de_casos_14.html ; http://www.lanacion.com.ar/1607299-colectivos-el-mejor-negocio-de-la-argentina

keep constant this last variable, the assets value should compensate for the negative effect of the growing number of trips.

The assets are influenced by the investment rate of the private company analysed and their obsolescence/depreciation rate. The investments should be enough to compensate this last variable effect and keep the assets value constant. However, in the scenario portrayed above, (growing population and growing number of trips) it is not enough to keep the assets' stock constant in order to maintain a certain quality standard of service.

In order to tackle this issue the investment flow should take into account the service quality behaviour. Even though both investments and quality can be monitored and directly influenced by the same service provider, a regulatory intervention is needed to avoid possible behavioural distortion inducing the company to use the financial resources received for remunerate shareholders instead of investing in the service.

By adopting a DPM approach for this case, we may identify two kind of indicators in relation the case under analysis.

Indicator 1 – Assets: If we want to achieve a certain result in terms of investments (which is the flow that foster the strategic resource 'Assets') we can build a first performance indicator by comparing the actual assets level with a desired level. However the desired assets level cannot be a fixed or external variable because it should consider the change in service quality caused by the growing number of trips.

Indicator 2 – Service Quality: It is possible to determine the desired asset level by defining another performance indicator which compares the actual service quality with a standard one. In this case, standards valid for all the service providers should be defined by the public actors regulating the service so as to address citizen expectations.

Transportation service quality has been framed by Eboli and Mazzulla (2012) into seven features that has been explored in the first chapter of this study (service availability, service reliability, fare, comfort and cleanliness, safety and security, information, customer care, environmental impacts).

Therefore, the service quality performance indicator can be split into different indicators once a standard for each of them has been identified (i.e. in the Palermo's case the quality indicators that were defined based on the information available concerned service availability – extensiveness -, reliability – frequency -, fare - ticket price - and comfort, safety and environmental impacts - bus age).

Identifying performance indicators is a core step if we want to improve the service. However it is not sufficient per se. The standards identified and the intermediate results achieved must then be shared between the authority and the concessioners. This will allow us to design performance oriented policy and to align the objectives, aims and expectations of the stakeholders involved in the service provision.

4.4 Discussion and Policy Options

Based on what has been explained previously, the policy designed for this case is about creating a feedback process between the service quality and the employment of financial resources. Even though the asset level may appear endogenous to the system, shareholders' interests influence the choice between devoting financial resource to dividends or to new assets, 'neutralizing' the system's performance feedback. Due to that, it is necessary for the authority to regulate the investments that private providers make in assets through a new feedback from the system's performance that may fully 'endogenize' the stock of assets.

At a managerial level, given the subsidies policy of ensuring that ticket prices are blocked and that determines a rise in subsidies – due to the inflation growth -, the resource that is managed without considering the whole system performance is the asset level. Since the service quality depends by the asset level and the number of users, in order to keep it stable (and so to have the end-result ‘change in service quality’ non-negative), the investment in assets should counter, not only the depreciation/obsolescence process, but also the negative effect of an increase in the number of users on service quality level.

The resulting overall structure is portrayed in figure 4.8. As we may notice, the model has now one more loop (B2) that represents the policy suggested. With this policy the share of financial resources to be invested in assets will take into account the service quality level.

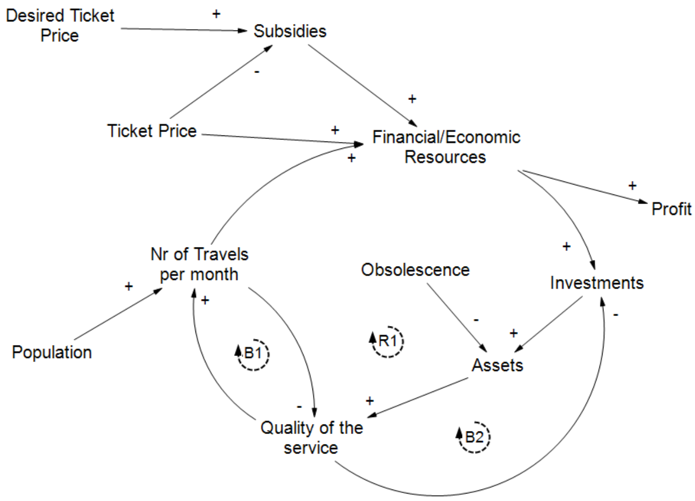


Figure 4.9: Policy option - CLD

The two kind of Performance Indicators identified for this case (assets and quality) may help us in formulate the policy portrayed in the CLD (figure 6) and, therefore, to tackle this particular wicked and governance related issue. The feedback we need to add to the model is shown in the following diagram.

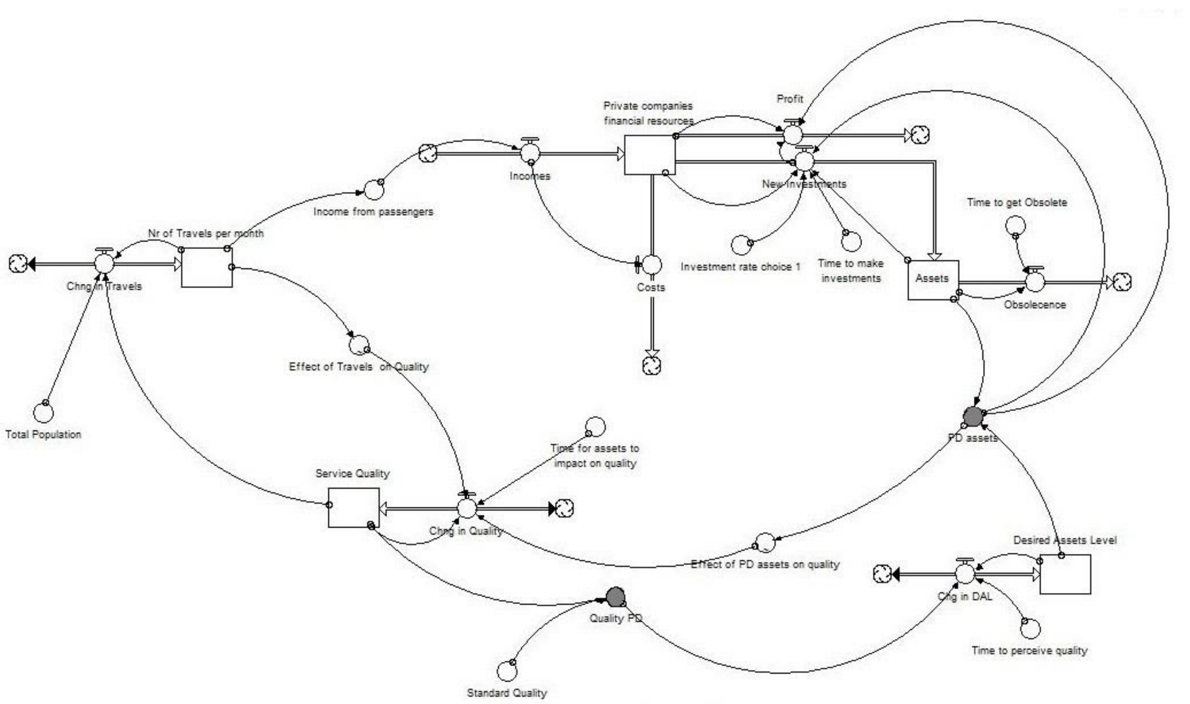


Figure 4.10: Policy option - SFD

In paragraph 4.3 it was discussed how to determine a service quality indicator. Whenever the indicators developed score below 1.00, and the service quality is below the service quality target fixed, the desired assets level will be adjusted. In these cases the company will be asked to increase the level of assets accordingly to the community expectations expressed as performance targets. The desired asset level represents the target used in order to build the assets performance indicator which, in the designed policy, has the effect of influencing the company investment rate in new assets. If the asset level is below the desired one, the company will have to invest in new assets (accordingly to the service quality pitfalls identified by the previous kind of indicator). Once the asset level is aligned with the target one, it will positively affect the service quality and the community satisfaction.

By applying this policy, the out-coming simulation results are portrayed in figure 4.10.

As we may notice starting from the 13th year (156th month), the service quality rapidly increases. Therefore such a policy, that only focus on improving the governance rules between the actors involved, can have an immediate impact on the service performance.

Although the policy designed is specifically addressed at solving a problem at a managerial level, not considering other external resources that may be 'endogenized' in the system – i.e. subsidies -, this case teaches us that sharing performance information perceived by different governance levels may help the system to avoid distortions deriving from policy badly implemented. The 'endogenization' process in the Buenos Aires case concerns the desired asset level whose value was determined without any reference with the actual service quality.

However, from this simulation, it also emerges that the subsidies decision making process may be not sustainable for the state financial resources. In fact the exponential growth behaviour of subsidies would bring the central government at paying about AR$ 165.000.000,00 per month to the bus company in 2020.

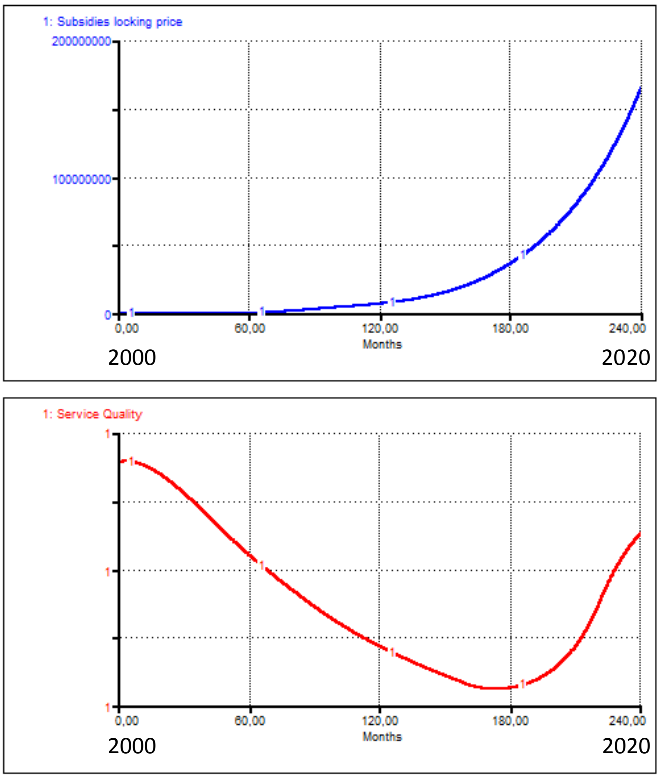


Figure 4.11: Policy simulation results

Although the tactical policy proposed results in a better performance for the system, in the long run, if not integrated with the strategic level, it may result non-sustainable for the government finances. For this reason, the simulation has also been performed by fixing an arbitrary limit for the government expenditure (figure 4.12). We may observe that, in the medium term, even with an expenditure limit (the same amount achieved in 2013 – i.e. AR$ 20.000.000 per month) the switch in behaviour determined by the applied policy does not change but only reduces its strength.

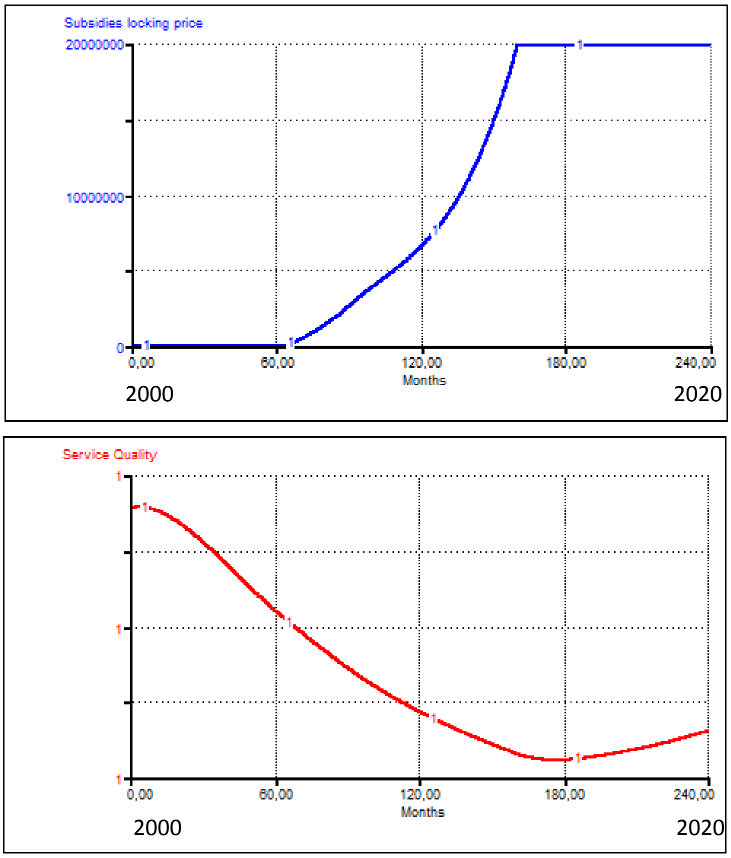


Figure 4.12: Policy simulation results with expenditures limit

Chapter 5: Two Case Studies Compared

This study focuses on the management of public transportation systems in cities.

Cities are becoming central in our society. While world population has been growing exponentially, in the recent decades more people have moved from rural to urban areas (United Nations, 2014). In the last 50 years this global trend has caused a rapid urbanization and the sprawling of many urban areas. Nevertheless, not all cities present the same patterns of development. Each case is unique and deserves attention.

The following figure shows the urbanization trend in each world continent.

