

DOMINO EFFECT: STRATEGIC OPTIONS DEVELOPMENT AND ANALYSIS FOR THE BRAZILIAN RAILWAYS¹

Efeito dominó: desenvolvimento e análise de opções estratégicas para as ferrovias brasileiras

Ion Georgiou²

Resumo

Este artigo é baseado em um estudo preliminar cuja intenção é revelar parte da dinâmica envolvida no planejamento de um sistema ferroviário nacional no Brasil. As perspectivas publicadas de especialistas reconhecidos (atores) na indústria ferroviária brasileira foram mapeadas usando a metodologia de estruturação de problemas conhecida como Strategic Options Development and Analysis (SODA). Este artigo discute os seguintes resultados do modelo: a distribuição de decisões/construtos através de questões e atores; as causas principais e os objetivos do planejamento ferroviário; as decisões mais afetadas e as que mais afetam; as decisões dominantes e suas complexidades; e a identificação de um sistema de feedback degenerativo no coração da tomada de decisão ferroviária. De maneira geral, o artigo mostra que a situação enfrentada pelo desenvolvimento ferroviário no Brasil é constituída por uma interação dinâmica de problemas não-independentes, indicando a presença de um complexo sistema de problemas que requer uma estrutura conceitual que permita análise sem ignorar a integridade sistêmica. Como tal, o artigo serve como uma plataforma a partir da qual o uso adicional de SODA neste contexto poderia ser considerado.

Keywords: Brazil, railways, planning, strategic options development and analysis, problem structuring

Introduction

On 18 February 2008, the Brazilian company Vale announced that major client companies in Asia had accepted a 65% increase in the price of exported Brazilian iron ore (Folha Online, 2008a). The news was reported by international news agencies such as Bloomberg, Reuters, MarketWatch, and The Canadian Press. The price increase was justified due to rising worldwide demand for iron ore. Vale was reported by the Folha de São Paulo as also noting that the rise in foreseeable demand requires significant investment in the Brazilian railway system, as well as the ports it serves.

¹ Baseado na Conferência proferida no III Congresso Brasileiro e I Congresso Catarinense de Sistemas, realizado em Florianópolis (SC), de 24 a 25 de outubro de 2007.

² Escola de Administração de Empresas de São Paulo, Fundação Getúlio Vargas, Departamento de Informática e Métodos Quantitativos
E-mail: Phokion.Georgiou@fgv.br

Twelve days earlier, the Brazilian President, Luiz Inácio Lula da Silva, had sent a letter to Congress in which he reiterated the positive results expected from his national Plano de Aceleração do Crescimento (Accelerated Growth Plan) first announced in January 2007 (Folha Online, 2008b). According to the Plan, by 2010 R\$504 billion is to be invested in developing infrastructure. Of this amount, R\$7.8 billion is targeted at railway infrastructure development, for the construction or maintenance of 2,518 kilometers of track. Although a significant amount, it does not compare with the projected R\$33.4 billion targeted at the maintenance or construction of some 45,337 kilometers of road across the country (Governo Federal, 2007). Although evidence exists that road improvements have substantially higher returns than railway schemes (Affuso et al., 2003), it is by no means universally conclusive (Fremdling, 1977) - but it might explain the country's continuing reluctance to bet on the railways.

Back in 2005, President Lula had announced that 2005 and 2006 would be the years for rail in Brazil (Briginshaw, 2005). With a legacy of governments favoring road transport, this prediction proved somewhat of an overstatement. In an article updated on 7 February 2008, Wikipedia ranks Brazil as having the world's 11th largest railway (this assumes that the European Union is considered as one entity) (Wikipedia, 2008). The country, with only 29,000 kilometers of track, is placed behind Argentina and, unsurprisingly perhaps, Japan. Given that Brazil is the fifth largest country in the world, the size of its railway network remains embarrassingly disproportional. Given, furthermore, its booming (and foreseeable robust) economy, reported even in local newspapers across the globe (Clendenning and Lehman, 2008), there is no doubt that the sky is the limit for railway development in Brazil.

The history of railway development in Brazil is well-documented (Ferreira, 1959; Campos, 2001; Estache et al., 2001; Summerhill, 2003; Gerodetti and Cornejo, 2005). Its adherents claim that what is missing is a railway development plan on a national scale (ANTF, 2007; Garrido, 2006, Fleury, 2006). The 2,518 kilometers proposed in Brazil's Accelerated Growth Plan appear disproportional to the geographical scale of the country, and its powerhouse potential. So the question arises: from where does one begin to plan for national railway development in a country of continental proportions such as Brazil? The parameters for development are easily summarized: privatized railway companies engaged in cargo transportation operating on a government-controlled track system, with little interest in developing a national passenger railway system. The basic challenge is to provide a railway network that matches the country's size and the geographical expanse of its agro-industrial centers and, as such, one that matches its economic reality and potential.

This paper is based on a preliminary study intended to uncover some of the dynamics involved in planning for a national Brazilian railway system. Given that railway development brings infrastructural, political, social, economic, and even cultural repercussions (Gough and Evans, 2003; Carpenter, 1994), and, furthermore, given that the study was undertaken over a brief six-month period,

the paper does not pretend to offer a comprehensive view. A comparison with railway development in other, similarly proportioned countries was considered. That, however, would invite the rather superficial ‘it worked there, it could here’ approach. Instead, a holistic approach to limited information under time constraints was desired, information from national sources addressing the national railway concerns.

There was no opportunity to arrange interviews with major players of the Brazilian railway industry, nor to attend conferences or meetings where Brazilian railway development might be discussed. Raw material was sought in documents that address the contemporary challenges faced by Brazilian railways. Time constraints (as well as foreseeable analytical challenges) required that the documents to be consulted should not be spread thinly across a spectrum of publications. A local and homogenous source was desired that simultaneously offered a healthy mix of conflicting points of view from recognized experts in the field.

Fortunately, in Brazil there exists an independent, reliable source of information on the railway industry: the *Revista Ferroviária* (see www.revistaferroviaria.com.br/). It is interesting to note that the *Revista Ferroviária* has been in circulation ever since 1940. No other privately published Brazilian monthly magazine has been in circulation longer. A fixture in each issue is an article, written by an acknowledged authority, which reports on a specific challenge facing the industry. The collection of these articles over the years reads like a history of past and present problems and opportunities facing the Brazilian railways. Readily available and authoritative in nature, these articles meet the information requirements of the investigation reported in this paper.

Time constraints, coupled with the desire to maintain a contemporary focus, led to the consultation of thirty-six of these articles, covering the years 2004-2007. An initial reading identified seventeen articles as providing original, interesting, and potentially fruitful information for the purposes of the research. Of these, twelve were finally selected based upon a second reading and some preliminary analysis designed to discard those articles that included unwanted repetition, heavy focus on advertising successes rather than tackling problems, and regional or industrial concentration (for example, articles focused on the Rio de Janeiro metro system, a topic deemed too specialized for the national focus of the research). Table 1 lists the article references.

de Lima (2006)	Dreckmann (2006)	Fernandes (2006)
Neves (2005)	da Silveira (2006)	Passos (2006)
Bollinger (2004)	Vilaça (2005, 2006)	Steinbruch (2007)
Reis (2004)	Hees (2005)	

Table 1: *Revista Ferroviária* articles used in the research

The authors are recognized authorities in the Brazilian railway industry. They include consultants, engineers, directors of associations related to, or entities

that speak for, the Brazilian railway industry, railway concession directors, politicians with transport portfolios, industrial clients of the railways, and academics. Henceforth, they will be referred to as actors, and the term *stakeholders* will be used to refer to the wider groups involved in railway decision making.

Methodology

Each actor addresses a number of issues, presenting his perception of the situation through a concise argument. What was required was a methodology that could model the actor's perceptions using his own language and line of argument. Perceptions are cognitive views of a situation. As such, cognitive mapping was a logical methodological approach to follow.

The usefulness of cognitive mapping has gained currency during the last twenty years (Bryant, 1984; Langfield-Smith, 1992; Fiol, 1992; Kitchin, 1994; Nicolini, 1999; Daniels and Johnson, 2002; Tegarden and Sheetz, 2003). A number of variants exist. Social science methodology, in conjunction with information visualization, has put forward Concept Mapping (Kane and Trochim, 2007). The Florida University System, in the state of Florida, incorporates the Institute for Human and Machine Cognition which has devised, and made freely available, the *Cmap tools* program that 'empowers users to construct, navigate, share and criticize knowledge models represented as concept maps' (see <http://www.ihmc.us/>). A string of mind mapping gurus have emerged, the most famous being Tony Buzan, the self-proclaimed 'inventor of mind mapping' (Buzan, 2002; see also <http://www.imindmap.com>). Furthermore, no matter whether one calls them concept maps, cognitive maps, or mind maps, particular structures have spawned spidergrams, bubble diagrams, logic diagrams, and tree diagrams (to name but a few). Clearly, cognitive mapping is a flourishing industry, one that is driven by a market demand for such tools.

Operational research offers its own version of cognitive mapping: Strategic Options Development and Analysis, or SODA (Eden, 1988, 2004; Eden and Sims, 1981; Eden and Huxham, 1988). Although mainly applied in group decision making situations, it has also been applied to the analysis of documents (Cossette, 2002; Klein and Cooper, 1982). What differentiates SODA from other cognitive mapping approaches is its basis in George Kelly's (1955/1991, 1963, 1970) psychological theory of personal constructs. Although SODA does not pretend to appropriate Kelly's theory *en masse*, it does borrow two key ideas: one procedural, and one theoretical.

Procedure of bipolar construct design

Procedurally, SODA insists upon the creation of a bipolar construct for each element of an actor's argument. In order to understand the constitution and usefulness of bipolar constructs, consider a basic example of sense-making with reference to contemporary events: the war in Iraq. In particular, consider the decision of whether we invade Iraq or not – where *we* is loosely understood for the present purposes.