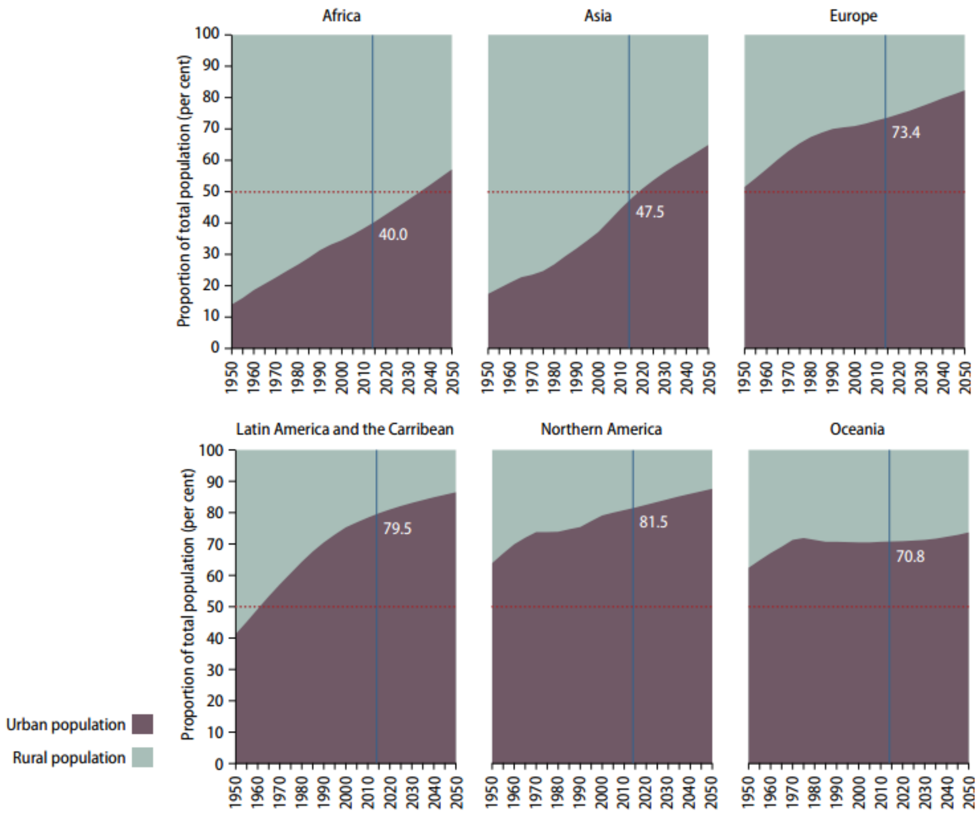


Figure 5.1: Urban and rural population as proportion of total population, by mayor areas, 1950-2050 (UN,2014)

When studying its transportation system, the main determinants that characterize a city can be found in the degree of urbanization of the area, dimensions, institutional settings and organizational form of urban transportation.

Palermo and Buenos Aires are heterogeneous with regards to all the above-mentioned features. While Buenos Aires is a growing city that is attracting many people from all over its own country and the rest south American, Palermo's population, after a phase of rapid growth in the 1970s is now constant. Buenos Aires, which is the capital city of Argentina, is a 'megacity' in which the population overrun the territorial boundaries and now has about 15 million inhabitants (considering the neighbouring municipalities). Palermo, which is the fifth largest city in Italy and capital city of the Sicilian Region, is a middle-sized urban area whose population is about 1 million (considering the neighbouring municipalities).

Considering these differences, it is not possible to generalize the results here obtained. More generally, it is not possible to generalize any result when analysing city mobility since every city is unique and has its own specific characteristics. The reason why these two cities have been taken into consideration lies in the fact that their heterogeneity allowed us to understand how a DPM approach may be adapted to different wicked contexts and frame a system, even when several actors are participating.

5.1 A Comparative Chart

In order to help the comparison between the two cases a table has been developed. The columns of the table show the cities' name, while the lines show the main characteristics used to compare the cases, namely: organizational form, kind of provider, governance levels, role of the authority, population served.

	Palermo	Buenos Aires
Organizational form	Public network	Hybrid form: regulated authorization and private concession
Provider	Public owned company	Private company
Governance levels	4	3
Authority role	Entrepreneur	Watchdog and Subsidiser
Population served	About 700.000 inhabitants	About 1.100.000 inhabitants

Table 5.2: A comparative table

First of all, the organizational forms differ since in the Italian city the service is run through an authority initiative that takes the form of a public network; while in the Argentinian capital the organizational form has the characteristics of both authority and market initiatives. Even though a public network may appear less problematic in determining wicked issues coming from fragmentation, the analysis of the Palermo case showed us that when various administrations (with unaligned aims and expectations) are involved in the service provision, this may still cause unsatisfactory performances. This is particularly true when top governance levels interfere in the service management by setting goals and posing conflicting constraints (e.g. fixing ticket prices).

The Palermo's case study was built around the public owned provider, AMAT. This company runs the service in a monopolistic context providing it for the whole city population.

Even though AMAT is formally a joint stock company, all of its shares are owned by the municipality. This 'public network' structure helps the system to consider the importance of social outcomes. However, the company is required to perform a high quality of service even when operating unprofitable routes to guarantee transportation facilities to each group of individuals; also other governance levels – particularly the Municipality of Palermo and the Sicilian Region – make AMAT to operate with a decreasing amount of funds, in the pursuit of a more efficient service. The result is an inefficient and ineffective transportation service for the whole city, demonstrated by the decreasing trends of the performance indicators defined. From this brief case description it can be seen how AMAT top managers have to deal with three other governance levels, each with different needs. While it is formally a private company, it aims at being financially self-sustainable.

Focusing now on the other case, a more market-oriented initiative is ought to be more efficient in term of public expenditure and effective in terms of service quality. However, in Argentina the service regulation and the fragmentation of institutions generated distortions, resulting in a growing public expenditure and a decreasing service quality offered by the private provider.

In Buenos Aires the analysed provider is a private company that has the same dimensions, in term of assets, as AMAT. However in this case the provider operates in a regulated market where other companies also run competing services that serve other parts of the urban area.

In such a structure the company does not feel any pressure in terms of pursuing a social outcome. Citizens are customers, and the company aims to make a profit for its shareholders. However, the biggest source of revenues (more than 50%) is related to central government subsidies. This fact provokes distortions in the company behaviour since it is not encouraged to invest in the service so as to raise quality to a certain level through new investment in assets.

In order to take into account these differences and run a comparative analysis, both cases have been developed from a micro to a macro perspective. Particularly, the starting point of the analysis was the provider's one. This choice allows us to read the cases adopting the same point of view. Also, the 'micro to macro' perspective is coherent with the used methodology since it allows us to clearly define the system end-results as perceived by the lower governance levels, and then to build a conceptual chain, transversal to the governance structure, towards the strategic resources' identification.

Framing the system and identifying the resource needed and activated by the provider, was useful for having the inter-institutional perspective mentioned in the second chapter. In fact, in both cases, identifying the system end-results leads to performance indicators and strategic resources definition. Once the resources were framed in the system, an analysis was run so as to: a) understand who is controlling each of them; b) understand how the management of each resource is related – in a two-way causation perspective - to the system performance.

From the analysis of both cases it emerged that the systems performance depends on the choices of different actors. Even though this situation is not bad in itself, since it allows the various actors to make a contribution to the service provision, if the stakeholders do not stay constructively engaged, it is unlikely that the capacity to tackle wicked problems can be maintained in long term (Weber & Khademian, 2008). Decision-makers that are faced with wicked problems should consider collaborative practices among the stakeholders when designing their performance management systems, and may find that the presence of multiple actors and perspectives provides a strong environment for this critical approach (Putansu, 2015).

Governance fragmentation emerged clearly in both cases once the systems had been framed through the DPM approach. Many strategic resources identified were seen to be managed without receiving any feedback or information from the system performance; or, as happens in the Argentinian case, the influence of a major stakeholder disturbs the normal functioning of the system. In fact, in this case, even though the company resources appeared to be endogenous in the system, the contract between the provider and the central government created distortions which have a negative impact on the service quality.

In order to enhance coordination between different governance players, and to solve the dynamic problems which characterize the two systems, a process of ‘endogenization’ was tested. Thanks to ‘endogenization’, strategic resources that do not receive any performance feedback (because they are under the control of a different stakeholder) were connected through a causal link with the systems’ end-results. These structural changes are based on communication and information exchanges between stakeholders owning strategic resources and stakeholders experiencing the overall system performance (Noto & Bianchi, 2015).

Conclusions

The aim of this dissertation has been to make a contribution to the field of wicked problems related to fragmented governance, with particular reference to urban transportation systems.

Multi-level governances are characterized by the interplay of different actors in a production/provision process. In a multi-level governance structure various stakeholders influence the system, since they control one or more of its specific strategic resources.

The problems that arise in these kinds of structures are related to the different goals, interests and values that these stakeholders have with regard to the end product or service. This situation not only leads to contradiction and tension between different policies and action programs, but primarily prevents stakeholders from agreeing on the definition of problems.

The first chapter introduced us to the topic, discussing the current state of wicked problems studies, and multi-level governance in the public sector. Having retraced the last 40 years of public management reforms it was necessary to understand the causes and the fertile context in which wickedness emerges.

The introduction of performance management, privatization and decentralization determined a new and more efficient approach to performing public services; however it also enhanced governance fragmentation and 'silos mentality', which, together with pluralism and uncertainty, are the causes of the rise of wicked problems.

Urban transportation did not escape the waves of public management reform. However, their actual implementation varies across countries on the basis of different political, cultural and environmental factors.

What emerged from the literature analysis is that the most successful way of overcoming the distortions caused by governance fragmentation is to enhance coordination and collaboration between the different governance levels participating in the creation of public value.

In order to do this, a systematic approach is strongly recommended. This would allow us to focus on the 'big picture' of the transportation systems. Literature suggests that we adopt methods that allow the analyst to deal with complexity. The research methodology hereby adopted is Dynamic Performance Management. This approach allowed us to understand who the governing players are, what their roles are, and how they influence the production and provision processes. DPM merges Performance Management Theory with System Dynamics. While the PM framework helped the analysist adopt the perspective of Public Administrations studies; SD allows the analyst to simulate the behaviour of a certain system over time.

Given that, it is important to underline that SD does not have a predictive power. Simulation value as a scientific method lies mainly in three features (Axelrod, 1997): prediction (or forecasting), existence proof, and discovery (of new structures). However, in social sciences such as management, simulation value lies also in its education and training features. In this thesis, simulation has mainly been used as a tool for testing models' structures, forecasting systems' behaviours, analysing scenarios and testing policies.

DPM resulted to be an outstanding tool for framing urban transportation systems so as to outline results and resources involved. Furthermore it allows us to think strategically about what information needs to be shared in the system in order to foster coordination between stakeholders and network logics.

In order to answer the research questions of this study, two case studies of two municipalities were developed: Palermo (Italy) and Buenos Aires (Argentina). Even though the two case studies were based on two cities with different social characteristics, the conclusions obtained from their analysis are similar.

In both cases it was seen that the transportation system performance was influenced by several actors with different values, aims and resources. Building a set of performance indicators helps the analyst to focus attention on the performance levers, so as to understand how the employment of the system resources impacts on the service provision. Furthermore, by focusing on the strategic resources on which the indicators depend, we can identify those who manage them, and how the decision-making process regarding each resource is run.

When a strategic resource is managed as an external input to the transportation system, its 'endogenization' has been proved to be a 'good enough' solution to overcome the external interference on the system, deriving from governance issues (contracts, prevailing interests, etc.).

Limitations and future perspectives

One limitation to this study could derive from the research methodology which takes advantage of a modelling tool. As "all models are wrong" (Sterman, 2002), in the sense that our knowledge about complex systems is limited and we need to simplify our models in order to represent the complexity within them, we need to distinguish between the model and the reality it attempts to represent. Even though the models here developed are 'wrong', in the sense that a model cannot represent all the details present in the real world, their usefulness comes from their helping us understand the main causal relationships that form the systems' structure. With the aid of the models, a set of performance indicators that help us to understand the impact of the governing structure on the system's performance was created. These indicators can inform stakeholders about how the system works (how end-results are achieved), allowing them to develop shared understanding and meaning about any problems that arise. The indicators helped us in reforming the systems through improved coordination of the actors involved in governing it, thus reducing the wickedness of the production process. Overall, the models can be used as a tool for engagement and communication with other levels of governance.

Even though the approach used takes in all the three level of PM systems – namely, strategic, tactical and operational - another limitation of this study could be due to the fact that the policy solutions proposed are only focused on the tactical level of PM systems. Briefly, transportation strategies and goals that emerged from the analysis were considered as given, and the policy options were focused on finding a 'good enough' way to pursue them. This limit emerged more clearly in the Buenos Aires case, where simulation showed that an exclusive focus on the tactical level would determine a non-sustainable policy at the strategic level. A further development of this work may also consider the possibility of including the strategy formulation/revision process.

This work focused very much on the conceptual understanding of how coordination may help when multi-level governance settings have a negative influence on the system's performance. In particular some policy options were identified for specific cases. However, no practical solutions are provided within the frame of this dissertation. It does not emerge who has to implement the identified policies and how one actor may obtain legitimacy for intervening in the system decision-making process, even if only for coordination purposes. This issue represents an opportunity for further development of the current study. Some authors concerned with this topic (Sørensen & Torfing, 2009; Acuto, 2012) suggest adopting a 'meta-governor' for fostering coordination and avoiding the risk of ducking responsibility.

It is also due to mention the data gap for what concern the Argentinian case. In fact, it was not possible to have access to many of the data regarding the internal structure of the private company analysed due to privacy concerns. However, thanks to the experts interviews and the available data it was possible to build a useful and valid simulation model even for this case.

References

Ackoff RL. 1974. Redesigning the Future: A Systems Approach to Societal Problems; John Wiley & Sons: New York, USA.

Akkermans HA, van Oorschot KE. 2005. Relevance Assumed: A Case Study of Balanced Scorecard Development Using System Dynamics. Journal of the Operational Research Society 56(8): 931-941.

Albino V, Berardi U, Dangelico RM. 2015. Smart Cities: Definitions, Dimensions, Performance, and Initiatives. Journal of Urban Technology 22(1):3-21.

Anselmi L. 1995. Il processo di trasformazione della Pubblica Amministrazione. Il "percorso aziendale"; Giappichelli, Torino.

Auping WL, Pruyt E, Kwakkel JH. 2015. Societal Ageing in The Netherlands: a Robust System Dynamics Approach. System Research And Behavioural Science 32:485-501.

Australian Public Service Commission. 2007. Tackling Wicked Problems: A Public Policy Perspective; Commonwealth of Australia, Barton.

Axelrod R. 1997. Advancing the Art of Simulation in the Social Sciences. Complexity 3(2): 16-22.

Barbero J, Castro L, Abad J, Szenkman P. 2011. Un transporte para la equidad y el crecimiento. Aportes para una estrategia nacional de movilidad y logística para la Argentina del Bicentenario. CIPPEC, Working paper n.79.

Barlas Y. 1996. Formal Aspects of Model Validity and Validation in System Dynamics. System Dynamics Review 12(3):183-210.

Benington J, Moore MH. 2011. Public Value: Theory and Practice. Palgrave Macmillan: London, UK.

Bianchi C, Bivona E, Cognata A, Ferrara P, Landi T, Ricci P. 2010. Applying System Dynamics to Foster Organizational Change, Accountability and Performance in the Public Sector: A Case-Based Italian Perspective. System Research and Behavioral Science 27, 395-420.

Bianchi C, Cosenz F, Marinković M. 2015. Designing dynamic performance management systems to foster SME competitiveness according to a sustainable development perspective:

empirical evidences from a case-study. International Journal of Business Performance Management 16(1): 84–108.

Bianchi C, Rivenbark, W. 2012. Using System Dynamics to Enhance Performance Management in Local Government: An Application to Residential Refuse Collection. In Proceedings at the 2012 APPAM Fall Research Conference, Baltimore (USA), November 8-10.