A bipolar construct for this decision is *invade Iraq... not*, where the three dots separate the two poles of the construct, and the second pole abbreviates the decision *not to invade*. The problem is that this construct is rather superficial. It immediately raises questions of motives, reasons, pressures that might be acting upon the decision itself. Why should we invade Iraq? So what if we invade Iraq? And, more pertinently, what would be the alternative to invading Iraq (invade Iraq instead of doing what?). Procedurally, the task is to make this reason explicit within the confines of a bipolar construct, and thus shed some light on the first pole. Consider a number of alternatives for the secondary pole. They are given in Table 2 with notes explaining how each alternative serves to explain the decision to invade Iraq.

Table 2 identifies only some reasons for the invasion: ideological, philosophical, political, economic, tactical, strategic, as well as reasons to do with pressure from lobbyists and costs of pursuing research and development. Of course, they are not mutually exclusive and any combination might serve as an explanatory apparatus. For any one primary pole, however, only one alternative pole is sought from an actor. Multiple secondary poles require their subdivision into multiple bipolar constructs. This renders contrast construction a nontrivial process.

What primarily differentiates SODA from other cognitive mapping approaches is its adherence to bipolar construct design, an adherence that enables a richer description of a situation than might otherwise be the case. Concept Mapping (Kane and Trochim, 2007), for example, would focus only on the idea *invade Iraq*, which would rekindle the question of motives, the so-what of the decision, and the inability to trace alternatives through secondary poles. Bipolar construct design also requires two types of links (or arrows). An unsigned link between two constructs indicates that their respective primary or secondary poles are to be read in order, from the arrow's tail to the arrow's head. An arrow signed with a negative symbol indicates that, at that point, one must switch poles when following the argument along the link.

	<u>First pole invade Iraq...</u>	<u>Possible explanatory inferences from bipolar construct</u>
Possible second poles	... remain indifferent to dictators	We invade because we will no longer remain indifferent to dictators.
	... allow democracy to flourish in its own time	We invade because democracy is desired by every rational human being and can therefore be precipitated.
	... do not support the armaments industry	We invade because we either yield to the armaments lobby or because the armaments industry provides much needed jobs.
	... question the electoral advantage of wars	We invade because wars, more often than not, help win elections.
	... unite the allies in war against terrorism	We invade because we prefer unilateral action rather than seek the consensus of our allies in the war against terrorism.
	... pursue alternative sources of energy	We invade because it allows us access to oil, thus saving us the costly pursuit of alternative energies.
	... pursue diplomatic channels	We invade because diplomatic channels do not serve our interests.
	... focus on Afghanistan	We invade in order to fight the enemy on all fronts.
... invade North Korea (or Palestinian Territories, or Iran, or some other country/region)	We invade because other candidates for invasion are less threatening.	

Table 2: Possible bipolar constructs for the decision to invade Iraq

Theoretical Approach of SODA

George Kelly's theory is highly developed, so much so that there exist international journals, such as the *International Journal of Personal Construct Psychology*, dedicated singularly to his psychological approach. As the title of his theory indicates, Kelly's central theme is the manner in which human beings understand the world through mental *constructs*.

George Kelly was interested in uncovering the meaning behind what we say so as to minimize ambiguity. He noted that problems tended to be analyzed or interpreted according to the type of analyst one consulted. So, for example, if you took your problem to a Freudian analyst, it would be structured and analyzed according to Freudian principles. The same would be expected in the case of a Jungian. A Behaviorist, in turn, would most probably analyze the situation and draw conclusions in terms of conditioning. All of this implies that the frame of reference of the analyst delimits what is perceived, how it is described, and what the ultimate prescription might be. Kelly's objective was to

devise a theory, coupled with an analytical technique, which would remove (as far as possible) the analyst's frame of reference, and so undertake problem description and resolution from the client's point of view. This implies a significant change in the role of the analyst. Where once the analyst was seen as some type of specialist in the contents of the mind, s/he would now be appreciated more as a process facilitator specializing in structuring the client's thoughts as the client sees them. This view of analysis and of the role of the analyst underpins SODA; what the client needs is help in structuring complex perceptions so that the client him/herself can then resolve the problem using this structure.

Kelly developed a number of intricate analytical tools for his theory, the most famous of which is the repertory grid (Fransella et al., 2004; Jankowicz, 2004). SODA does not use such tools (Eden and Jones, 1984). The maps designed through SODA, however, are models whose essential structure is that of a graph (nodes and links) or, more exactly, a directed graph (also known as a digraph) (Cartwright et al., 1965). As such, SODA maps are amenable to the powerful analytical tools of digraph theory (Langfield-Smith & Wirth, 1992; Montibeller & Belton, 2006; Wang, 1996; Eden et al., 1992). In summary, therefore, SODA offers a qualitative, bipolar structuring approach to complex situations that is amenable to quantitative analysis.

Mapping the Railways

Model Overview

The situation faced by railway development in Brazil is constituted by a dynamic interaction of non-independent problems, indicating the presence of a complex problem-system requiring conceptual structure in a manner that permits analysis without ignoring systemic integrity (Ackoff, 1979). It is thus ripe for the application of problem structuring methods, as provided by operational research (Rosenhead and Mingers, 2001), of which one is SODA. A total of 98 constructs were uncovered in the twelve articles used for the research. The constructs were categorized according to ten issues (henceforth identified by **bold font**) that emerged from the reading. Table 3 shows the ten issues, the number of constructs categorized in each issue, the number of constructs in each issue that were addressed by each actor, and the total number of actors that addressed each issue.

Railway planning and development, in other words, addresses not only interrelated perceptions from relevant stakeholders representing various interests, but also interrelated issues impacting upon such development. The names of issues are, in the main, self-explanatory. **Governo**, for example, incorporates the 22 constructs that point to perceptions, facts, or decisions that have to do with the government. Eight constructs were seen as addressing consequences of national significance. These were grouped under the issue **Consequência**.

Table 3 also allows us to identify the top issues which, according to this group of actors, face the Brazilian railways. If we focus upon the number of

constructs in each issue, the top three issues in order are the role of the government (**Governo**, with 22 constructs), the challenges facing the railway concessions (**Concessionárias**, with 14 constructs), and the maintenance and modernization of the track system (**Malha**, with 11 constructs). If we focus upon the number of actors addressing each issue, we find that **Governo** again tops the list, with 9 of the 11 actors addressing this issue in some manner. In joint second place are **Concessionárias** and the requirements of/for intermodal transport choices (**Intermodalidade**) – with 7 actors addressing each issue. Taken together, the top issues indicate that Brazilian railway development depends strongly upon: (1) an effective governmental role; (2) the ability of the concessions to meet market demand whilst working closely with the government; (3) the development of a national intermodal transport infrastructure; and, (4) the maintenance and modernization of the railway track system. It is worth noting that these priority issues reflect the opinion of international railway development experts, who recommend a mix of light governmental regulation, line-of-business concession awards, and intermodal and intramodal competition (Moyer & Thompson, 1992).

Issue	per issue	Number of Constructs addressed by each actor										Total actors	
		Neves	DeLima	Dreckmann	DaSilveira	Vilaça	Hees	Fernandes	Passos	Steinbruch	Bollinger		Reis
Concessionarias	14	3	6	0	0	2	1	0	2	2	6	0	7
Consequencia	8	0	0	3	4	1	0	0	0	0	0	1	4
Governo	22	1	4	1	2	11	0	5	4	3	0	1	9
Intermodalidade	8	2	0	4	3	3	1	0	0	2	2	0	7
Logistica	6	4	0	0	1	1	0	0	0	0	3	1	5
Malha	11	6	0	0	0	0	0	1	2	0	2	6	5
Manutenção	9	1	1	0	0	0	0	0	0	0	8	0	3
Portos	4	0	0	2	0	0	0	0	1	0	0	2	3
Trans Rodoviario	6	0	0	4	3	4	0	0	0	0	0	0	3
Urbano	10	1	0	0	0	0	0	1	1	0	0	9	4
Total constructs	98	18	11	14	13	22	2	7	10	7	21	20	

Table 3: Issue categories, and breakdown of all constructs

The 98 constructs were modeled by first mapping each individual article and then merging them into one group model called *the merged map*, upon which all ensuing analyses were based. All mapping and most analyses were undertaken with the support of Decision Explorer® software designed especially for SODA (see www.banxia.com). The model yielded the summary results shown in Table 4.

Number of constructs of particular type per issue					
Issue	Tails	Heads	Imploding	Exploding	Dominant
Governo	14	0	3	1	4
Concessionarias	2	3	3	4	5
Intermodalidade	2	1	3	2	2
Logistica	1	1	1	0	1
Malha	3	0	1	3	3
Consequencia	0	2	0	0	0
Urbano	6	1	1	0	1
Manutenção	5	0	1	1	1
Portos	3	0	0	0	0
Trans Rodoviario	1	1	0	1	1
Totals	37	9	13	12	18

Tails have no constructs leading into them; their indegree is 0. They are otherwise known as prime causes.

Heads have no constructs leading out of them; their outdegree is 0. They are otherwise known as objectives.

Implosions are constructs with a relatively high number of constructs leading into them; they have a relatively high indegree. Indegrees in the merged map ranged from 0 to 11. The criterion used here was indegree ≥ 3 .

Explosions are constructs with a relatively high number of constructs leading out of them; they have a relatively high outdegree. Outdegrees in the merged map ranged from 0 to 6. The criterion used here was outdegree ≥ 3 .

Dominants are constructs with a relatively high total number of constructs leading into them and leading out of them; they have a relatively high degree (sum of indegrees and outdegrees). Degrees in the merged map ranged from 1 to 13. The criterion used here was degree ≥ 5 .

Table 4: Number of constructs of particular type per issue, with explanatory notes

Table 4 allows us to uncover the following basic characteristics about the situation faced by the Brazilian railways (In what follows, italicized numbers in brackets indicate the construct number on the merged map. Appendices 1 and 2 provide the list of constructs and the merged map, respectively):

Tails

The distribution of tails shows that there is no single prime cause or trigger to railway development. The government's fourteen tails, however, indicate that it is a crucial initiator – as in all national railway development projects. The model revealed that the government can promote developmental effectiveness by:

- Developing and promoting investment conduits (97, 106);
- Promoting the correct use of resources from taxes (92, 105), whilst reconsidering taxes or penalties that work against the developmental ideal (99, 98); and,
- Managing corporate or otherwise regional interests in favor of the national or wider betterment (101).

On the other end of the scale, the seemingly small contribution afforded by road transport management (**Trans-Rodoviário**) hides a complex of variables. Dreckmann (2006), for example, highlighted the need to reduce costs embedded in road maintenance (63), particularly policing, emergency services, traffic engineering, pollution and accident management. These increase in proportion to the demands placed upon the road system. As long as such demands are allowed to increase, due to the lack of alternative transport modes such as railways, the road transport sector will continue to drain infrastructure funds away from railway development objectives. Here is a clear signal that national and regional planning must incorporate alternative transportation modes simultaneously, a perception echoed in the two tails assigned to the intermodal issue (**Intermodalidade**).

Clearly, a multitude of agencies is involved in triggering national railway development, and the model especially highlights urban planners (**Urbano**, 6 tails) and those responsible for the system's maintenance (**Manutenção**, 5 tails). Interestingly, urban planning and maintenance were treated in-depth by only two actors, Reis(2004) and Bollinger (2004), respectively. The urban planning issue is discussed with reference to rail cargo converging upon major cities, whilst the discussion of maintenance highlights the paucity of attention paid to this issue as a prime variable in operating an effective railway system. Basically, railway development will continue to be detrimentally affected as long as there continue to be improper urban rail facilities and rights of way (i.e. railway tracks), and as long as the industry lacks a systematic and methodological approach to maintenance.

Heads

The concessions (**Concessionárias**) account for one third of the objectives, reflecting that railway development cannot ignore their role. However, there are a couple of surprising results regarding the concessions. One objective in the model (20) calls for the railway concessions to not only run their businesses, but to equally act as caretakers of the system. It is desirable, in other words, for railway planning to meet commercial as well as caretaking interests, and to

delegate the management of such interests to the concessions. Similarly, another objective (108) highlights the government policy that the concessions continue to operate with lease agreements from the government, including the use of leased assets subject to non-prejudicial recall. In other words, the concessions are in the seemingly paradoxical position of running commercial businesses as well as acting in the national interest, and all this with assets that belong not to them but to the government. From a purely commercial point of view, this is a precarious situation for any railway director. Given, however, the impact of railways upon society, it is arguably quite a realistic configuration.

The other objectives in the model reflect a healthy mix of issues. An increasing role for trains in intermodal transport is desired (72). A disturbing trend must be reversed, namely that the railways are losing in the long-distance market, the very market where they should be dominating (24). The lack of a cohesive nationwide network is probably the major culprit in this case, with the result that logistics lag behind any appreciable satisfactory level (24). Related to this is the continuing tendency – or, due to lack of alternatives, obligation - to use road transport, resulting in the seemingly endless queue of trucks perceptible at any port or transit point (59). The model uncovered this latter fact as being the product of multiple feedback loops, making the problem particularly challenging. Feedback dynamics will be discussed shortly.

Implosions

Although the government, the concessions, and the issue of intermodality between them account for 9 of the 13 significantly imploding constructs, one particularly significant construct emerged from the analysis. Construct 112 (**Concessionárias**) has the highest indegree in the entire model: 11 constructs lead into it. It refers to the provision of a smooth, continuous service and the variables that impact upon this issue. Undoubtedly, quality service provision depends upon numerous variables in any situation. The question is: which ones? Figure 1 highlights the relevant area of the model, demonstrating the value of SODA mapping in making explicit what might otherwise pass unseen.

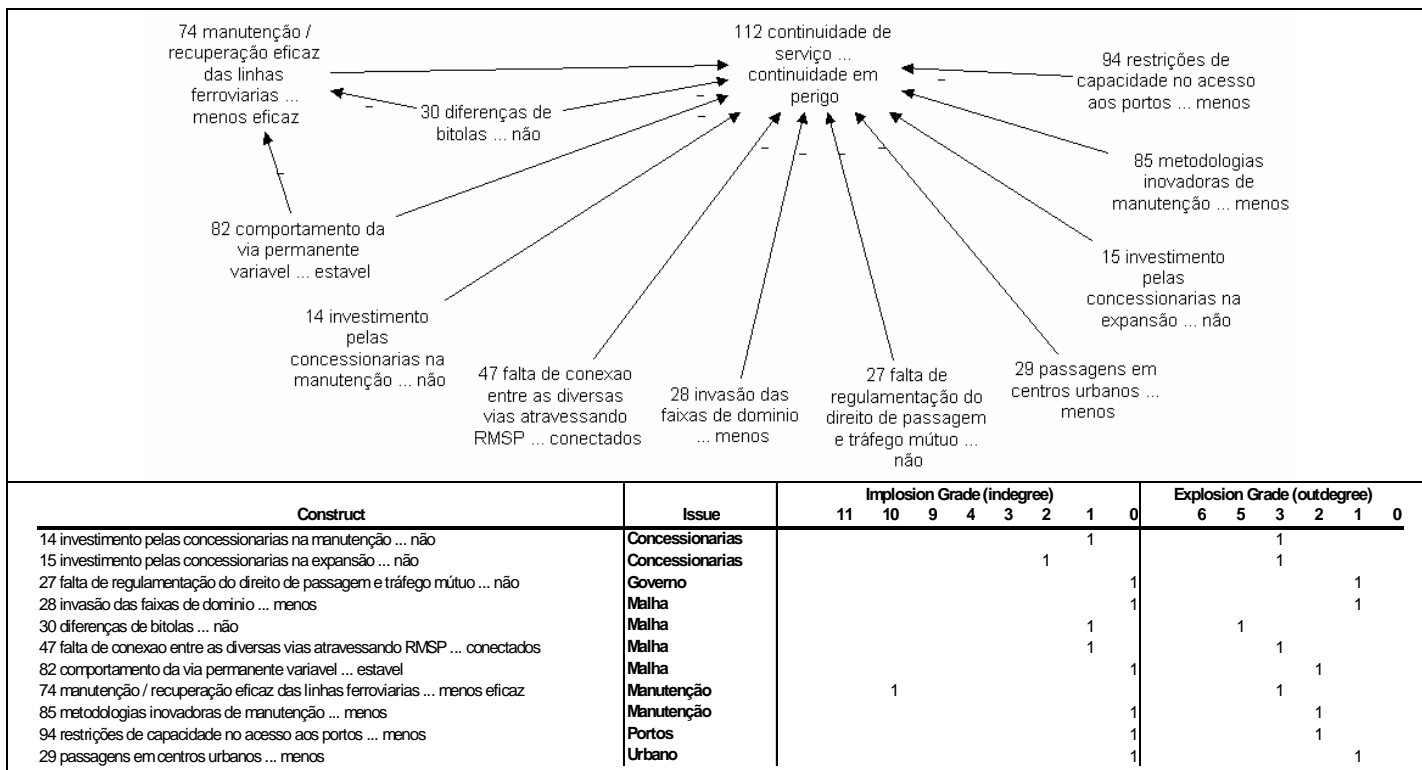


Figure 1: The constructs affecting 112, with supplementary data

Four out of the eleven affecting constructs concern the track system (**Malha**), making this the single most important issue in the provision of quality service. The track system suffers from illegal or dangerous trespassing (28), differences in gauge (30), lack of connectivity between the various tracks converging upon the metropolitan region of São Paulo (47), and variable operational quality of the track system itself (82). The remaining constructs indicate that part of the solution depends on state legislature (27), on investments in expansion and maintenance (14, 15, 74, 85), and on serious redesign of ports and urban areas (94, 29). In brief, quality service provision will require multi-agency planning that involves government (legislature, track system), the concessions (investments in expansion and maintenance), the port authorities, and urban planners.

Explosions

Similar to the analysis of implosions, an especially significant – and, arguably, polemical - exploding construct was identified in the model: construct 92, concerning the alleged misappropriation, by the government, of the Contribuição de Intervenção no Domínio Econômico (CIDE). Details are described by Fernandes (2006) as follows: “CIDE é um imposto, instituído pela Lei Federal 10.336, de dezembro/2001, com o objetivo de unificar a tributação sobre os combustíveis e financiar programas de infra-estrutura de transportes (incluindo rodovias, bem como ferrovias, metrô e outros meios de transporte público de passageiros) e projetos ambientais relacionados com a indústria do petróleo e do gás”. Fernandes goes on to point out: “Apesar dos seus quatro anos e meio de existência, a CIDE é conhecida por poucos, mas muitas pessoas pagam esse imposto. Cada vez que abastecemos nossos carros, estamos contribuindo para a CIDE. Só para se ter uma idéia, se o veículo for movido a gasolina, pagamos R\$ 0,28 por litro. Ao encher o tanque com 40 litros, injetamos um total de R\$ 11,20 nesse imposto. Entre 2002 e 2004, a soma de todas as contribuições para a CIDE resultou em cerca de R\$ 22 bilhões aos cofres da União”.

The ‘desvios’ referred to in construct 92 include, according to the author: “geração de superávit primário... outros tipos de desvios foram detectados. O levantamento do Sistema Integrado de Administração Financeira (Siafi) constatou que o governo federal destinou recursos da CIDE para despesas de custeio e pessoal. O trabalho acusou, por exemplo, o uso desse imposto para pagamento de assinatura de TV a cabo, serviços de segurança e planos de saúde de servidores públicos”.

Construct 92 is a divergent construct: its high outdegree indicates that it affects various areas of the map. Any discussion about misappropriation of public money will inevitably point to multiple and collateral effects. As with the provision of quality service, earlier, the question is not whether such effects exist. The question is, rather: what exactly is affected?

The impact of construct 92 can be best appreciated in levels. Figure 2 shows the first level of impact, in other words, those constructs directly affected by the misappropriation of funds.