Bianchi C. 2004. Sistemi di Programmazione e Controllo per l'Azienda "Regione" . CUSA, Giuffrè Editore: Milano.

Bianchi C. 2010. Improving Performance and Fostering Accountability in the Public Sector through System Dynamics Modelling: From an 'External' to an 'Internal' Perspective. System Research and Behavioral Science 27, 361-384.

Bianchi C. 2012. Enhancing Performance Management and Sustainable Organizational Growth Through System-Dynamics Modelling. Groesser SN, Zeier R (eds), Systemic Management for Intelligent Organizations. Springer: Berlin (DE).

Bianchi C. 2015. Enhancing Joined-Up Government and Outcome-Based Performance Management through System Dynamics Modelling to Deal with Wicked Problems: the Case of Societal Ageing. Systems Research and Behavioral Science 32: 502-505.

Bianchi C, Montemaggiore GB. 2008. Enhancing strategy design and planning in public utilities through "dynamic" balanced scorecards: insights from a project in a city water company. System Dynamics Review 24(2), 175-213.

Bisbe J, Malagueño R. 2012. Using strategic performance measurement systems for strategy formulation: Does it work in dynamic environments?. Management Accounting Research, 23(4): 296-311.

Bititci US, Carrie AS, McDevitt L. 1997. Integrated performance measurement systems: a development guide. International Journal of Operations & Production Management 17(5): 522-534.

Bivona E, Montemaggiore GB. 2010. Understanding short- and long-term implications of "myopic" fleet maintenance policies: A system dynamics application to a city bus company. System Dynamics Review 26(3): 195-215.

Bouckaert G, Halligan J. 2006. A Framework for Comparative Analysis of Performance Management. In Proceedings at the Conference of European Group of Public Administration, Milan, 6-9 September 2006.

Bouckaert G, van Dooren W. 2003. Performance measurement and management in public sector organizations. In Bovaird T, and Löffler E (eds.), Public Management and Governance. Routledge: London, UK.

Broussine M. 2003. Public Leadership. In Bovaird T, and Löffler E (eds.), Public Management and Governance. Routledge: London, UK.

Bryson JM, Crosby BC, Bloomberg L. 2014. Public Value Governance: Moving Beyond Traditional Public Administration and the New Public Management. Public Administration Review 74(4): 445-456.

Caragliu A, Del Bo C, Nijkamp P. 2011. Smart Cities in Europe. Journal of Urban Technology 18(2): 65–82.

Carey G, McLoughlin P, Crammond B. 2015. Implementing Joined-Up Government: Lessons from the Australian Social Inclusion Agenda. Australian Journal of Public Administration 74(2): 176-186.

Cascajo R, Monzon A. 2014. Assessment of innovative measures implemented in European bus systems using key performance indicators. Public Transport 6(3): 257-283.

Castro L, Szenkman P. 2012. El ABC de los subsidios al transporte. CIPPEC, Documento de Polìticas Pùblicas n.102.

Cavalieri E. 2010. Le nuove dimensioni dell’equilibrio aziendale. Giappichelli, Torino.

Checkland PB. 1988. Soft systems methodology: An overview. Journal of Applied Systems Analysis 15, 27-30.

Christensen T, Laegreid P. 2007. The Whole-of-Government Approach to Public Sector Reform. Public Administration Review 67(6), 1059-1066.

Coda V. 2010. Entrepreneurial Values and Strategic Management: Essays in Management Theory; Palgrave Macmillan: Basingstocke, UK.

Cosenz F. 2010. A System Dynamics Approach to Analysing the Effect of Clientelism on Public Organizations Performance in Italy. Review of International Comparative Management 11, 325-337.

Cosenz F. 2013. Designing Performance Management Systems in Academic Institutions: a Dynamic Performance Management View. In proceedings at the XXXVI AIDEA Conference Lecce, September 19 – 21, 2013.

Cosenz F, Noto G. 2014. A Dynamic Simulation Approach to Frame Drivers and Implications of Corruption Practices on Firm Performance. European Management Review 11: 239-257.

Della Porta A, Gitto A. 2013. Reforming Public Transport Management in Italy: the Continuous Search for Spending Better. Sargiacomo M. (eds) in Public Sector Management in Italy. McGraw-Hill: UK

Della Porta A. 2013. Migliorare il Servizio di Trasporto Pubblico Locale: Cosa Significa?. Della Porta A, Gitto A. (eds) in La riforma del trasporto pubblico locale in Italia nella prospettiva aziendale. Il difficile compromesso tra economicità aziendale ed efficacia sociale. FrancoAngeli: Milano.

Den Heyer G. 2011. New public management. Policing: An International Journal of Police Strategies & Management 34(3): 419-433.

Eboli L, Mazzulla G. 2012. Performance indicators for an objective measure of public transport service quality. European Transport /Trasporti Europei 51, 3.

Eccles R. 1991. The Performance Measurement Manifesto. The Harvard Business Review 71(1): 131-137.

Eden C. 2004. Analyzing cognitive maps to help structure issues or problems, European Journal of Operational Research 159, 673–686.

Ferlie E, Fitzgerald L, McGive G, Dopson S, Bennet C. 2011. Public Policy Networks And “Wicked Problems”: A Nascent Solution?. Public Administration 89(2): 307–324.

Forrester JW. 1961. Industrial Dynamics; Cambridge: MIT Press.

Goodwin PB. 1997. Solving Congestion, in Inaugural Lecture for the Professorship of Transport Policy, University College Lodon, October 23rd.

Hall RE. 2000. The Vision of a Smart City. Proc. of the 2nd International Life Extension Technology Workshop, Paris, France.

Head BW, Alford J. 2013. Wicked Problems: Implications for Public Policy and Management. Administration & Society XX(X): 1-29.

Hefez A, Warner M. 2004. Privatization and Its Reverse: Explaining the Dynamics of the Government Contracting Process. Journal of Public Administration Research and Theory 14(2): 171-190.

Hjorth P, Bagheri A. 2006. Navigating towards sustainable development: A system dynamics approach. Futures 38: 74-92.

Hood C. 1991. A Public Management for All Season? Public Administration 69(1): 3-19.

Hull A. 2005. Integrated Transport Planning in the UK: from Concept to Reality. Journal of Transport Geography 13: 318-328.

Jennings NR, Sycara, K, Wooldridge M. 1998. A Roadmap of Agent Research and Development. Autonomous Agents and Multi-Agent Systems 1: 7–38.

Karré P, der Steen M, Twist M. 2013. Joined-Up Government in The Netherlands: Experiences with Program Ministries. International Journal of Public Administration 36(1): 63-73.

Kelly G, Mulgan G, Muers S. 2002. Creating Public Value: an Analytical Framework for Public Service Reform. Working paper, Cabinet Office Strategy Unit, UK.

Kettl D. 2006. Managing Boundaries in American Administration: The Collaboration Imperative. Public Administration Review 66(1): 10–19.

Lane DC, Oliva R. 1998. The greater whole: Towards a synthesis of system dynamics and soft systems methodology. European Journal of Operational Research 107: 214-235.

Linard K, Dvorsky L. 2001. People - not human resources: the system dynamics of human capital accounting, In Proceedings of the Operations Research Society Conference, Bath, University of Bath.

Ling T. 2002. Delivering Joined-Up Government in the UK: dimensions, issues and problems. Public Administration 80(4): 615-642.

Lioukas S, Bourantas D, Papadakis V. 1993. Managerial Autonomy of State-Owned Enterprises: Determining Factors. Organization Science 4(4): 645-666.

Litman T. 2014. Well Measured: Developing Indicators for Sustainable and Livable Transport Planning. Working paper at Victoria Transport Policy Institute.

Lo Bue M. 2014. From Fiscal Compact to the United States of Europe: Some Remarks on a Difficult Pathway, The Digest. N.I.A.B.A. Law Journal, 22.

Lombardi P, Giordano S, Farouh H, Yousef W. 2012. Modelling the Smart City Performance. Innovation: The European Journal of Social Science Research 25(2): 137–149.

Lopez M, Wadell J (2007) Investigación de transporte urbano público de Buenos Aires, INTRUPBA. Secretaria de Transporte de la Naciòn Argentina.

Marcon G, Russo S (2014) Assumptions for a combination of public value and performance management. In Proceedings at IV Workshop Nazionale di Azienda Pubblica, Novara.

Meadows D. 1980. The Unavoidable a Priori in: Randers J. (eds) in *Elements of the system dynamics method*. Pegasus Communications : Waltham, MA.

Melse E. 2006. The Financial Accounting Model from a System Dynamics' Perspective. Munich Personal RePEc Archive, Working Paper.

Miller JS, Hoel LA. 2002. The “Smart Growth” Debate: Best Practices for Urban Transportation Planning. Socio-Economic Planning Sciences 36(1): 1-24.

Meyer M, Miller E. 2000. Urban Transportation Planning: a decision oriented approach. McGraw Hill: New York.

Modell S. 2009. Institutional Research On Performance Measurement And Management In The Public Sector Accounting Literature: A Review And Assessment. Financial Accountability & Management 25(3): 277-303.

Moore M. 1995. Creating Public Value: Strategic Managemetn in Government. Harvard University Press: Cambridge, MA.

Morecroft JDW. 1984. Strategy Support Models. Strategic Management Journal 5(3): 215-229.

Morecroft JDW. 1985. Rationality in the Analysis of Behavioral Simulation Models. Management Science 31(7): 900-916.

Morecroft JDW. 1999. Visualising and Rehearsing Strategy. Business Strategy Review 10(3): 17-32.

Neely A. 1999. The performance management revolution: why now and what next?. International Journal of Operations & Production Management 19(2): 205-228.

Noto G, Bianchi C. 2015. Dealing with Multi-Level Govrnence and Wicked Problems in Urban Transportation Systems: The Case of Palermo Municipality. Systems 3: 62-80.

O’Flynn J. 2007. From New Public Management to Public Value: Paradigmatic Change and Managerial Implications. The Australian Journal of Public Administration, 66(3): 353-366.

O’Flynn J, Alford J. 2005. Inside and Beyond the Black Box of Contracting Out: Evidence from Local Government. In proceedings at PAC Annual Conference, University of Nothingam, 5-7 September.

Otley D. 1999. Performance management: a framework for management control systems research. Management Accounting Research 10(4): 363–382.

Pidd M. 1996. Tools for Thinking. Modelling in Management Science. Wiley, Chichester.

Poister TH, Pasha OQ, Hamilton Edwards L. 2013. Does Performance Management Lead to Better Outcomes? Evidence from the US Public Transit Industry. Public Administration Review 73(4): 625-636.

Pollit C. 2003. Joined-Up Government: a Survey. Political Studies Review 1: 34-49.

Qi J, Li L, Ai H. 2009. A System Dynamics Approach to Competitive Strategy in Mobile Telecommunication Industry. Systems Research and Behavioral Studies 26: 155-168.

Pucher J. 1996. Verkhehrsverbund: the Success of Regional Public in Germany, Austria and Switzerland. Transport Policy 2(4): 279-291.

Putansu S. 2015. Cross agency priority goals in the U.S. government: Can directed collaboration be a stepping stone toward politic-centered performance?. Policy and Society 34(1): 25-35.

Richmond B. 1994. System dynamics/systems thinking: let's just get on with it. International Systems Dynamics. Conference, Sterling, Scotland.

Rittel HWJ, Webber MM. 1973. Dilemmas in a General Theroy of Planning. Policy Sciences 4: 155-169.

Sager F. 2004. Metropolitan Institutions and Policy Coordination: The Integration of Land Use and Transport Policies in Swiss Urban Areas. Governance: An International Journal of Policy, Administration, and Institutions, 18(2): 227–256.

Schieritz N, Milling PM. 2003. Modeling the Forest or Modeling the Trees A Comparison of System Dynamics and Agent-Based Simulation. In Proceedings of the 2003 International System Dynamics Conference, New York, System Dynamic Society.

Sloper P, Linard K, Paterson D. 1999. Towards a dynamic feedback framework for public sector performance management. In Proceedings of the 1999 International System Dynamics Conference, Wellington, System Dynamic Society.

Stanley J, Smith A. 2013. Governance, Contracting, Ownership and Competition Issues in Public Transport: Looking Up not Down. Research in Transportation Economics, 39 (1): 167-174.

Steane P, Dufour Y, Gates D. 2015. Assessing impediments to NPM change. Journal of Organizational Change Management 28(2): 263-270.

Sterman JD. 2000. Business Dynamics: System Thinking and Modelling for a Complex World; McGraw-Hill, London, UK.

Sterman JD. 2002. All models are wrong: reflections on becoming a systems scientist. System Dynamics Review 18(4): 501-531.

Sterman JD. 2014. Interactive web-based simulations for strategy and sustainability: The MIT Sloan LearningEdge management flight simulators, Part I. System Dynamics Review 30(1-2): 89-121.

Stocker G. 2006. Public Value Management: a New Narrative for Network Governance ?. American Review of Public Administration 36(1): 41-57.

Turnquist M, Blume S. 1980. Evaluating potential effectiveness of headway control strategies for transit systems. Transportation Research Record 746: 25-29.

United Nations. 2014. World Urbanization Prospect: The 2014 Revision. United Nation - Department of Economic and Social Affairs: New York.

Van Bueren EM, Klijn EH, Koppenjan JFM. 2003. Dealing with wicked problems in networks: analyzing an environmental debate from a network perspective. J Public Admin Res Theory, 13:193-212.

Van de Velde DM. 1999. Organisational forms and entrepreneurship in public transport Part 1: classifying organisational forms. Transport Policy, 6: 147–157.

Vennix JAM. 1990. Mental Models and Computer Models, Design and evaluation of a computer-based learning environment for policy-making, Unpublished doctoral dissertation, Radboud University, Nijmegen.

Wang J, Lu H, Peng H. 2008. System Dynamics Model of Urban Transportation System and Its Application. J Transpn Sys Eng & IT, 2008, 8(3), 83-89.

Warren K. 1999. The Dynamics of Strategy. Business Strategy Review 10(3): 1-16.

Warren K. 2000. The Softer Side of Strategy Dynamics. Business Strategy Review 11(1): 45-58.

Warren K. 2002. Competitive Strategy Dynamics. Wiley, Chichester.

Warren K. 2004. Why Has Feedback Systems Thinking Struggled to Influence Strategy and Policy Formulation? Suggestive Evidence, Explanations and Solutions. Systems Research and Behavioral Studies 21: 331-347.

Warren K. 2005. Improving Strategic Management with the fundamental principles of system dynamics. System Dynamics Review 21(4): 329–350.

Warren K. 2008. Strategic Management Dynamics, Chichester: John Wiley & Sons.

Weber E, Khademian A. 2008. Wicked Problems, Knowledge Challenges, and Collaborative Capacity Builders in Network Settings. Public Administration Review 68(2): 334–49.

Weiner E. 1999. Urban transportation planning in the United States: An historical overview. Westport, CT: Praeger.