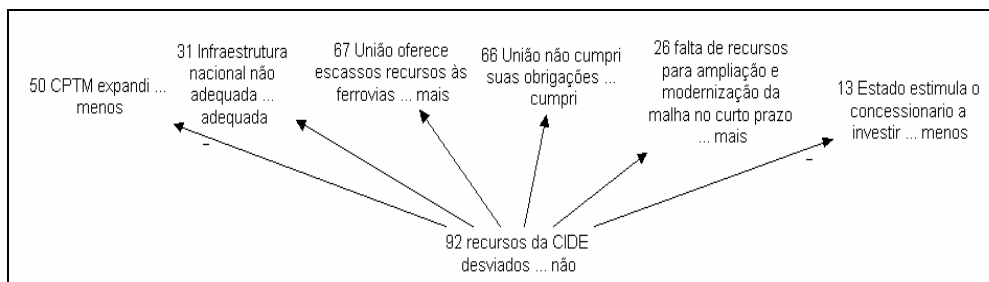


Figure 2: Constructs directly affected by construct 92 - recursos da CIDE desviados... não

What is striking about this first level of impact is that four out of the six directly affected constructs are government-related (**Governo**) constructs. The misappropriation of CIDE affects the government's ability to provide adequate national infrastructure (31) and sufficient resources to the railway concessions (67). It also contributes to the government being unable to meet its obligations (obligations agreed under contract with the concessions) (66), and results in the government being unable to provide sufficient stimuli to the concessions so that they may be encouraged to invest (13). These are four basic decision areas within government that affect railway development, and all of them are to some degree affected by the government's own misappropriation of CIDE. In addition, the expansion of the CPTM regional passenger railway system of São Paulo is affected (50), as well as the ability to expand and modernize the track system in the short term (26).

This mapping of the directly affected constructs enables stakeholders to easily identify the fundamental pressure points resulting from the misappropriation of CIDE. The direct benefits to the government of correcting the misappropriation would include: the ability to support an effective infrastructure development plan; the ability to meet its obligations and thus demonstrate commitment; and, the ability to materially assist the railway concessions and, by association, the growth of the railway system itself.

The second level of impact of construct 92 begins to enrich one's appreciation of the negative effects of misappropriating public funds. It is shown in Figure 3.

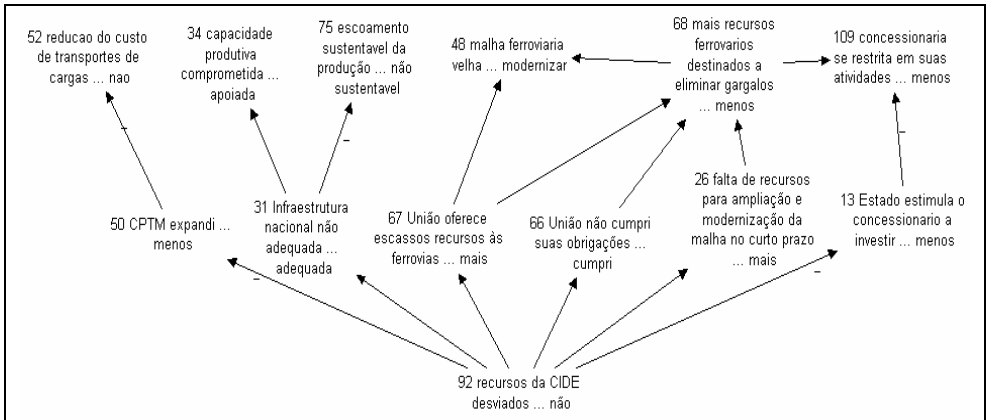


Figure 3: Second level impact of construct 92 - recursos da CIDE desviados... não

Here we begin to see additional issues being affected: **logistics** (52), national **consequences** (34, 75), and the **concessions** themselves (68, 109). The national consequences are appreciably obvious. We begin to see, however, that a combination of factors (67, 66, 26) lead to the concessions having to use more and more of their own resources to eliminate bottlenecks in the system (68). The government's own paralysis, due its alleged misappropriation practices, reduces the potential of the concessions, and thus of the system as a whole. As a result, the concessions are unduly restricted in what they can do to further the development of the system (109), and the track – the basic infrastructure upon which the system must run – remains decrepit. The consequences of construct 92, in other words, are gradually getting more serious.

One surprise at this second level is that misappropriation of CIDE leads to a reduction in the costs of cargo transport (52). Here we have a case that illustrates how carefully maps must be interpreted. The result is not as it first appears to be. What actually happens is that misappropriation of CIDE (92) reduces the ability of the CPTM to expand (50). A stagnant or diminishing CPTM will then allow a reduction in the cost of rail cargo transportation (52). Reis (2004) argues in his article that, were the CPTM to expand, it would encroach upon space that could be used for rail cargo transport. In this sense, the cost of rail cargo would increase as the railways seek new, more restrictive solutions for track. It stands to reason, therefore, that if fewer CIDE funds are made available to the CPTM, the cargo railways can benefit. Of course, in reality, neither the railways nor the CPTM benefit from the misappropriation of public money. The sequence 92-50-52 is more about how CPTM expansion can be played against the rail cargo concessions, than it is about any inherent 'benefits' of federal misappropriations. The railways benefit only because of the

limitations imposed upon the CPTM; they cannot be read as benefiting indirectly from a misappropriation of public funds. The correct interpretation would be as follows: misappropriation of funding reduces the ability of the CPTM to expand; a stagnant or diminished CPTM enables the railways to expand their right of way into zones that would otherwise be reserved for CPTM expansion; an expansion of this sort by the railways would eventually enable them to reduce the cost of cargo transport.

The third level of impact arising from the misappropriation of CIDE introduces effects on **intermodal** transport. This is shown in Figure 4.

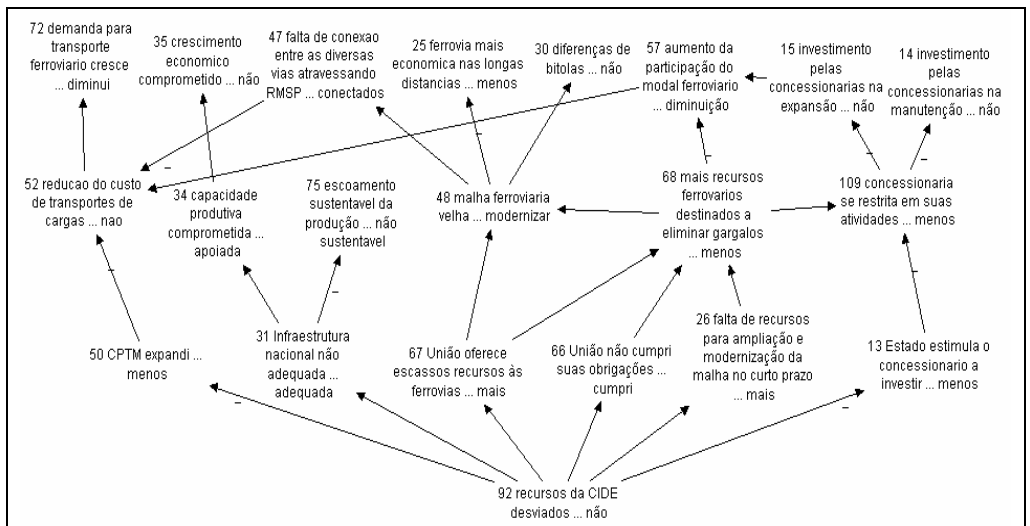


Figure 4: Third level impact of construct 92 - recursos da CIDE desviados... não

Intermodal transportation implies the participation of, as well as demand for, the railways. Constructs 72 and 57 address these issues. As can be seen by following the argument through the arrows, however, the misappropriation of CIDE inhibits such participation and demand. Indeed, if the government is keen to promote intermodal infrastructure - as it has been saying at least since 2003 (Folha Online, 2003) - it seems to be shooting itself in the foot through one singular questionable practice: the misappropriation of public money collected exactly for the purpose of constructing an effective intermodal system.

By the time we reach the fourth level of impact, shown in Figure 5, additional issues are introduced: **maintenance** (17, 74) and **road transport** (65). Note how construct 30 explodes, demonstrating the undesirable effects of maintaining varying gauges. Note, also, how the government practice of misappropriation results in a shorter utility life of railway equipment (17), thus exacerbating the potential for railway development. Ultimately, we find that the

nation's dependence on trucking is reinforced (65), and indeed increased – the very result one seeks to combat through railway development.

In brief, Figure 5 makes explicit an exact chain of events stemming from a seriously questionable governmental practice. Note that, so far, construct 92 has affected thirty-one other constructs, or one third of all the decisions mapped in the whole model. The figure could be extended until all heads are included in the map. Indeed, upon analysis, construct 92 detrimentally affects eight of the nine objectives of the model (see Table 5). Moreover, no other primary cause is responsible for a higher percentage of paths to each of the eight objectives. This makes the misappropriation of public money the single most significant negative cause in meeting railway development objectives. No doubt, the seriousness of alleged government malpractice is now well appreciated, and interested parties are tangibly better informed than before.

All Objectives (Heads)	Total number of Tail-to-Head paths	Primary cause	Number of paths from primary cause	%age of paths from primary cause
72 demanda para transporte ferroviário cresce ... diminui	1372	92 recursos da CIDE desviados ... não	273	19,9%
54 resolver problema de transposicao da RVMSP ... não	207	93 recursos da CIDE desviados ... não	29	14,0%
36 qualidade de vida da população comprometida ... não	149	94 recursos da CIDE desviados ... não	40	26,8%
75 escoamento sustentável da produção ... não sustentável	80	95 recursos da CIDE desviados ... não	24	30,0%
113 operação logística ajustada às necessidades e particularidades do cliente ... não	72	96 recursos da CIDE desviados ... não	21	29,2%
20 atenção em gestão patrimonial ... foco só em andar trens ou produzir resultados	72	97 recursos da CIDE desviados ... não	8	11,1%
24 ferrovias perdem mercado da longa distancia ... ganham	69	98 recursos da CIDE desviados ... não	6	8,7%
59 diminuição de filas de caminhões ... aumento	69	99 recursos da CIDE desviados ... não	14	20,3%

Table 5: The impact of construct 92 on 8 objectives, showing the detrimental effects in bold, and data for comparing the number of paths