Weisbrod G. 2009. Economic impact of public transportation investment. American Public Transportation Association.

Willson RW, Payne M, Smith E. 2003. Does Discussion Enhance Rationality? A Report from Transportation Planning Practice. Journal of the American Planning Association 69(4): 354-367.

Winch GW, Bianchi C. 2006. Drivers and dynamic processes for SMEs going global. Journal of Small Business and Enterprise Development 13(1): 73-88.

Winch GW. 2010. Three System Dynamics Cases Addressing the Challenge in Performance Improvement in the Public Sector. System Research and Behavioral Science 27, 421-424.

World Bank. 2002. Cities on the Move: World Bank Urban Transportation Strategy Review. World Bank: Washington.

Web

http://dati.istat.it/Index.aspx?DataSetCode=DCIS_POPORESBIL1&Lang=en accessed on 30/01/2015.

http://interactivos.lanacion.com.ar/manual-data/estudio_de_casos_14.html accessed on 30/11/2015.

http://www.cnrt.gov.ar/content/estadisticas/automotor accessed on 28/04/2015.

http://www.ec.gba.gov.ar/estadistica/index.htm accesed on 10/07/2015.

http://www.indec.mecon.ar/Economico2005/definitivos/inc_definitivos_empresa.asp accessed on 28/04/2015.

http://www.lanacion.com.ar/1607299-colectivos-el-mejor-negocio-de-la-argentina accessed on 30/01/2015.

http://www.transporte.gov.ar/content/subsidios/ accesed on 22/12/2014.

Appendix A (Palermo's model)

Palermo's model equations with no policies:

Administrative_Staff(t) = Administrative_Staff(t - dt) + (Adm_Hiring - Adm_Attrition) * dt

INIT Administrative_Staff = 209

INFLOWS:

Adm_Hiring = Adm_Hiring_Rate*Administrative_Staff

OUTFLOWS:

Adm_Attrition = Administrative_Staff*Adm_Attr_rate

Assets(t) = Assets(t - dt) + (Increase_in_assets - Depreciation - Disinvestments) * dt

INIT Assets = 48025183

INFLOWS:

Increase_in_assets =

Assets*Investment_rate/Year*0+Cash_Inflow/10*0+(4700000+Cash/10)

OUTFLOWS:

Depreciation = Assets*Depreciation_rate/Year

Disinvestments = Assets*Disinvestment_Rate*Cash_proportion_from_disinvestments/Year

Avg_Bus_Speed(t) = Avg_Bus_Speed(t - dt) + (Chg_in_Speed) * dt

INIT Avg_Bus_Speed = 13.99

INFLOWS:

Chg_in_Speed = (Effect_of_PT_on_Avg_Speed-Avg_Bus_Speed)/Time_for_PT_to_impact

Buses_0_to_5_yr(t) = Buses_0_to_5_yr(t - dt) + (Bus_Purchase_rate - ageing_rate) * dt

INIT Buses_0_to_5_yr = 120

INFLOWS:

Bus_Purchase_rate = Funds_per_Buses/Cost_per_Bus

OUTFLOWS:

ageing_rate = Buses_0_to_5_yr/Ageing_time

Buses_5_to_10_yr(t) = Buses_5_to_10_yr(t - dt) + (ageing_rate - ageing_rate_2) * dt

INIT Buses_5_to_10_yr = 130

INFLOWS:

ageing_rate = Buses_0_to_5_yr/Ageing_time

OUTFLOWS:

ageing_rate_2 = Buses_5_to_10_yr/Ageing_time

Bus_over_10_yr(t) = Bus_over_10_yr(t - dt) + (ageing_rate_2 - Bus_disposal) * dt

INIT Bus_over_10_yr = 250

INFLOWS:

ageing_rate_2 = Buses_5_to_10_yr/Ageing_time

OUTFLOWS:

Bus_disposal = Bus_over_10_yr/Disposal_time

Cash(t) = Cash(t - dt) + (Cash_Inflow + Disinvestments - Cash_outflow - Increase_in_assets) * dt

INIT Cash = 2070812

INFLOWS:

Cash_Inflow = Collected_revenues+(if Chg_in_Equity>0 then Chg_in_Equity else 0)+(if Change__in_debt>0 then Change__in_debt else 0)

Disinvestments = Assets*Disinvestment_Rate*Cash_proportion_from_disinvestments/Year

OUTFLOWS:

Cash_outflow = Payed_Expenses-(if Chg_in_Equity<0 then Chg_in_Equity else 0)+(if Change__in_debt<0 then Change__in_debt else 0)

Increase_in_assets = Assets*Investment_rate/Year*0+Cash_Inflow/10*0+(4700000+Cash/10)

Equity(t) = Equity(t - dt) + (Net_Income - Chg_in_Equity) * dt

INIT Equity = 91719133

INFLOWS:

Net_Income = Revenues-Expenses

OUTFLOWS:

Chg_in_Equity = 0

Mainteinance_Staff(t) = Mainteinance_Staff(t - dt) + (Maint_Hiring - Maint_Attrition) * dt

INIT Mainteinance_Staff = 328

INFLOWS:

Maint_Hiring = Maint_Hiring_Rate*Mainteinance_Staff

OUTFLOWS:

Maint_Attrition = Maint_Attr_rate*Mainteinance_Staff

N_of_Lines(t) = N_of_Lines(t - dt) + (Chg_in_Lines) * dt

INIT N_of_Lines = 91

INFLOWS:

Chg_in_Lines = 0

Private_Transportation(t) = Private_Transportation(t - dt) + (Chg_in_PT) * dt

INIT Private_Transportation = 1

INFLOWS:

Chg_in_PT = (Effect_of_Service_on__Private_Transportation-Private_Transportation)/Time_to_affect_Private_Transportation

Quality_of_Service(t) = Quality_of_Service(t - dt) + (Chg_in_Quality) * dt

INIT Quality_of_Service = 1

INFLOWS:

Chg_in_Quality = ((Frequency_P_Driver+Lines_P_Driver+Timeliness_P_driver)/3-Quality_of_Service)/Time_to_impact_on_quality

Seasonal_Ticket(t) = Seasonal_Ticket(t - dt) + (Chg_in_ST) * dt

INIT Seasonal_Ticket = 4506

INFLOWS:

Chg_in_ST = (Combined_effect_on_S_ticket_sales*Seasonal_Ticket-Seasonal_Ticket)/Year

Tickets(t) = Tickets(t - dt) + (Chg_in_Tickets) * dt

INIT Tickets = 8158012

INFLOWS:

Chg_in_Tickets = (Combined_effect_on_ticket_sales*Tickets-Tickets)/Year

Customer_Satisfaction(t) = Customer_Satisfaction(t - dt) + (Chg_in_Cust_Sat) * dt

INIT Customer_Satisfaction = 1

INFLOWS:

Chg_in_Cust_Sat = (Quality_of_Service-Customer_Satisfaction)/Time_to_perceive_chg_in_Quality

Debt(t) = Debt(t - dt) + (Change__in_debt) * dt

INIT Debt = 112684331

INFLOWS:

Change__in_debt = -Cash/Time_to_perceive_fin_position+Debt_rate*Debt*0

Drivers(t) = Drivers(t - dt) + (Drivers_Hiring - Drivers_Atttrition) * dt

INIT Drivers = 1237

INFLOWS:

Drivers_Hiring = Driv_Hiring_Rate*Drivers

OUTFLOWS:

Drivers_Atttrition = Drivers*Driv_Attr_rate

Frequence(t) = Frequence(t - dt) + (Chg_in_Frequence) * dt

INIT Frequence = 31078

INFLOWS:

Chg_in_Frequence = IF Effect_of_Drivers__on_Frequence=0 THEN Extreme_case ELSE IF Total_nr_of_Buses=0 THEN Extreme_case ELSE ((Effect_of_Buses_on_Frequence*0.4+Effect_of_Drivers__on_Frequence*0.4+Effect_of_Avg_Speed_on_Frequence*0.2)-Frequence)/Time_to_impact_on_frequence

Nr_of_Km_Traveled(t) = Nr_of_Km_Traveled(t - dt) + (Chg_in_Km_Trav) * dt

INIT Nr_of_Km_Traveled = 21012982

INFLOWS:

Chg_in_Km_Trav = (Frequence*N_of_Lines*Avg_route_leght*Year)-Nr_of_Km_Traveled

Regional_Service_Contracts(t) = Regional_Service_Contracts(t - dt) + (Chg_in_RSC) * dt

INIT Regional_Service_Contracts = 56077317

INFLOWS:

Chg_in_RSC = ((Effect_of_KM_Driver_on_RSC*Contract_change)-Regional_Service_Contracts)/TIme_to_adjust_RSC

Route_loss_perc(t) = Route_loss_perc(t - dt) + (Chg_in_Timeliness) * dt

INIT Route_loss_perc = 0.17

INFLOWS:

Chg_in_Timeliness = ((Effect_of_Drivers_on___Timeliness+Effect_of_Buses_on___Timeliness+Effect_of_Traffic_on_Timeliness)/3-Route_loss_perc)/Year

Ticket_Price_level(t) = Ticket_Price_level(t - dt)

INIT Ticket_Price_level = 1.2

Adm_Attr_rate = 0.198

Adm_cost = Administrative_Staff*Avg_Wage_Adm

Adm_Hiring_Rate = 0

Ageing_time = 5

Avg_Bus_Age = ((Buses_5_to_10_yr*Ageing_time)+(Buses_0_to_5_yr*Ageing_time)+(Bus_over_10_yr*Disposal_time))/Total_nr_of_Buses

Avg_Bus_Age_benchmark = 10

Avg_consumption_of_fuel = 3*0.85+5*0.15

Avg_Price_of_Fuel = Price_of_Gasoline*0.85+Price_of_Methane*0.15

Avg_route_leght = 7.43

Avg_Wage_Adm = 80000

Avg_Wage_driv = 30000

Avg_Wage_Maint = 35000

Bus_age_Driver = Avg_Bus_Age/Avg_Bus_Age_benchmark

Cash_proportion_from_disinvestments = 0.2

Collected_revenues = Revenues/Collection_rate

Collection_rate = 2

Combined_effect_on_S_ticket_sales =

Weighted_Effect_of_Price_on_S_tickets*Weighted_Effect_of_Customer_Sat_on_S_tickets

Combined_effect_on_ticket_sales =

Effect_of_price_on_tickets*Effect_of_Customer_Satisfaction_on_Ticket_sales

Contract_change = GRAPH(TIME)

(2009, 1.00), (2010, 1.00), (2011, 1.00), (2012, 0.8)

Cost_of_manteinance =

Effect_of_Bus_age_on_raw_material_acquisition/2+Effect_of_Nr_Bus_on_Maintenance/2

Cost_per_Bus = 80000

Cost_per_KM = Expenses/Nr_of_Km_Traveled

Debt_rate = -0.051

Depreciation_rate = 0.15

Desired_Frequency = 31000

Desired_Nr_of_Km_Traveled = 19000000

Desired_N_of_Lines = 91

Disinvestment_Rate = 0.0122

Disposal_time = 12

Drivers_cost = Drivers*Avg_Wage_driv

Driv_Attr_rate = 0.0416

Driv_Hiring_Rate = 0.0153

Effect_of_Avg_Speed_on_Frequence = GRAPH(Avg_Bus_Speed)

(10.0, 9000), (11.3, 16000), (12.7, 23000), (14.0, 31000)

Effect_of_Buses_on_Frequence = GRAPH(Total_nr_of_Buses)

(400, 24256), (425, 25235), (450, 26323), (475, 28281), (500, 30456)

Effect_of_Buses_on___Timeliness = GRAPH(Total_nr_of_Buses)

(480, 0.25), (487, 0.22), (493, 0.2), (500, 0.17)

Effect_of_Bus_age_on_raw_material_acquisition = GRAPH(Bus_age_Driver)

(0.00, 0.00), (0.222, 2e+006), (0.444, 4e+006), (0.667, 5.4e+006), (0.889, 6e+006), (1.11, 8e+006), (1.33, 1e+007), (1.56, 1.1e+007), (1.78, 1.1e+007), (2.00, 1.1e+007)

Effect_of_Customer_Satisfaction_on_Ticket_sales = GRAPH(Customer_Satisfaction)

(0.00, 0.751), (0.0579, 0.814), (0.116, 0.842), (0.174, 0.87), (0.232, 0.905), (0.289, 0.93), (0.347, 0.935), (0.405, 0.94), (0.463, 0.945), (0.521, 0.95), (0.579, 0.955), (0.637, 0.96), (0.695, 0.965), (0.753, 0.97), (0.811, 0.975), (0.868, 0.98), (0.926, 0.999), (0.984, 1.00), (1.04, 1.04), (1.10, 1.01)

Effect_of_Drivers_on___Timeliness = GRAPH(Drivers)

(1090, 0.25), (1139, 0.22), (1188, 0.2), (1237, 0.17)

Effect_of_Drivers__on_Frequence = GRAPH(Drivers)

(0.00, 0.00), (124, 6535), (248, 12845), (372, 17127), (496, 22986), (620, 25912), (744, 26208), (868, 26380), (992, 26627), (1116, 26824), (1240, 27120)

Effect_of_KM_Driver_on_RSC = GRAPH(KM_Travelled_Driver)

(0.00, 0.00), (0.5, 9.5e+006), (1.00, 4.8e+007), (1.50, 8e+007), (2.00, 8e+007)

Effect_of_Nr_Bus_on_Maintenance = GRAPH(Total_nr_of_Buses)

(0.00, 0.00), (167, 3e+006), (333, 4e+006), (500, 5.4e+006)

Effect_of_price_on_S_ticket = GRAPH(ST_Price_Driver)

(0.00, 1.50), (0.5, 1.10), (1.00, 1.00), (1.50, 0.9), (2.00, 0.7)

Effect_of_price_on_tickets = GRAPH(Ticket_Price_Driver)

(0.00, 1.41), (0.333, 1.24), (0.667, 1.09), (1.00, 0.989), (1.33, 0.925), (1.67, 0.807), (2.00, 0.702), (2.33, 0.632), (2.67, 0.554), (3.00, 0.519)

Effect_of_PT_on_Avg_Speed = GRAPH(Private_Transportation)

(0.00, 15.0), (0.667, 14.0), (1.33, 13.5), (2.00, 12.5)

Effect_of_Service_on__Private_Transportation = GRAPH(Quality_of_Service)

(0.00, 4.00), (0.5, 2.00), (1.00, 1.00), (1.50, 0.00), (2.00, 0.00)

Effect_of_Traffic_on_Timeliness = GRAPH(Avg_Bus_Speed)

(13.9, 0.28), (13.9, 0.25), (13.9, 0.22), (14.0, 0.17)

Expenses =

Cost_of_manteinance+Gasoline_per_year+Total_Personnel_cost+Depreciation+Leftover+Other_Expenses+Financial_Costs