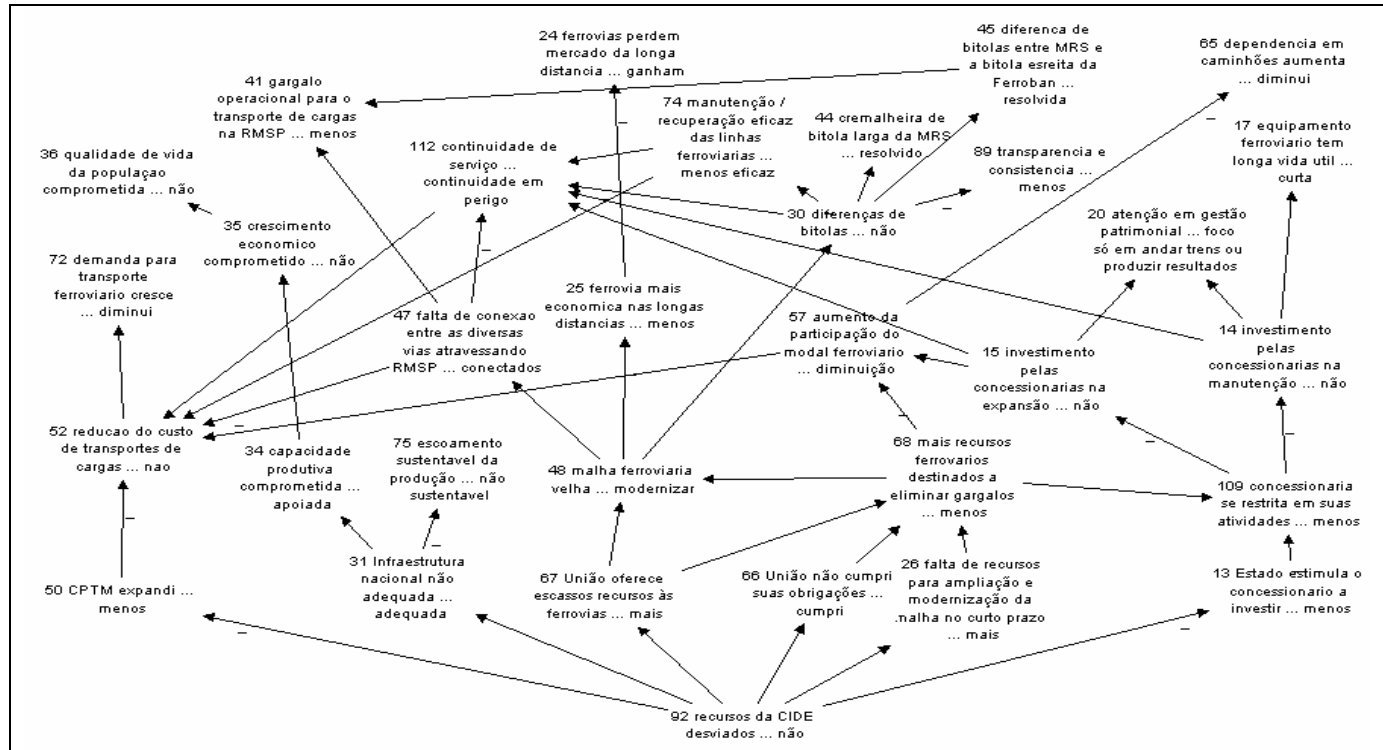


Figure 5: Fourth level impact of construct 92 - recursos da CIDE desviados... não

Dominants

Compared to the type of constructs discussed so far, dominants require a refined interpretation. These are constructs with a relatively high degree, in other words, with a relatively large total number of constructs leading into them and out of them. Earlier, for example, construct 112 was seen to have an indegree of 11. It also has an outdegree of 2, making for a total degree of 13. Indeed, it is one of only two constructs in the entire model to hold the highest degree.

A construct with high degree indicates a focal point in the model where issues or decisions converge from, and diverge to, other parts of the map. Dominants may be interpreted as constructs enjoying privileged centrality in a map (Wasserman & Faust, 1994: 169-219). Since they simultaneously affect, and are affected by, a large number of surrounding constructs, they may also be perceived as reflecting particularly complex areas of the decision making process. Dominance and complexity, however, should not be so easily associated. In order to understand why, consider the following. Based on the entire model (the merged map), Table 6 lists those constructs with degree greater than or equal to 6.

Degree	Construct(s)
13	74 manutenção / recuperação eficaz das linhas ferroviárias ... menos eficaz 112 continuidade de serviço ... continuidade em perigo
11	31 Infra-estrutura nacional não adequada ... adequada
10	52 redução do custo de transportes de cargas ... nao 13 Estado estimula o concessionário a investir ... menos
7	60 maior integração dos modais ... menos
6	68 mais recursos ferroviários destinados a eliminar gargalos ... menos 30 diferenças de bitolas ... não 92 recursos da CIDE desviados ... não

Table 6: Constructs with degree ≥ 6 , in descending order of degree (based on complete model)

Note the prominence of construct 112, as discussed earlier. Now consider a construct around the middle of this list, say, construct 13 with degree 10. How is this construct focal to the model, and how complex is the decision which it addresses, namely, the manner in which the government stimulates the concessions to invest? Construct 13 is mapped in Figure 6.

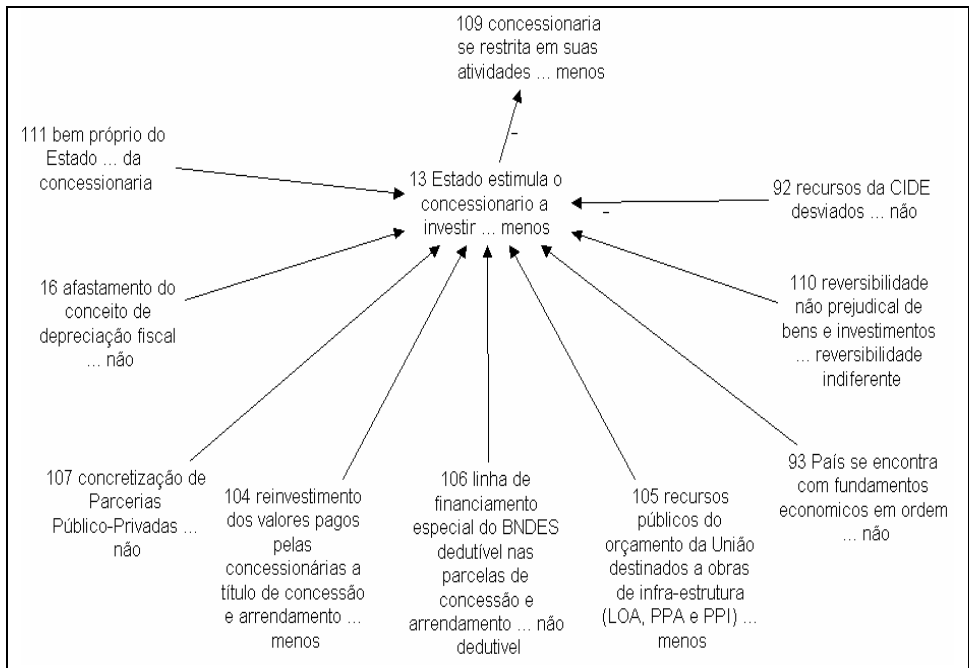


Figure 6: Map of construct 13 - the degree to which the state stimulates investment by the concessions

Now, construct 13 is a **Governo** construct. All of its nine tails are also **Governo** constructs. This means that the degree to which the government stimulates the concessions to invest (13) wholly depends upon the government's own mechanisms for ensuring such investment, namely on whether the government:

- retains control of the assets (111);
- relieves the concessions of certain fiscal reporting obligations (16);
- reaffirms public-private partnerships (107);
- uses funds appropriately (104, 105, 92);
- offers fiscal relief on loans (106);
- maintains a non-prejudicial asset recall position (110); and,
- maintains the country's economy in order (93).

No doubt this covers a range of variables, and the high implosion grade of construct 13 reflects this. But its implosion grade is wholly constituted by constructs from within its own issue: **Governo**. The government's decision on stimulating the concessions to invest depends upon nine other decisions that the government itself will make. There is only one agency, the government, that will take its own decision, dependent upon only its own prior decisions. From this we can conclude two things. First, if construct 13 is focal to the model at all,

it is so only due to the manner in which it converges constructs from within its own issue. Second, if construct 13 is complex at all, it is merely enumeratively complex. It is not quite systemically complex, for instance, since multiple stakeholders or multiple issues are missing from this particular decision making process. If the complexity of a construct (or a decision) is to be judged according to different types of issues impacting upon it, or upon which it impacts, 13 is not complex.

This leads to the following warning: a high degree does not necessarily indicate complexity. An internal decision might have a high degree but, due to its homogeneous nature, it demands little external attention from other issues. Of course, how the state stimulates concessions might require discussions with the concessions themselves (indeed, a concessions construct is the only outdegree of construct 13). But the decision implicit in construct 13 itself is very much a governmental one.

In brief, the results of Table 6 fail to make explicit the degree to which any construct on the list actually connects with constructs that do not belong to its own issue. For example, although construct 13 has a degree of 10, this alone does not tell us whether the connections implied by this degree stretch to issues other than that to which the construct itself belongs. Figure 6 illustrates the minimal connection this construct has with other issues.

Consider then a different list of dominants with high degrees – see Table 7. This time, the list is not based upon the complete model. It is based upon a sub-map constituted only by those constructs that have connections to issues other than the ones under which they are respectively categorized. The constructs in question, in other words, serve to link one issue to another. For this reason, they may be terms *issue linkers*. Construct 13 may be argued to be one such construct, for it links the issues of **Governo** and **Concessionárias**, as discussed above. But in the list of issue-linkers with high degrees, given in Table 7, construct 13 does not even appear.

Degree	Construct(s)
13	112 continuidade de serviço ... continuidade em perigo
11	31 Infra-estrutura nacional não adequada ... adequada
9	52 redução do custo de transportes de cargas ... não 74 manutenção / recuperação eficaz das linhas ferroviárias ... menos eficaz
7	60 maior integração dos modais ... menos
6	68 mais recursos ferroviários destinados a eliminar gargalos ... menos 92 recursos da CIDE desviados ... não

Table 7: Issue linkers with degree ≥ 6 , in descending order of degree (based upon a sub-map constituted only by those constructs that have connections to issues other than the ones under which they are respectively categorized).