Extreme_case = -90000

Financial_Costs = Debt*0.02/Year

FInancial_Cost_Indicator = Financial_Costs/Expenses

Frequence_per_route_per_year = GRAPH(TIME)

(2009, 31078), (2010, 28993), (2011, 26049), (2012, 25296)

Frequency_P_Driver = Frequence/Desired_Frequency

Funds_per_Buses = Increase_in_assets*Percentage_of_Bus_on_Tot_Investment

Gasoline_per_year = Avg_Price_of_Fuel*Nr_of_Km_Traveled/Avg_consumption_of_fuel

Investment_rate = 0.098

KM_Travelled_Driver = Nr_of_Km_Traveled/Desired_Nr_of_Km_Traveled

Leftover = GRAPH(TIME)

(2009, -4.1e+005), (2010, 425512), (2011, 109374), (2012, 104633)

Lines_performance_indicator = Regional_Service_Contracts/N_of_Lines

Lines_P_Driver = N_of_Lines/Desired_N_of_Lines

Maint_Attr_rate = 0.057

Maint_cost = Mainteinance_Staff*Avg_Wage_Maint

Maint_Hiring_Rate = 0

Municipality_Service_Contract = GRAPH(TIME)

(2009, 2.7e+007), (2010, 2.4e+007), (2011, 2.4e+007), (2012, 2.4e+007)

Other_Expenses = GRAPH(TIME)

(2009, 1.7e+007), (2010, 1.8e+007), (2011, 1.8e+007), (2012, 1.9e+007)

Other_Revenues = GRAPH(TIME)

(2009, 2.1e+006), (2010, 2.1e+006), (2011, 2.1e+006), (2012, 2.1e+006)

Payed_Expenses = (Expenses/Payment_rate)-Leftover-Depreciation

Payment_rate = GRAPH(TIME)

(2009, 1.57), (2010, 2.07), (2011, 1.97), (2012, 2.78)

Percentage_of_Bus_on_Tot_Investment = 0.3

Price_of_Gasoline = GRAPH(TIME)

(2009, 1.40), (2012, 1.90)

Price_of_Methane = 1

Reference_cash = GRAPH(TIME)

(2009, 2.1e+006), (2010, 85875), (2011, 59464), (2012, 215754)

Reference_Net_Income = GRAPH(TIME)

(2009, -6.9e+006), (2010, -8.1e+006), (2011, -7.7e+006), (2012, -1.3e+007)

Revenues =

Regional_Service_Contracts+Revenues_from_Tickets+Other_Revenues+Municipality_Servic
e_Contract

Revenues_from_Tickets = (Ticket_Price_level*Tickets)+(Seasonal_Ticket*ST_avg_Price)

ST_avg_Price = 576

ST_Price_Benchmark = 550

ST_Price_Driver = ST_avg_Price/ST_Price_Benchmark

Ticket_Price_Benchmark = 1

Ticket_Price_Driver = Ticket_Price_level/Ticket_Price_Benchmark

Timeliness_P_driver = 1-Route_loss_perc

Time_for_PT_to_impact = 0.5

TIme_to_adjust_RSC = 1

Time_to_affect_Private_Transportation = 0.5

Time_to_impact_on_frequence = 0.2

Time_to_impact_on_quality = 0.5

Time_to_perceive_chg_in_Quality = 0.5

Time_to_perceive_fin_position = 0.5

Total_nr_of_Buses = Buses_0_to_5_yr+Buses_5_to_10_yr+Bus_over_10_yr

Total_Personnel_cost = Drivers_cost+Adm_cost+Maint_cost

Total_Staff = Drivers+Administrative_Staff+Mainteinance_Staff

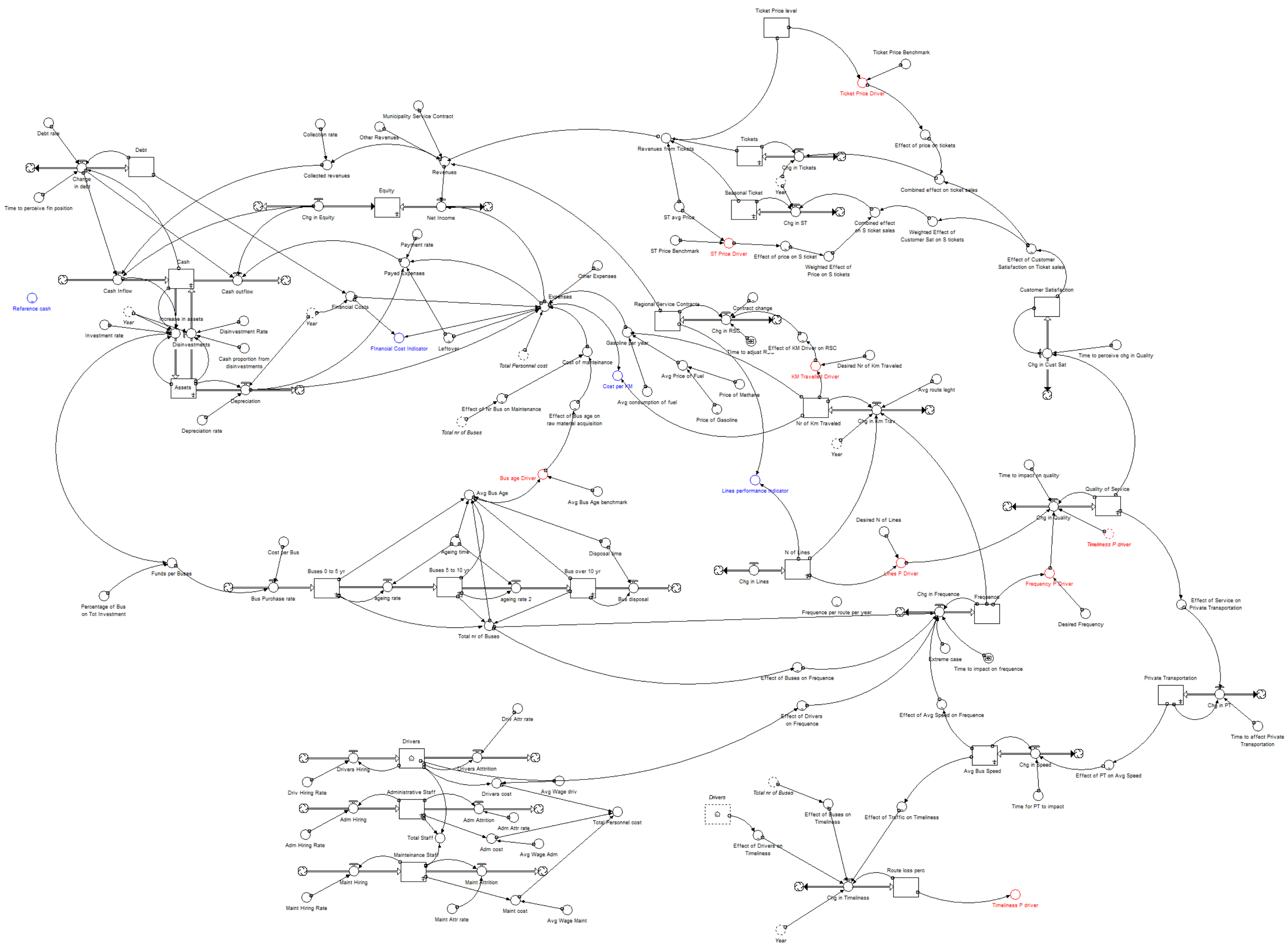
Weighted_Effect_of_Customer_Sat_on_S_tickets =

Effect_of_Customer_Satisfaction_on_Ticket_sales*2

Weighted_Effect_of_Price_on_S_tickets = Effect_of_price_on_S_ticket/2

Year = 1

Palermo's model structure with no policies:



Ticket Price level
Ticket Price Benchmark
Ticket Price Driver
Effect of price on tickets
Tickets
Revenues from Tickets
Chg in Tickets
Year
Combined effect on ticket sales
Seasonal Ticket
Chg in ST
Combined effect on S ticket sales
Weighted Effect of Customer Sat on S tickets
ST avg Price
ST Price Benchmark
ST Price Driver
Effect of price on S ticket
Weighted Effect of Price on S tickets
Effect of Customer Satisfaction on Ticket sales
Customer Satisfaction
Chg in Cust Sat
Time to perceive chg in Quality
Debt rate
Debt
Change in debt
Time to perceive fin position
Collection rate
Other Revenues
Municipality Service Contract
Collected revenues
Revenues
Equity
Chg in Equity
Net Income
Cash
Cash Inflow
Cash outflow
Payment rate
Payed Expenses
Reference cash
Year
Investment rate
Increase in assets
Disinvestment Rate
Disinvestments
Cash proportion from disinvestments
Assets
Depreciation
Depreciation rate
Financial Costs
Financial Cost Indicator
Leftover
Expenses
Other Expenses
Total Personnel cost
Cost of maintenance
Regional Service Contracts
Contract change
Chg in RSC
Time to adjust RSC
Effect of KM Driver on RSC
Desired Nr of Km Traveled
KM Traveled Driver
Gasoline per year
Avg Price of Fuel
Price of Methane
Price of Gasoline
Cost per KM
Avg consumption of fuel
Nr of Km Traveled
Chg in Km Trav
Avg route leght
Effect of Nr Bus on Maintenance
Total nr of Buses
Effect of Bus age on raw material acquisition
Bus age Driver
Avg Bus Age
Avg Bus Age benchmark
Lines performance indicator
Desired N of Lines
N of Lines
Chg in Lines
Lines P Driver
Time to impact on quality
Quality of Service
Chg in Quality
Timeliness P driver
Frequency P Driver
Desired Frequency
Effect of Service on Private Transportation
Cost per Bus
Funds per Buses
Percentage of Bus on Tot Investment
Bus Purchase rate
Buses 0 to 5 yr
ageing rate
Ageing time
Buses 5 to 10 yr
ageing rate 2
Bus over 10 yr
Disposal time
Bus disposal
Total nr of Buses
Chg in Frequence
Frequence
Frequence per route per year
Extreme case
Time to impact on frequence
Effect of Buses on Frequence
Effect of Drivers on Frequence
Effect of Avg Speed on Frequence
Private Transportation
Chg in PT
Time to affect Private Transportation
Drivers
Drivers Hiring
Drivers Attrition
Driv Hiring Rate
Driv Attr rate
Drivers cost
Avg Wage driv
Administrative Staff
Adm Hiring
Adm Attrition
Adm Hiring Rate
Adm Attr rate
Total Staff
Adm cost
Avg Wage Adm
Total Personnel cost
Mainteinance Staff
Maint Hiring
Maint Attrition
Maint Hiring Rate
Maint Attr rate
Maint cost
Avg Wage Maint
Avg Bus Speed
Chg in Speed
Effect of PT on Avg Speed
Time for PT to impact
Effect of Traffic on Timeliness
Total nr of Buses
Effect of Buses on Timeliness
Effect of Drivers on Timeliness
Route loss perc
Chg in Timeliness
Timeliness P driver
Year

Palermo's model equations with policies:

Administrative_Staff(t) = Administrative_Staff(t - dt) + (Adm_Hiring - Adm_Attrition) * dt

INIT Administrative_Staff = 209

INFLOWS:

Adm_Hiring = Adm_Hiring_Rate*Administrative_Staff

OUTFLOWS:

Adm_Attrition = Administrative_Staff*Adm_Attr_rate

Assets(t) = Assets(t - dt) + (Increase_in_assets - Depreciation - Disinvestments) * dt

INIT Assets = 48025183

INFLOWS:

Increase_in_assets =

Assets*Investment_rate/Year*0+Cash_Inflow/10*0+(4700000+Cash/10)

OUTFLOWS:

Depreciation = Assets*Depreciation_rate/Year

Disinvestments = Assets*Disinvestment_Rate*Cash_proportion_from_disinvestments/Year

Avg_Bus_Speed(t) = Avg_Bus_Speed(t - dt) + (Chg_in_Speed) * dt

INIT Avg_Bus_Speed = 13.99

INFLOWS:

Chg_in_Speed = (Effect_of_PT_on_Avg_Speed-Avg_Bus_Speed)/Time_for_PT_to_impact

Buses_0_to_5_yr(t) = Buses_0_to_5_yr(t - dt) + (Bus_Purchase_rate - ageing_rate) * dt

INIT Buses_0_to_5_yr = 120

INFLOWS:

Bus_Purchase_rate = Funds_per_Buses/Cost_per_Bus

OUTFLOWS:

ageing_rate = Buses_0_to_5_yr/Ageing_time

Buses_5_to_10_yr(t) = Buses_5_to_10_yr(t - dt) + (ageing_rate - ageing_rate_2) * dt

INIT Buses_5_to_10_yr = 130

INFLOWS:

ageing_rate = Buses_0_to_5_yr/Ageing_time

OUTFLOWS:

ageing_rate_2 = Buses_5_to_10_yr/Ageing_time

Bus_over_10_yr(t) = Bus_over_10_yr(t - dt) + (ageing_rate_2 - Bus_disposal) * dt

INIT Bus_over_10_yr = 250

INFLOWS:

ageing_rate_2 = Buses_5_to_10_yr/Ageing_time

OUTFLOWS:

Bus_disposal = Bus_over_10_yr/Disposal_time

Cash(t) = Cash(t - dt) + (Cash_Inflow + Disinvestments - Cash_outflow - Increase_in_assets) * dt

INIT Cash = 2070812

INFLOWS:

Cash_Inflow = Collected_revenues+(if Chg_in_Equity>0 then Chg_in_Equity else 0)+(if Change__in_debt>0 then Change__in_debt else 0)

Disinvestments = Assets*Disinvestment_Rate*Cash_proportion_from_disinvestments/Year

OUTFLOWS:

Cash_outflow = Payed_Expenses-(if Chg_in_Equity<0 then Chg_in_Equity else 0)+(if Change__in_debt<0 then Change__in_debt else 0)

Increase_in_assets = Assets*Investment_rate/Year*0+Cash_Inflow/10*0+(4700000+Cash/10)

Equity(t) = Equity(t - dt) + (Net_Income - Chg_in_Equity) * dt

INIT Equity = 91719133

INFLOWS:

Net_Income = Revenues-Expenses

OUTFLOWS:

Chg_in_Equity = 0

Mainteinance_Staff(t) = Mainteinance_Staff(t - dt) + (Maint_Hiring - Maint_Attrition) * dt

INIT Mainteinance_Staff = 328

INFLOWS:

Maint_Hiring = Maint_Hiring_Rate*Mainteinance_Staff

OUTFLOWS:

Maint_Attrition = Maint_Attr_rate*Mainteinance_Staff

N_of_Lines(t) = N_of_Lines(t - dt) + (Chg_in_Lines) * dt

INIT N_of_Lines = 91

INFLOWS:

Chg_in_Lines = 0

Private_Transportation(t) = Private_Transportation(t - dt) + (Chg_in_PT) * dt

INIT Private_Transportation = 1

INFLOWS:

Chg_in_PT = (Effect_of_Service_on__Private_Transportation-Private_Transportation)/Time_to_affect_Private_Transportation

Quality_of_Service(t) = Quality_of_Service(t - dt) + (Chg_in_Quality) * dt

INIT Quality_of_Service = 1

INFLOWS:

Chg_in_Quality = ((Frequency_P_Driver+Lines_P_Driver+Timeliness_P_driver)/3-Quality_of_Service)/Time_to_impact_on_quality

Seasonal_Ticket(t) = Seasonal_Ticket(t - dt) + (Chg_in_ST) * dt

INIT Seasonal_Ticket = 4506

INFLOWS:

Chg_in_ST = (Combined_effect_on_S_ticket_sales*Seasonal_Ticket-Seasonal_Ticket)/Year

Tickets(t) = Tickets(t - dt) + (Chg_in_Tickets) * dt

INIT Tickets = 8158012

INFLOWS:

Chg_in_Tickets = (Combined_effect_on_ticket_sales*Tickets-Tickets)/Year

Customer_Satisfaction(t) = Customer_Satisfaction(t - dt) + (Chg_in_Cust_Sat) * dt

INIT Customer_Satisfaction = 1

INFLOWS:

Chg_in_Cust_Sat = (Quality_of_Service-Customer_Satisfaction)/Time_to_perceive_chg_in_Quality

Debt(t) = Debt(t - dt) + (Change__in_debt) * dt

INIT Debt = 112684331

INFLOWS:

Change__in_debt = -Cash/Time_to_perceive_fin_position+Debt_rate*Debt*0

Drivers(t) = Drivers(t - dt) + (Drivers_Hiring - Drivers_Atttrition) * dt

INIT Drivers = 1237

INFLOWS:

Drivers_Hiring = Driv_Hiring_Rate*Drivers

OUTFLOWS:

Drivers_Atttrition = Drivers*Driv_Attr_rate

Frequence(t) = Frequence(t - dt) + (Chg_in_Frequence) * dt
INIT Frequence = 31078
INFLOWS:
Chg_in_Frequence = IF Effect_of_Drivers__on_Frequence=0 THEN Extreme_case ELSE IF
Total_nr_of_Buses=0 THEN Extreme_case ELSE
((Effect_of_Buses_on_Frequence*0.4+Effect_of_Drivers__on_Frequence*0.4+Effect_of_Av
g_Speed_on_Frequence*0.2)-Frequence)/Time_to_impact_on_frequence
Municipal_Contract_Service(t) = Municipal_Contract_Service(t - dt) + (Chg_in_MCS) * dt
INIT Municipal_Contract_Service = 27312615
INFLOWS:
Chg_in_MCS = if time<2012 then (Municipality_Service_Contract-
Municipal_Contract_Service)/Year else MIN ((MAX_Municipal_CS-
Municipal_Contract_Service)/Year, (Municipal_Contract_Service*(2-Bus_age_Driver)-
Municipal_Contract_Service)/Year)
Nr_of_Km_Traveled(t) = Nr_of_Km_Traveled(t - dt) + (Chg_in_Km_Trav) * dt
INIT Nr_of_Km_Traveled = 21012982
INFLOWS:
Chg_in_Km_Trav = (Frequence*N_of_Lines*Avg_route_leght*Year)-Nr_of_Km_Traveled
Regional_Service_Contracts(t) = Regional_Service_Contracts(t - dt) + (Chg_in_RSC) * dt
INIT Regional_Service_Contracts = 56077317
INFLOWS:
Chg_in_RSC = ((Effect_of_KM_Driver_on_RSC*Contract_change)-
Regional_Service_Contracts)/TIme_to_adjust_RSC
Route_loss_perc(t) = Route_loss_perc(t - dt) + (Chg_in_Timeliness) * dt
INIT Route_loss_perc = 0.17
INFLOWS:
Chg_in_Timeliness =
((Effect_of_Drivers_on___Timeliness+Effect_of_Buses_on___Timeliness+Effect_of_Traffic
_on_Timeliness)/3-Route_loss_perc)/Year
Ticket_Price_level(t) = Ticket_Price_level(t - dt) + (Chg_in_ticket_price) * dt
INIT Ticket_Price_level = 1.2
INFLOWS:

Chg_in_ticket_price = if time<2012 then (Ticket_Price-Ticket_Price_level)/Year else (Effect_of_NT_on_TP-Ticket_Price_level)/Year

Adm_Attr_rate = 0.198

Adm_cost = Administrative_Staff*Avg_Wage_Adm

Adm_Hiring_Rate = 0

Ageing_time = 5

Avg_Bus_Age = ((Buses_5_to_10_yr*Ageing_time)+(Buses_0_to_5_yr*Ageing_time)+(Bus_over_10_yr*Disposal_time))/Total_nr_of_Buses

Avg_Bus_Age_benchmark = 10

Avg_consumption_of_fuel = 3*0.85+5*0.15

Avg_Price_of_Fuel = Price_of_Gasoline*0.85+Price_of_Methane*0.15

Avg_route_leght = 7.43

Avg_Wage_Adm = 80000

Avg_Wage_driv = 30000

Avg_Wage_Maint = 35000

Bus_age_Driver = Avg_Bus_Age/Avg_Bus_Age_benchmark

Cash_proportion_from_disinvestments = 0.2

Collected_revenues = Revenues/Collection_rate

Collection_rate = 2

Combined_effect_on_S_ticket_sales = Weighted_Effect_of_Price_on_S_tickets*Weighted_Effect_of_Customer_Sat_on_S_tickets

Combined_effect_on_ticket_sales = Effect_of_price_on_tickets*Effect_of_Customer_Satisfaction_on_Ticket_sales

Contract_change = GRAPH(TIME)

(2009, 1.00), (2010, 1.00), (2011, 1.00), (2012, 0.8)

Cost_of_manteinance = Effect_of_Bus_age_on_raw_material_acquisition/2+Effect_of_Nr_Bus_on_Maintenance/2

Cost_per_Bus = 80000

Cost_per_KM = Expenses/Nr_of_Km_Traveled

Debt_rate = -0.051

Depreciation_rate = 0.15

Desired_Frequency = 31000

Desired_Nr_of_Km_Traveled = 19000000

Desired_N_of_Lines = 91

Disinvestment_Rate = 0.0122

Disposal_time = 12

Drivers_cost = Drivers*Avg_Wage_driv

Driv_Attr_rate = 0.0416

Driv_Hiring_Rate = 0.0153

Effect_of_Avg_Speed_on_Frequence = GRAPH(Avg_Bus_Speed)

(10.0, 9000), (11.3, 16000), (12.7, 23000), (14.0, 31000)

Effect_of_Buses_on_Frequence = GRAPH(Total_nr_of_Buses)

(400, 24256), (425, 25235), (450, 26323), (475, 28281), (500, 30456)

Effect_of_Buses_on___Timeliness = GRAPH(Total_nr_of_Buses)

(480, 0.25), (487, 0.22), (493, 0.2), (500, 0.17)

Effect_of_Bus_age_on_raw_material_acquisition = GRAPH(Bus_age_Driver)

(0.00, 0.00), (0.222, 2e+006), (0.444, 4e+006), (0.667, 5.4e+006), (0.889, 6e+006), (1.11, 8e+006), (1.33, 1e+007), (1.56, 1.1e+007), (1.78, 1.1e+007), (2.00, 1.1e+007)

Effect_of_Customer_Satisfaction_on_Ticket_sales = GRAPH(Customer_Satisfaction)

(0.00, 0.751), (0.0579, 0.814), (0.116, 0.842), (0.174, 0.87), (0.232, 0.905), (0.289, 0.93), (0.347, 0.935), (0.405, 0.94), (0.463, 0.945), (0.521, 0.95), (0.579, 0.955), (0.637, 0.96), (0.695, 0.965), (0.753, 0.97), (0.811, 0.975), (0.868, 0.98), (0.926, 0.999), (0.984, 1.00), (1.04, 1.04), (1.10, 1.01)

Effect_of_Drivers_on___Timeliness = GRAPH(Drivers)

(1090, 0.25), (1139, 0.22), (1188, 0.2), (1237, 0.17)

Effect_of_Drivers__on_Frequence = GRAPH(Drivers)

(0.00, 0.00), (124, 6535), (248, 12845), (372, 17127), (496, 22986), (620, 25912), (744, 26208), (868, 26380), (992, 26627), (1116, 26824), (1240, 27120)

Effect_of_KM_Driver_on_RSC = GRAPH(KM_Travelled_Driver)

(0.00, 0.00), (0.5, 9.5e+006), (1.00, 4.8e+007), (1.50, 8e+007), (2.00, 8e+007)

Effect_of_Nr_Bus_on_Maintenance = GRAPH(Total_nr_of_Buses)

(0.00, 0.00), (167, 3e+006), (333, 4e+006), (500, 5.4e+006)

Effect_of_NT_on_TP = GRAPH(Tickets)

(0.00, 1.02), (700000, 1.02), (1.4e+006, 1.02), (2.1e+006, 1.02), (2.8e+006, 1.02), (3.5e+006, 1.03), (4.2e+006, 1.06), (4.9e+006, 1.08), (5.6e+006, 1.14), (6.3e+006, 1.21), (7e+006, 1.27)

Effect_of_price_on_S_ticket = GRAPH(ST_Price_Driver)

(0.00, 1.50), (0.5, 1.10), (1.00, 1.00), (1.50, 0.9), (2.00, 0.7)

Effect_of_price_on_tickets = GRAPH(Ticket_Price_Driver)

(0.00, 1.41), (0.333, 1.24), (0.667, 1.09), (1.00, 0.989), (1.33, 0.925), (1.67, 0.807), (2.00, 0.702), (2.33, 0.632), (2.67, 0.554), (3.00, 0.519)

Effect_of_PT_on_Avg_Speed = GRAPH(Private_Transportation)

(0.00, 15.0), (0.667, 14.0), (1.33, 13.5), (2.00, 12.5)

Effect_of_Service_on__Private_Transportation = GRAPH(Quality_of_Service)

(0.00, 4.00), (0.5, 2.00), (1.00, 1.00), (1.50, 0.00), (2.00, 0.00)

Effect_of_Traffic_on_Timeliness = GRAPH(Avg_Bus_Speed)

(13.9, 0.28), (13.9, 0.25), (13.9, 0.22), (14.0, 0.17)

Expenses = Cost_of_manteinance+Gasoline_per_year+Total_Personnel_cost+Depreciation+Leftover+Other_Expenses+Financial_Costs

Extreme_case = -90000

Financial_Costs = Debt*0.02/Year

FInancial_Cost_Indicator = Financial_Costs/Expenses

Frequency_P_Driver = Frequence/Desired_Frequency

Funds_per_Buses = Increase_in_assets*Percentage_of_Bus_on_Tot_Investment

Gasoline_per_year = Avg_Price_of_Fuel*Nr_of_Km_Traveled/Avg_consumption_of_fuel

Investment_rate = 0.098

KM_Travelled_Driver = Nr_of_Km_Traveled/Desired_Nr_of_Km_Traveled

Leftover = GRAPH(TIME)

(2009, -4.1e+005), (2010, 425512), (2011, 109374), (2012, 104633)

Lines_performance_indicator = Regional_Service_Contracts/N_of_Lines

Lines_P_Driver = N_of_Lines/Desired_N_of_Lines

Maint_Attr_rate = 0.057

Maint_cost = Mainteinance_Staff*Avg_Wage_Maint

Maint_Hiring_Rate = 0

MAX_Municipal_CS = 33000000

Municipality_Service_Contract = GRAPH(TIME)

(2009, 2.7e+007), (2010, 2.4e+007), (2011, 2.4e+007), (2012, 2.4e+007)

Other_Expenses = GRAPH(TIME)

(2009, 1.7e+007), (2010, 1.8e+007), (2011, 1.8e+007), (2012, 1.9e+007)

Other_Revenues = GRAPH(TIME)

(2009, 2.1e+006), (2010, 2.1e+006), (2011, 2.1e+006), (2012, 2.1e+006)

Payed_Expenses = (Expenses/Payment_rate)-Leftover-Depreciation

Payment_rate = GRAPH(TIME)

(2009, 1.57), (2010, 2.07), (2011, 1.97), (2012, 2.78)

Percentage_of_Bus_on_Tot_Investment = IF Municipal_Contract_Service>28000000 then 0.5 else 0.3

Price_of_Gasoline = GRAPH(TIME)

(2009, 1.40), (2012, 1.90)

Price_of_Methane = 1

Reference_Net_Income = GRAPH(TIME)

(2009, -6.9e+006), (2010, -8.1e+006), (2011, -7.7e+006), (2012, -1.3e+007)

Revenues = If time<2012 then Regional_Service_Contracts+Revenues_from_Tickets+Other_Revenues+Municipality_Service_Contract else Other_Revenues+Revenues_from_Tickets+Regional_Service_Contracts+Municipal_Contract_Service+Municipality_Service_Contract*0

Revenues_from_Tickets = (Ticket_Price_level*Tickets)+(Seasonal_Ticket*ST_avg_Price)

ST_avg_Price = 576

ST_Price_Benchmark = 550

ST_Price_Driver = ST_avg_Price/ST_Price_Benchmark

S_Ticket_trend = GRAPH(TIME)

(2009, 4506), (2010, 5489), (2011, 4415), (2012, 4277)

Ticket_Price = GRAPH(TIME)

(2009, 1.20), (2010, 1.30), (2011, 1.30), (2012, 1.30)

Ticket_Price_Benchmark = 1

Ticket_Price_Driver = Ticket_Price_level/Ticket_Price_Benchmark

Ticket_trend = GRAPH(TIME)

(2009, 8.2e+006), (2010, 8e+006), (2011, 7.6e+006), (2012, 7.1e+006)