Table 7 lists those constructs/decisions that are complex, because the high domain grades indicate the involvement of decision makers from various groups representing the different underlying issues. Consider construct 112: who decides on how and whether service provision remains continuous, that is, runs smoothly? The domain grade of this construct is 13, and it covers the following issues: logistics (its only outdegree), ports, concessions, maintenance, the track, the government, and urbanism. Arguably, this is a far more complex issue than how the state will stimulate the concessions to invest (13) – and its higher complexity does not arise solely because it has a higher domain grade.

Feedback Dynamics

The identification and analysis of feedback loops in any model is important because it can highlight problems as well as opportunities in a situation. More ominously, feedback loops can serve to identify areas of uncontrolled degenerative or regenerative dynamics. Both cases are dangerous since they lead to the ultimate collapse of the system under consideration. For the case of the railways, a system of 35 wholly degenerative loops, constituted by 22 constructs, was uncovered. This signals that a major detrimental force is acting upon the entire situation.

Notions such as degeneration and regeneration imply decreasing and increasing levels, respectively. Levels refer to things, and thus nouns. SODA maps, however, are systems of constructs constituted by verbs. In order to illustrate the feedback effects, therefore, a translation was required from action-based constructs to noun-based concepts, as per the recommendations of the general methodology for constructing causal loop diagrams (Sherwood, 2002). This process is a non-trivial exercise. In the first place, it requires rewriting the content of each construct as a concept, whilst remaining faithful to the original source material. Rewriting, more often than not, leads to changes in the direction and influence of arrows. This calls for double-checking the entire model for consistency. Finally, upon examination of the resulting causal loop diagram, there might arise the need to delete any number of concepts because the content of other newly-written concepts has either led to redundancies, or to links that seem out of place with the spirit of the original source material. In short, the translation of a SODA map into a causal loop diagram offers an opportunity for a deeper analysis of the model, with the aim of providing a transparent and logically consistent reflection of the situation at hand. The final causal loop diagram of the feedback dynamics inherent in the model is shown in Figure 7. There are 20 loops constituted by 18 concepts in this diagram (the numbering reflects that of the original constructs).

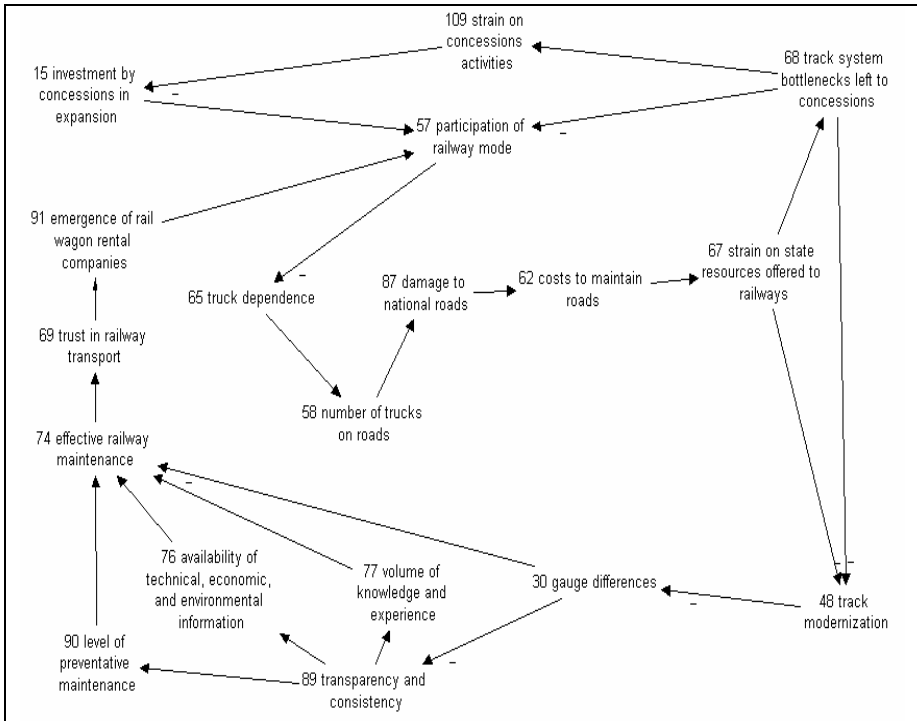


Figure 7: Causal loop feedback dynamics

A quick way to enter this model is as follows. The less the State spends on updating the infrastructure (67), the more the concessions are obliged to use their own resources to fix infrastructure problems (68). This diminishes the possibility of overhauling the track system (48), as well as restrains the concessions from undertaking other activities (109), such as investing in their own expansion (15). Following this chain of argument along the remaining concepts quickly reveals a situation of causal degeneration consisting of, among other things: increasing dependence on truck transportation (65), ineffective railway maintenance (74), and low participation by the railways in the modal matrix (57).

But why does the State spend a relatively low amount on railway infrastructure? And how can truck dependence be controlled? Indeed, what factors can come into play to provide some control to the degenerative spiral highlighted by this combination of feedback loops? The model provides some immediate answers in terms of factors that directly impinge upon the system of loops. Figure 8 shows them superimposed in bold upon the causal loop feedback dynamics.

The concessions can expand their activities through the provision (by the government) of more conducive investment mechanisms (97) and lower

import duties (99). Truck dependence can be controlled through national planning that supports a wider availability of transport means (33). The adoption of methodologically-founded organizational learning (83) can temper a series of problems leading to effective maintenance practices. But the single most important factor that can contribute to alleviating the degenerative dynamics is the proper appropriation of CIDE funds (92). Misappropriation directly impacts one of the concepts in the causal loop diagram (67), and indirectly impacts another two (68, 109), thus providing a three-fold influence upon the loop system. Halting misappropriation will enable the State to channel more resources to the railway system (67, 26), meet its contractual obligations with the concessions (66), and offer financial stimuli for investment by the concessions (13) – three areas that will inevitably lead to positive repercussions around all the loops, and further lead to positive outcomes in the situation as a whole.

Conclusion

Brazil has officially toyed with the idea of a national railway system ever since 1835 (Mattoon, 1977). Economic history shows that, in the main, national railway development positively contributes toward national economic progress. As such, railway planning must be considered as a major contributor to the future of Brazil. This paper has provided some of the major results from a preliminary investigation into the issues surrounding national railway development in Brazil. The study was able to pinpoint various causes and consequences of taking certain decisions. A summary of the resulting insights is as follows:

- On the high level of strategic decision making, the major players are the government and the concessions, whilst the major issues are the lack of national intermodal infrastructure and the lack of methodology in maintaining and modernizing (and expanding) the track system;
- National railway development in Brazil is prone to the coordination of a large number of prime triggers. The most important of these is the redesign of the system where it meets urban centers, the adoption of effective maintenance practices, the overhaul of the track system, and port accessibility;
- Decisions on railway development in Brazil will inevitably address the role of the government and of the concessions but, more importantly, they should be directed toward multi-modal transport availability;
- At the core of government decision making lies the issue of alleged misappropriation of public funding. The study has pinpointed exact consequences of this practice, and has analyzed the extent to which this practice negatively affects the objectives of railway development in Brazil;

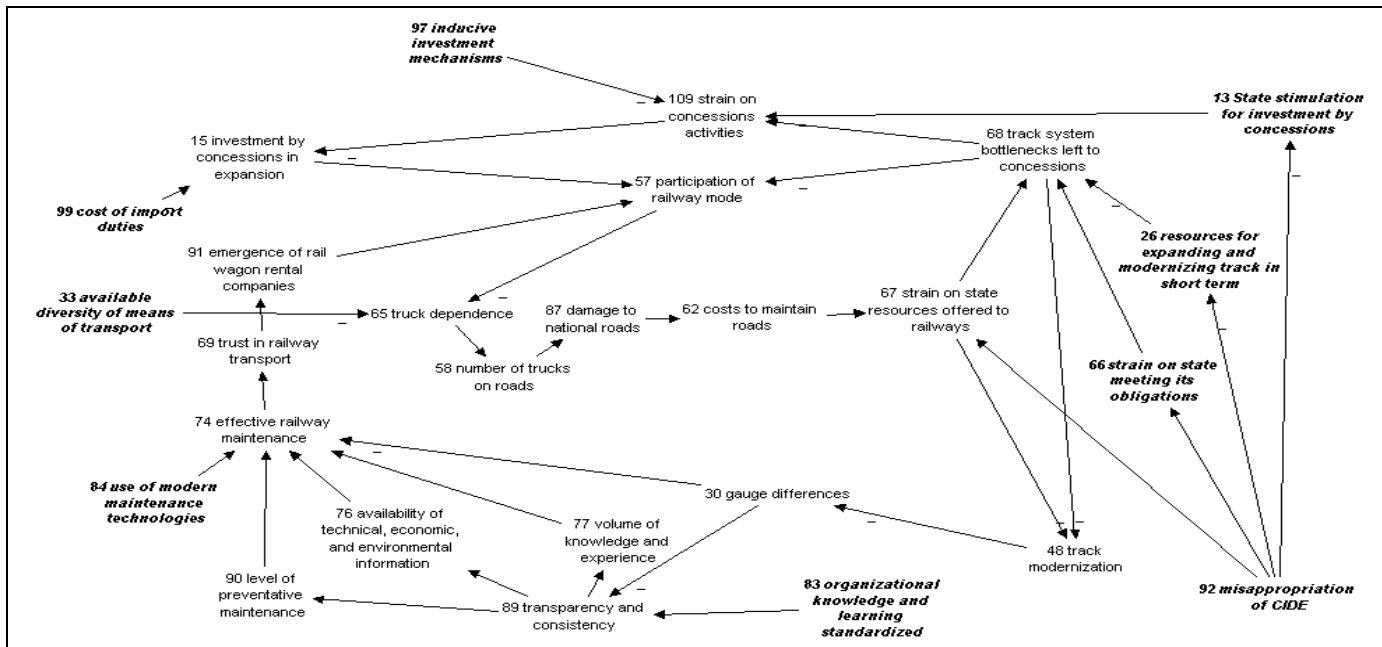


Figure 8: Possible control contributors in bold

- Attempts at Brazilian railway development are prone to a degenerative system of feedback loops. The central influence of this system points to a disturbing conclusion. Unless the feedback dynamics are tackled, any attempt at national railway expansion and development in Brazil is likely to fail because, according to the model, the majority of decisions are affected by the degenerative dynamics stemming from the feedback loops. This is equivalent to shooting for the stars, but inevitably getting trapped inside a black hole.