Timeliness_P_driver = 1-Route_loss_perc

Time_for_PT_to_impact = 0.5

TIme_to_adjust_RSC = 1

Time_to_affect_Private_Transportation = 0.5

Time_to_impact_on_frequence = 0.2

Time_to_impact_on_quality = 0.5

Time_to_perceive_chg_in_Quality = 0.5

Time_to_perceive_fin_position = 0.5

Total_nr_of_Buses = Buses_0_to_5_yr+Buses_5_to_10_yr+Bus_over_10_yr

Total_Personnel_cost = Drivers_cost+Adm_cost+Maint_cost

Total_Staff = Drivers+Administrative_Staff+Mainteinance_Staff

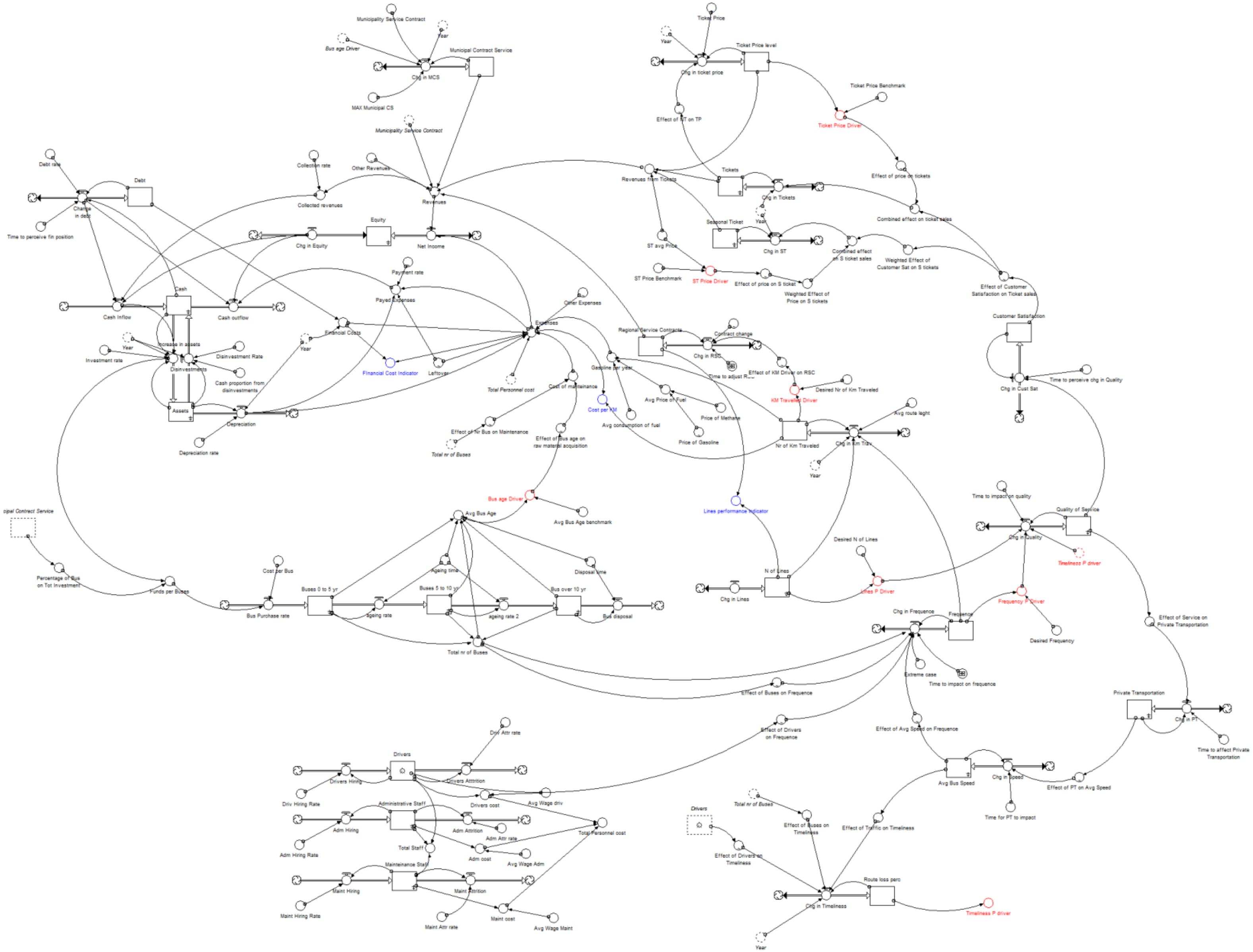
Weighted_Effect_of_Customer_Sat_on_S_tickets =

Effect_of_Customer_Satisfaction_on_Ticket_sales*2

Weighted_Effect_of_Price_on_S_tickets = Effect_of_price_on_S_ticket/2

Year = 1

Palermo's model structure with policy:



Municipality Service Contract
Year
Bus age Driver
Municipal Contract Service
Chg in MCS
MAX Municipal CS
Municipality Service Contract
Ticket Price
Year
Ticket Price level
Chg in ticket price
Ticket Price Benchmark
Ticket Price Driver
Effect of ST on TP
Debt rate
Debt
Change in debt
Time to perceive fin position
Collection rate
Other Revenues
Collected revenues
Revenues
Revenues from Tickets
Tickets
Chg in Tickets
Effect of price on tickets
Combined effect on ticket sales
Equity
Chg in Equity
Net Income
Seasonal Ticket
Chg in ST
ST avg Price
Combined effect on S ticket sales
Weighted Effect of Customer Sat on S tickets
ST Price Benchmark
ST Price Driver
Effect of price on S ticket
Weighted Effect of Price on S tickets
Effect of Customer Satisfaction on Ticket sales
Payment rate
Payed Expenses
Cash
Cash Inflow
Cash outflow
Other Expenses
Expenses
Financial Costs
Year
Investment rate
Increase in assets
Disinvestments
Disinvestment Rate
Cash proportion from disinvestments
Financial Cost Indicator
Leftover
Total Personnel cost
Assets
Depreciation
Depreciation rate
Regional Service Contracts
Contract change
Chg in RSC
Time to adjust RSC
Effect of KM Driver on RSC
Gasoline per year
Cost of maintenance
Cost per KM
Avg Price of Fuel
Price of Methane
Avg consumption of fuel
Price of Gasoline
Desired Nr of Km Traveled
KM Traveled Driver
Customer Satisfaction
Chg in Cust Sat
Time to perceive chg in Quality
Avg route lenght
Nr of Km Traveled
Chg in Km Trav
Year
Effect of Nr Bus on Maintenance
Total nr of Buses
Effect of Bus age on raw material acquisition
Bus age Driver
Avg Bus Age
Avg Bus Age benchmark
Lines performance indicator
Time to impact on quality
Quality of Service
Chg in Quality
Timeliness P driver
Municipal Contract Service
Percentage of Bus on Tot Investment
Funds per Buses
Cost per Bus
Buses 0 to 5 yr
Bus Purchase rate
Ageing rate
Ageing time
Buses 5 to 10 yr
ageing rate 2
Disposal time
Bus over 10 yr
Bus disposal
Total nr of Buses
Desired N of Lines
N of Lines
Chg in Lines
Lines P Driver
Chg in Frequence
Frequence
Frequency P Driver
Desired Frequency
Effect of Service on Private Transportation
Extreme case
Time to impact on frequence
Effect of Buses on Frequence
Private Transportation
Chg in PT
Time to affect Private Transportation
Drivr Attr rate
Effect of Drivers on Frequence
Effect of Avg Speed on Frequence
Drivers
Drivers Hiring
Drivers Attrition
Driv Hiring Rate
Drivers cost
Avg Wage driv
Administrative Staff
Adm Hiring
Adm Attrition
Adm Attr rate
Adm Hiring Rate
Total Staff
Adm cost
Avg Wage Adm
Total Personnel cost
Maintenance Staff
Maint Hiring
Maint Attrition
Maint Hiring Rate
Maint Attr rate
Maint cost
Avg Wage Maint
Avg Bus Speed
Chg in Speed
Effect of PT on Avg Speed
Time for PT to impact
Total nr of Buses
Effect of Buses on Timeliness
Effect of Traffic on Timeliness
Drivers
Effect of Drivers on Timeliness
Route loss perc
Chg in Timeliness
Timeliness P driver
Year

Appendix B (Buenos Aires' model)

Buenos Aires' model equations with no policies:

Desired_Ticket_Price(t) = Desired_Ticket_Price(t - dt) + (Chng_in_DTP) * dt

INIT Desired_Ticket_Price = 1

INFLOWS:

Chng_in_DTP = (Desired_Ticket_Price+(Desired_Ticket_Price)*Inflation_Perceived-Desired_Ticket_Price)/4.8*Month^Time_rate_converter

Funds_for_Subsidies(t) = Funds_for_Subsidies(t - dt) + (FFSIT - Subsidies_locking_price) * dt

INIT Funds_for_Subsidies = 5226.45

INFLOWS:

FFSIT = Subsidies_locking_price

OUTFLOWS:

Subsidies_locking_price = Nr_of_Travels_per_month*GAP_in_Price

Nr_of_Travels_per_month(t) = Nr_of_Travels_per_month(t - dt) + (Chng_in_Travels) * dt

INIT Nr_of_Travels_per_month = 2819437

INFLOWS:

Chng_in_Travels = (((Total_Population*Fraction_of_Population_Travelling_with_line_60)-Nr_of_Travels_per_month)/Month)*Service_Quality

Private_companies__financial_resources(t) = Private_companies__financial_resources(t - dt) + (Incomes - Costs - Profit - New_Investments) * dt

INIT Private_companies__financial_resources = 0

INFLOWS:

Incomes = Subsidies_locking_price+Income_from_passengers

OUTFLOWS:

Costs = (Incomes)*0.95

Profit = Private_companies__financial_resources*Investment_rate_choice_2

New_Investments = Private_companies__financial_resources*Investment_rate_choice_1

Service_Quality(t) = Service_Quality(t - dt) + (Chng_in_Quality) * dt

INIT Service_Quality = 1

INFLOWS:

Chng_in_Quality = ((PD_assets+Effect_of_Travels__on_Quality)-Service_Quality)/Time_for_assets_to_impact_on_quality

Ticket_Price(t) = Ticket_Price(t - dt) + (Chng_in_Ticket_Price) * dt

INIT Ticket_Price = 1

INFLOWS:

Chng_in_Ticket_Price = 0.015

Assets(t) = Assets(t - dt) + (New_Investments - Obsolecence) * dt

INIT Assets = 222300000

INFLOWS:

New_Investments = Private_companies__financial_resources*Investment_rate_choice_1

OUTFLOWS:

Obsolecence = Assets/Time_to_get_Obsolete

Elder_Inhabitant(t) = Elder_Inhabitant(t - dt) + (Loosing_Fertility - Death_Rate) * dt

INIT Elder_Inhabitant = 580118

INFLOWS:

Loosing_Fertility = Inhabitants_fertile/Time_to_Loose__Woman_Fertility

OUTFLOWS:

Death_Rate = Elder_Inhabitant/Time_to_die

Inhabitants_Fertile(t) = Inhabitants_Fertile(t - dt) + (maturation + Migration - Loosing_Fertility) * dt

INIT Inhabitants_Fertile = 320839

INFLOWS:

maturation = Young_Inhabitants/time_to_mature

Migration = 1500

OUTFLOWS:

Loosing_Fertility = Inhabitants_fertile/Time_to_Loose__Woman_Fertility

Young_Inhabitants(t) = Young_Inhabitants(t - dt) + (Birth_rate - maturation) * dt

INIT Young_Inhabitants = 295140

INFLOWS:

Birth_rate = (Total_fertility_rate_Arg/Time_to_Loose__Woman_Fertility)*Fertile_womans

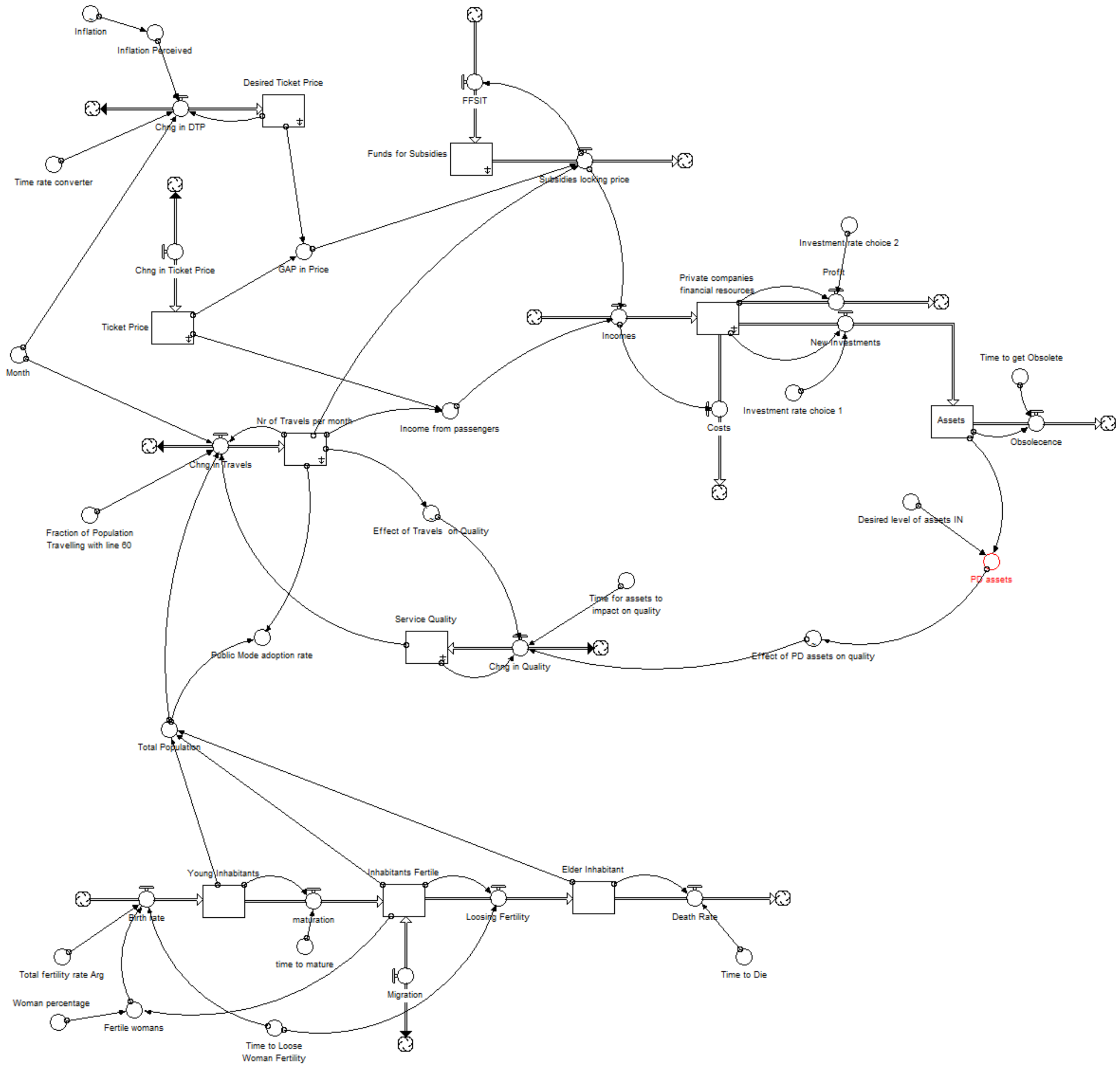
OUTFLOWS:

maturation = Young_Inhabitants/time_to_mature

Desired_level_of_assets_IN = 222300000

Effect_of_Travels__on_Quality = GRAPH(Nr_of_Travels_per_month)
(0.00, 0.273), (560000, 0.213), (1.1e+006, 0.116), (1.7e+006, 0.0787), (2.2e+006, 0.0487), (2.8e+006, 0.00), (3.4e+006, -0.0861), (3.9e+006, -0.116), (4.5e+006, -0.146), (5e+006, -0.169), (5.6e+006, -0.213)
Fertile_womans = Inhabitants_fertile*Woman_percentage
Fraction_of_Population_Travelling_with_line_60 = 2.35
GAP_in_Price = Desired_Ticket_Price-Ticket_Price
Income_from_passengers = Ticket_Price*Nr_of_Travels_per_month
Inflation = GRAPH(TIME)
(1.00, 0.00), (12.9, 0.00), (24.8, 25.9), (36.8, 13.4), (48.7, 4.42), (60.6, 9.64), (72.5, 10.9), (84.5, 0.39), (96.4, 8.46), (108, 6.27), (120, 10.5), (132, 9.80), (144, 10.0), (156, 10.6)
Inflation_Perceived = DELAYN(Inflation/100,24,2,Inflation)
Investment_rate_choice_1 = 0.05
Investment_rate_choice_2 = 0.95
Month = 1
PD_assets = Assets/Desired_level_of_assets_IN
Public_Mode_adoption_rate = Nr_of_Travels_per_month/Total_Population
Time_for_assets_to_impact_on_quality = 24
Time_rate_converter = 12
Time_to_Die = 150.12
Time_to_get_Obsolete = 180
Time_to_Loose__Woman_Fertility = 252
time_to_mature = 168
Total_fertility_rate_Arg = 2.25
Total_Population = Young_Inhabitants+Inhabitants_Fertile+Elder_Inhabitant
Woman_percentage = 0.5211