The study has also been able to critically examine some core theory – for example, the relationship between dominance and complexity was discussed. However, modeling improvements are required. For instance, too many constructs in the model used here have purely negative secondary poles. The weakness of this was discussed earlier. The research here was based on documentary analysis which precludes the participation of the actors themselves, or the wider stakeholders. This lack of personal interaction renders it difficult to second-guess what secondary pole an actor has in mind. In other words, although SODA can be used to model documentary sources effectively, an underlying weakness of relying solely on documents is that the potency of constructs is not fully attained. It is recommended that SODA maps based upon documentary analysis are used as a basis for undertaking either individual interviews or group decision workshops, thus providing the opportunity to improve the content of constructs as well as correct/amplify the map itself.

The model serves as the basis for group decision making in the area of railway management which, of necessity, requires multi-stakeholder participation. In complex situations, prior to any prescriptive action, an effective descriptive approach is required. This is exactly what SODA offers, leaving all stakeholders better informed as to what needs to be done.

This paper is based on research sponsored by the Escola de Administração de Empresas de São Paulo (EAESP) of the Fundação Getúlio Vargas (FGV). The research was first presented to the III Congresso Brasileiro de Sistemas of the Brazilian Chapter of the International Society for the Systems Sciences, organized by Universidade Federal de Santa Catarina, on 25 October 2007, in Florianopolis, SC, Brasil. The author is grateful to Pedro Stevaux (FGV) for his support in analyzing and interpreting the model.

References

- ACKOFF,R. The future of operational research is past. *Journal of the Operational Research Society*, 30(2): 93-104, 1979.
- AFFUSO,L.; MASSON,J.; NEWBERY,D. Comparing investments in new transport infrastructure: roads versus railways? *Fiscal Studies*, 24(3): 275-315, 2003.
- ANTF. 10 anos de concessões ferroviárias. Associação Nacional dos Transportadores Ferroviários: Brasília, 2007.
- BOLLINGER,B. A manutenção da via permanente: um encargo para a carga. *Revista Ferroviária*, 65(novembro): 31, 2004.
- BRIGINSHAW,D. Rail revival in Brazil. *International Railway Journal*, May, 2005.
http://findarticles.com/p/articles/mi_m0BQQ/is_5_45/ai_n13784632.
Accessed at: 18 feb. 2008.
- BRYANT,J. Modelling alternative realities in conflict and negotiation. *Journal of the Operational Research Society*, 35(11): 985-993, 1984.
- BUZAN,T. How to mind map. London: Thorsons, 2002.
- CAMPOS,J. Lessons from railway reforms in Brazil and Mexico. *Transport Policy*, 8(2): 85-95, 2001.
- CARPENTER,T.G. The environmental impact of railways. Chichester: Wiley, 1994.
- CARTWRIGHT,D.; HARARY,F.; NORMAN,R.Z. Structural models: an introduction to the theory of directed graphs. Chichester: Wiley, 1965.
- CLENDENNING,A.; LEHMAN,S. Brazil's booming. *The Columbus Dispatch*, 3/02/08. http://www.dispatch.com/live/content/business/stories/2008/02/13/booming_brazil.ART_ART_02-13-08_C8_HJ9AR6G.html.. Accessed at: 18 feb. 2008.
- COSSETTE,P. Analysing the thinking of F.W Taylor using cognitive mapping. *Management Decision*, 40(2): 168-182, 2002.
- Da SILVEIRA,L.C.A. O renascer da indústria ferroviária. *Revista Ferroviária*, 67(maio): 41, 2006.
- DANIELS,K.; JOHNSON,G. On trees and triviality traps: locating the debate on the contribution of cognitive mapping to organizational research. *Organization Science*, 23(1): 73-81, 2002.
- De LIMA,B.J. Colocando ordem na casa. *Revista Ferroviária*, 67(fevereiro): 49, 2006.
- DRECKMANN,R. Nos trilhos do desenvolvimento. *Revista Ferroviária*, 67(abril): 37, 2006.
- EDEN,C. Cognitive mapping. *European Journal of Operational Research*, 36(1): 1-13, 1988.
- EDEN,C. Analyzing cognitive maps to help structure issues or problems. *European Journal of Operational Research*, 159(3): 673-686, 2004.
- EDEN,C.; ACKERMANN,F.; CROPPER,S. The analysis of cause maps. *Journal of Management Studies*, 29(3): 309-324, 1992.

- EDEN,C.; HUXHAM,C. Action-oriented strategic management. *Journal of the Operational Research Society*, 39(10): 889-899, 1988.
- EDEN,C.; JONES,S. Using repertory grids for problem construction. *Journal of the Operational Research Society*, 35(9): 779-790, 1984.
- EDEN,C.; SIMS,D. Subjectivity in problem identification. *Interfaces*, 11(1): 68-74, 1981.
- ESTACHE,A.; GOLDSTEIN,A.; PITTMAN,R. Privatization and regulatory reform in Brazil: the case of freight railways. *Journal of Industry, Competition and Trade*, 1(2): 203-235, 2001.
- FERNANDES,J. Dinheiro desviado, população ludibriada. *Revista Ferroviária*, 67(agosto): 49, 2006.
- FERREIRA,M.R. *A ferrovia do diabo*. São Paulo: Melhoramentos, 1959.
- FIOL,C.M. Maps for managers: Where are we? Where do we go from here? *Journal of Management Studies*, 29(3): 267-285, 1992.
- FLEURY,P.F. Pontos fortes e fracos da fase pós-privatização. *Valor Setorial Ferrovias*, Setembro: 54-55, 2006.
- FOLHA ONLINE. Leia a íntegra do discurso do novo ministro dos Transportes de Lula, 02/01/2003.
- FOLHA ONLINE. Vale e siderúrgicas asiáticas acertam aumento de 65% no preço do minério. <http://www1.folha.uol.com.br/folha/dinheiro/ult91u373388.shtml>. Accessed at 18 feb. 2008a.
- FOLHA ONLINE. Lula manda mensagem ao Congresso no início do ano Legislativo. <http://www1.folha.uol.com.br/folha/brasil/ult96u370086.shtml>. Accessed at 18 feb. 2008b.
- FRANSELLA,F.; BELLI,R.; BANNISTER,D. *A manual for repertory grid technique*. Chichester: Wiley, 2004.
- FREMDLING,R. Railroads and German economic growth: a leading sector analysis with a comparison to the United States and Great Britain. *The Journal of Economic History*, 37(3): 583-604, 1977.
- GARRIDO,J. Mais carga nos mesmos trilhos. *Valor Setorial Ferrovias*, Setembro: 6-11, 2006.
- GERODETTI,J.E.; CORNEJO,C. *As ferrovias do Brasil: nos cartões-postais e álbuns de lembranças*. São Paulo: Solaris Edições Culturais, 2005 (Also available in English translation as *Railways of Brazil: in post-ards and souvenir albums*).
- GOUGH,J.V.; EVANS,A.K. *The impact of the railway on society in Britain: essays in honour of Jack Simmons*. Aldershot: Ashgate Publishing, 2003.
- GOVERNO FEDERAL. *Programa de aceleração do crescimento*. Brasília: Palácio do Planalto, 2007.
- HEES,B. Logística de transporte, armazenagem e movimentação de cargas. *Revista Ferroviária*, 66(julho): 25, 2005.
- JANKOWICZ,D. *The easy guide to repertory grids*. Chichester: Wiley, 2004.

- KANE,M.; TROCHIM,W.M.K. Concept mapping for planning and evaluation. Thousand Oaks: Sage, 2007.
- KELLY,G.A. The psychology of personal constructs. 2nd ed. London: Routledge, 1955/1991.
- KELLY,G.A. A theory of personality: the psychology of personal constructs. London: Norton, 1963.
- KELLY,G.A. A brief introduction to personal construct theory. In: BANNISTER,D. (ed). Perspectives in personal construct theory. London: Academic Press, 1970. p. 1-30.
- KITCHIN,R.M. Cognitive maps: what are they and why study them? *Journal of Environmental Psychology*, 14(1): 1-19, 1994.
- KLEIN,J.H.; COOPER,D.F. Cognitive maps of decision-makers in a complex game. *Journal of the Operational Research Society*, 33(1): 63-71, 1982.
- LANGFIELD-SMITH,K. Exploring the need for a shared cognitive map. *Journal of Management Studies*, 29(3): 349-368, 1992.
- LANGFIELD-SMITH,K.; WIRTH,A. Measuring differences between cognitive maps. *Journal of the Operational Research Society*, 43(12): 1135-1150, 1992.
- MATTOON,RHjr. Railroads, coffee, and the growth of big business in São Paulo, Brazil. *The Hispanic American Historical Review*, 57(2): 273-295, 1977.
- MONTIBELLER,G.; BELTON,V. Causal maps and the evaluation of decision options – a review. *Journal of the Operational Research Society*, 57(7): 779-791, 2006.
- MOYER,N.E.; THOMPSON,L.S. Options for reshaping the railway. Policy Research Working Paper WPS 0926, Infrastructure and Urban Development Department. Washington: The World Bank, 1992.
- NEVES,M.A.O. O futuro das concessionárias do modal ferroviário no Brasil. *Revista Ferroviária*, 66(novembro): 26, 2005.
- NICOLINI,D. Comparing methods for mapping organizational cognition. *Organization Studies*, 20(5): 833-860, 1999.
- PASSOS,P.S. Ferrovias – um novo paradigma. *Revista Ferroviária*, 67(novembro): 40-41, 2006.
- REIS,M.A.S. A importância do ferroanel e do rodoanel de SP na logística do País. *Revista Ferroviária*, 65(setembro): 31, 2004.
- ROSENHEAD,J.; MINGERS,J. (eds). Rational analysis for a problematic world revisited: problem structuring methods for complexity, uncertainty and conflict. 2nd edition. Chichester: Wiley, 2001.
- SHERWOOD,D. Seeing the forest for the trees: a manager's guide to applying systems thinking. London: Nicholas Brealey Publishing, 2002.
- STEINBRUCH,B. O País precisa ser rasgado por ferrovias. *Revista Ferroviária*, 68(fevereiro): 62-63, 2007.
- SUMMERHILL,W.R. Order against progress: government, foreign investment, and railroads in Brazil, 1854-1913. Stanford: Stanford University Press, 2003.