Buenos Aires' model structure with no policies


Inflation
Inflation Perceived
Desired Ticket Price
Chng in DTP
Time rate converter
FFSIT
Funds for Subsidies
Subsidies locking price
Chng in Ticket Price
GAP in Price
Ticket Price
Month
Investment rate choice 2
Private companies
financial resources
Profit
Incomes
New investments
Time to get Obsolete
Nr of Travels per month
Income from passengers
Costs
Investment rate choice 1
Assets
Obsolescence
Chng in Travels
Fraction of Population
Travelling with line 60
Effect of Travels on Quality
Desired level of assets IN
PD assets
Time for assets to
impact on quality
Service Quality
Public Mode adoption rate
Chng in Quality
Effect of PD assets on quality
Total Population
Young Inhabitants
Inhabitants Fertile
Elder Inhabitant
Birth rate
maturation
Loosing Fertility
Death Rate
time to mature
Total fertility rate Arg
Migration
Time to Die
Woman percentage
Fertile womans
Time to Loose
Woman Fertility

Buenos Aires' model equation with policies

Desired_Ticket_Price(t) = Desired_Ticket_Price(t - dt) + (Chng_in_DTP) * dt
INIT Desired_Ticket_Price = 1
INFLOWS:
Chng_in_DTP = (Desired_Ticket_Price+(Desired_Ticket_Price)*Inflation_Perceived-Desired_Ticket_Price)/4.8*Month^Time_rate_converter
Funds_for_Subsidies(t) = Funds_for_Subsidies(t - dt) + (FFSIT - Subsidies_locking_price) * dt
INIT Funds_for_Subsidies = 5226.45
INFLOWS:
FFSIT = Subsidies_locking_price
OUTFLOWS:
Subsidies_locking_price = MIN (Nr_of_Travels_per_month*GAP_in_Price; 20000000)
Nr_of_Travels_per_month(t) = Nr_of_Travels_per_month(t - dt) + (Chng_in_Travels) * dt
INIT Nr_of_Travels_per_month = 2819437
INFLOWS:
Chng_in_Travels = (((Total_Population*Fraction_of_Population_Travelling_with_line_60)-Nr_of_Travels_per_month)/Month)*Service_Quality
Ticket_Price(t) = Ticket_Price(t - dt) + (Chng_in_Ticket_Price) * dt
INIT Ticket_Price = 1
INFLOWS:
Chng_in_Ticket_Price = IF TIME <156 THEN 0.015 ELSE 0
Assets(t) = Assets(t - dt) + (New_Investments - Obsolecence) * dt
INIT Assets = 222300000
INFLOWS:
New_Investments = IF Private_companies__financial_resources =0 THEN 0 ELSE IF TIME< 156 THEN Private_companies__financial_resources*Investment_rate_choice_1 ELSE IF PD_assets<1 THEN Assets/PD_assets/Time_to_make_investments ELSE 0
OUTFLOWS:
Obsolecence = Assets/Time_to_get_Obsolete
Desired_Asset_level(t) = Desired_Asset_level(t - dt) + (Chg_in_DAL) * dt
INIT Desired_Asset_level = 222300000

INFLOWS:

Chg_in_DAL = (Desired_Asset_level*Quality_PD-Desired_Asset_level)/Time_to_perceive__chg_in_quality

Elder_Inhabitant(t) = Elder_Inhabitant(t - dt) + (Loosing_Fertility - Death_Rate) * dt

INIT Elder_Inhabitant = 580118

INFLOWS:

Loosing_Fertility = Inhabitants_fertile/Time_to_Loose__Woman_Fertility

OUTFLOWS:

Death_Rate = Elder_Inhabitant/Time_to_die

Inhabitants_Fertile(t) = Inhabitants_Fertile(t - dt) + (maturation + Migration - Loosing_Fertility) * dt

INIT Inhabitants_Fertile = 320839

INFLOWS:

maturation = Young_Inhabitants/time_to_mature

Migration = 1500

OUTFLOWS:

Loosing_Fertility = Inhabitants_fertile/Time_to_Loose__Woman_Fertility

Private_companies__financial_resources(t) = Private_companies__financial_resources(t - dt) + (Net_Income - Profit - New_Investments) * dt

INIT Private_companies__financial_resources = 0

INFLOWS:

Net_Income = (Subsidies_locking_price+Income_from_passengers)-(Subsidies_locking_price+Income_from_passengers)*0.95

OUTFLOWS:

Profit = IF Private_companies__financial_resources =0 THEN 0 ELSE IF TIME<156 THEN Private_companies__financial_resources*Investment_rate_choice_2 ELSE IF PD_assets<1 THEN (Private_companies__financial_resources/Montlhy_converter)-New_Investments ELSE Private_companies__financial_resources/Montlhy_converter

New_Investments = IF Private_companies__financial_resources =0 THEN 0 ELSE IF TIME< 156 THEN Private_companies__financial_resources*Investment_rate_choice_1 ELSE IF PD_assets<1 THEN Assets/PD_assets/Time_to_make_investments ELSE 0

Service_Quality(t) = Service_Quality(t - dt) + (Chng_in_Quality) * dt

INIT Service_Quality = 1

INFLOWS:

Chng_in_Quality = ((Effect_of_asset_on_Quality+Effect_of_Travels__on_Quality)-Service_Quality)/Time_for_assets_to_impact_on_quality

Young_Inhabitants(t) = Young_Inhabitants(t - dt) + (Birth_rate - maturation) * dt

INIT Young_Inhabitants = 295140

INFLOWS:

Birth_rate = (Total_fertility_rate_Arg/Time_to_Loose__Woman_Fertility)*Fertile_womans

OUTFLOWS:

maturation = Young_Inhabitants/time_to_mature

Desired_level_of_assets_IN = 222300000

Effect_of_asset_on_Quality = GRAPH(PD_assets)

(0.00, 0.509), (0.2, 0.509), (0.4, 0.547), (0.6, 0.644), (0.8, 0.787), (1.00, 1.00), (1.20, 1.21), (1.40, 1.30), (1.60, 1.35), (1.80, 1.38), (2.00, 1.40)

Effect_of_Travels__on_Quality = GRAPH(Nr_of_Travels_per_month)

(0.00, 0.161), (560000, 0.124), (1.1e+006, 0.109), (1.7e+006, 0.0787), (2.2e+006, 0.0487), (2.8e+006, 0.0112), (3.4e+006, -0.0337), (3.9e+006, -0.0712), (4.5e+006, -0.0861), (5e+006, -0.109), (5.6e+006, -0.116)

Fertile_womans = Inhabitants_fertile*Woman_percentage

Fraction_of_Population_Travelling_with_line_60 = 2.35

GAP_in_Price = Desired_Ticket_Price-Ticket_Price

Income_from_passengers = Ticket_Price*Nr_of_Travels_per_month

Inflation = GRAPH(TIME)

(1.00, 0.00), (12.9, 0.00), (24.8, 25.9), (36.8, 13.4), (48.7, 4.42), (60.6, 9.64), (72.5, 10.9), (84.5, 0.39), (96.4, 8.46), (108, 6.27), (120, 10.5), (132, 9.80), (144, 10.0), (156, 10.6)

Inflation_Perceived = DELAYN(Inflation/100,24,2,Inflation)

Investment_rate_choice_1 = 0.05

Investment_rate_choice_2 = 0.95

Month = 1

Montlhy_converter = 1

PD_assets = IF TIME < 156 THEN Assets/Desired_level_of_assets_IN ELSE Assets/Desired_Asset_level

Public_Mode_adoption_rate = Nr_of_Travels_per_month/Total_Population

Quality_PD = Standard_Quality/(Service_Quality)

Standard_Quality = 1

Time_for_assets_to_impact_on_quality = 24

Time_rate_converter = 12

Time_to_Die = 150.12

Time_to_get_Obsolete = 180

Time_to_Loose__Woman_Fertility = 252

Time_to_make_investments = 36

time_to_mature = 168

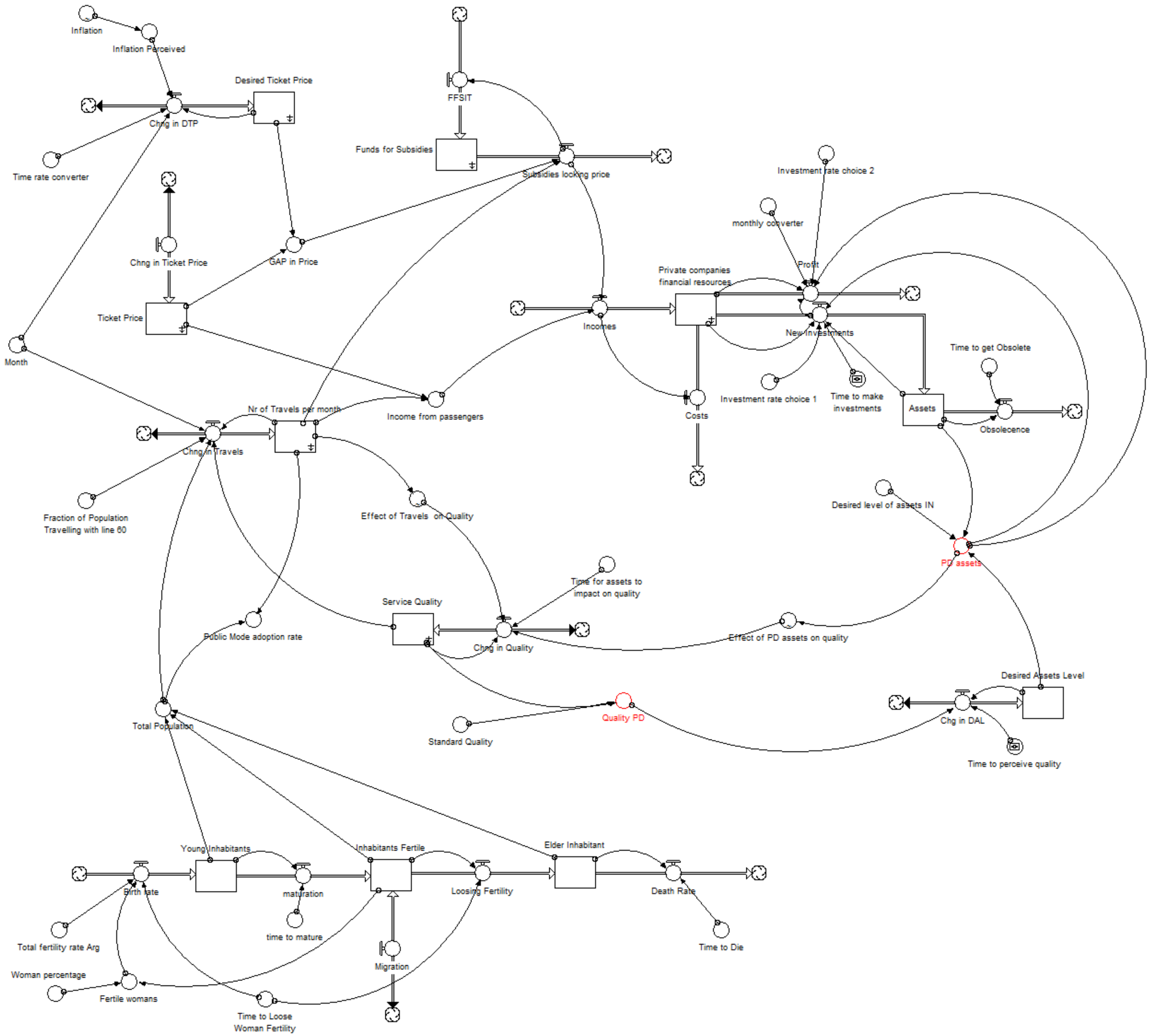
Time_to_perceive__chg_in_quality = 1000

Total_fertility_rate_Arg = 2.25

Total_Population = Young_Inhabitants+Inhabitants_Fertile+Elder_Inhabitant

Woman_percentage = 0.5211

Buenos Aires' model structure with policies:


Inflation
Inflation Perceived
Desired Ticket Price
Chng in DTP
Time rate converter
FFSIT
Funds for Subsidies
Subsidies locking price
Investment rate choice 2
monthly converter
Profit
Private companies financial resources
Chng in Ticket Price
GAP in Price
Ticket Price
Incomes
New investments
Time to get Obsolete
Month
Investment rate choice 1
Time to make investments
Assets
Costs
Obsolecence
Nr of Travels per month
Income from passengers
Chng in Travels
Fraction of Population Travelling with line 60
Effect of Travels on Quality
Desired level of assets IN
PD assets
Time for assets to impact on quality
Service Quality
Public Mode adoption rate
Chng in Quality
Effect of PD assets on quality
Desired Assets Level
Quality PD
Chg in DAL
Total Population
Standard Quality
Time to perceive quality
Young Inhabitants
Inhabitants Fertile
Elder Inhabitant
Birth rate
maturation
Loosing Fertility
Death Rate
time to mature
Migration
Total fertility rate Arg
Time to Die
Woman percentage
Fertile womans
Time to Loose Woman Fertility