- TEGARDEN,D.P.; SHEETZ,S.D. Group cognitive mapping: a methodology and system for capturing and evaluating managerial and organizational cognition. OMEGA The International Journal of Management Science, 31(2): 113-125, 2003.
- VILAÇA,R. Importância do setor ferroviário no cenário logístico e econômico do País. Revista Ferroviária, 66(dezembro): 35, 2005.
- VILAÇA,R. Não faltam propostas nem soluções. Revista Ferroviária, 67(setembro): 41, 2006.
- WANG,S. A dynamic perspective of differences between cognitive maps. Journal of the Operational Research Society, 47(4): 538-549, 1996.
- WASSERMAN,S.; FAUST,K. Social network analysis: methods and applications. Cambridge University Press: Cambridge, 1994.
- WIKIPEDIA. List of countries by rail transport network size. http://en.wikipedia.org/wiki/List_of_countries_by_rail_transport_network_size. Accessed at: 18 feb. 2008

Appendix 1

List of 98 Constructs in Merged Map

Note: As per the SODA methodology, the first pole in each construct reflects as accurately as possible what was explicitly stipulated by an actor. Some contrasting poles were made explicit by the actors, but the majority are educated guesses of the analyst.

- 13 Estado estimula o concessionário a investir ... menos
- 14 investimento pelas concessionárias na manutenção ... não
- 15 investimento pelas concessionárias na expansão ... não
- 16 afastamento do conceito de depreciação fiscal ... não
- 17 equipamento ferroviário tem longa vida útil ... curta
- 20 atenção em gestão patrimonial ... foco só em andar trens ou produzir resultados
- 21 desequilíbrio na distribuição das cargas entre os diversos modais ... equilíbrio
- 22 baixo preço do frete praticado no modal rodoviário ... alto
- 23 competição direta entre modal ferroviário e modal rodoviário ... menos
- 24 ferrovias perdem mercado da longa distância ... ganham
- 25 ferrovia mais econômica nas longas distâncias ... menos
- 26 falta de recursos para ampliação e modernização da malha no curto prazo ... mais
- 27 falta de regulamentação do direito de passagem e tráfego mútuo ... não
- 28 invasão das faixas de domínio ... menos
- 29 passagens em centros urbanos ... menos
- 30 diferenças de bitolas ... não
- 31 Infraestrutura nacional não adequada ... adequada
- 32 falta de ampliação dos meios de transportes ... ampliação
- 33 falta de diversificação dos meios de transportes ... diversificação
- 34 capacidade produtiva comprometida ... apoiada
- 35 crescimento econômico comprometido ... não
- 36 qualidade de vida da população comprometida ... não
- 37 direcionar investimentos federais para outras regiões ... investir em infraestrutura em SP
- 38 infraestrutura em SP superior a média nacional ... igual ou menor
- 39 alta demanda de transporte de carga em SP/RMSP ... menor
- 40 grande maioria das ferrovias convergem para RMSP ... menos
- 41 gargalo operacional para o transporte de cargas na RMSP ... menos
- 42 conflito com transportes urbano (CPTM) ... menos
- 43 capacidade limitada da MRS na descida da Serra do Mar ... aumentada
- 44 cremalheira de bitola larga da MRS ... resolvido
- 45 diferença de bitolas entre MRS e a bitola esreita da Ferroban ... resolvida
- 46 prejuizos em outras regiões ... menos
- 47 falta de conexaso entre as diversas vias atravessando RMSP ... conectados
- 48 malha ferroviária velha ... modernizar
- 49 fluxo intenso de trens de passageiros ... menos

- 50 CPTM expandi ... menos
- 52 redução do custo de transportes de cargas ... não
- 53 segregar trans ferr de carga em relacao ao trans de passageiros dentro da RMSP ... não
- 54 resolver problema de transposição da RMSP ... não
- 55 implantacao do ferroanel ... não
- 56 acesso ao porto de Santos controlado por uma minoria de concessionárias ... não
- 57 aumento da participação do modal ferroviário ... diminuição
- 58 menos caminhões nas estradas ... mais
- 59 diminuição de filas de caminhões ... aumento
- 60 maior integração dos modais ... menos
- 61 menos desperdícios ... mais
- 62 altos custos de manter estradas ... menos
- 63 custos embutidos na manutenção de estradas ... diminuição de serviços rodoviários
- 64 falta de ampliação dos portos ... não
- 65 dependência em caminhões aumenta ... diminui
- 66 União não cumpri suas obrigações ... cumpri
- 67 União oferece escassos recursos às ferrovias ... mais
- 68 mais recursos ferroviários destinados a eliminar gargalos ... menos
- 69 transporte ferroviário confiável ... menos
- 70 transporte ferroviário rápido ... não
- 71 operacionalização dos portos não adequada ... melhor operacionalização
- 72 demanda para transporte ferroviário cresce ... diminui
- 73 País aprecia suas necessidades condicionadas a sua dimensão continental ... não
- 74 manutenção / recuperação eficaz das linhas ferroviárias ... menos eficaz
- 75 escoamento sustentável da produção ... não sustentável
- 76 disponibilidade de informações técnicas econômicas e ambientais ... pouca
- 77 conhecimento e experiência extensivos ... poucos
- 78 manutenção aumenta resultados ... diminui
- 79 manutenção diminui custos ... aumenta
- 80 manutenção diminui riscos operacionais ... aumenta
- 81 manutenção diminui riscos ambientais ... aumenta
- 82 comportamento da via permanente variável ... estável
- 83 sistematizar conhecimento e aprendizagem ... falta de critérios estáveis e pessoais
- 84 tecnologias modernas de manutenção ... antigas
- 85 metodologias inovadoras de manutenção ... menos
- 86 competitividade dos produtos Brasileiros diminui ... aumenta
- 87 rodovias Brasileiras danificadas ... menos
- 88 variável ambiental incorporada ... não
- 89 transparência e consistência ... menos
- 90 manutenção preventiva ... intervenções emergenciais

- 91 surgimento de locadoras de vagões ... falta de locadoras
- 92 recursos da CIDE desviados ... não
- 93 País se encontra com fundamentos econômicos em ordem ... não
- 94 restrições de capacidade no acesso aos portos ... menos
- 95 maior integração operacional entre concessionários ... menor
- 96 expansão da malha para zonas produtoras ... não
- 97 inexistência de mecanismos indutores de investimentos ... existência
- 98 forma de incidência do ICMS penaliza transporte intermodal ... não
- 99 importações de equipamentos são injustificavelmente oneradas ... menos
- 100 falta planejamento de longo prazo duradouro e abrangente ... não falta
- 101 interesses corporativos ou setoriais isolados ... interesses nacionais
- 102 um plano apenas de governo ... de Estado
- 103 normas regulatórias inconsistentes/não-compativeis aos atuais requisitos do transporte intermodal ... reformuladas
- 104 reinvestimento dos valores pagos pelas concessionárias a título de concessão e arrendamento ... menos
- 105 recursos públicos do orçamento da União destinados a obras de infraestrutura (LOA, PPA e PPI) ... menos
- 106 linha de financiamento especial do BNDES dedutível nas parcelas de concessão e arrendamento ... não dedutível
- 107 concretização de Parcerias Público-Privadas ... não
- 108 concessionárias operam com ativos arrendados e reversíveis ... próprios
- 109 concessionária se restrita em suas atividades ... menos
- 110 reversibilidade não prejudicial de bens e investimentos ... reversibilidade indiferente
- 111 bem próprio do Estado ... da concessionária
- 112 continuidade de serviço ... continuidade em perigo
- 113 operação logística ajustada às necessidades e particularidades do cliente ... não

Appendix 2

List of 98 Constructs in Merged Map, classified by issue and construct reference number. For each construct, the 'Links to' column indicates those constructs *to which* it connects (symbolized by '>'). For example, construct 14 leads to constructs 112, 17, and 20; construct 68 leads to constructs 109, 48, and 57. The '+' or '-' prefixing the constructs to which the construct in question links indicates an unsigned (or positive arrow) or a negative (signed) arrow. Note also that the number of constructs to which a construct links is equal to that construct's outdegree. Given the 'Links to' column, the entire merged map can be reconstructed.

<u>Construct</u>	<u>Issue</u>	<u>Links to</u>
14 concessions invest in maintenance ... not	Concessions	14 > +112 +17 +20
15 concessions invest in expansion ... not	Concessions	15 > +57 +112 +20
20 attention placed on managing national heritage ... focus on running trains and producing results	Concessions	[is head/objective]
68 more concession resources applied to eliminating bottlenecks ... less	Concessions	68 > +109 +48 - 57
76 availability of technical, economic and environmental information ... unavailability	Concessions	76 > +74
77 extensive knowledge and experience ... little	Concessions	77 > +74
83 systematize knowledge and learning ... lack of stable and impersonal criteria	Concessions	83 > +89
88 environmental variable incorporated ... not	Concessions	88 > +81
89 transparency and consistency ... less	Concessions	89 > +90 +76 +77
95 greater operational integration between concessions ... less	Concessions	95 > -31
108 concessions operate with leased assets subject to recall by the government ... concessions own assets	Concessions	[is head/objective]
109 concession is restricted in its activities ... less	Concessions	109 > -15 -14
112 service continuity ... continuity endangered	Concessions	112 > +52 +70
113 logistics operations adjusted to the needs and particularities of the client ... no	Concessions	[is head/objective]
34 production capacity compromised ... bolstered	Consequences	34 > +35
35 economic growth compromised ... not	Consequences	35 > +36

36 population's quality of life compromised ... not	Consequences	[is head/objective]
46 detrimental effects in other regions (outside Sao Paulo) ... less	Consequences	46 > +37
61 less waste ... more	Consequences	61 > +52
75 sustainable production throughput ... unsustainable	Consequences	[is head/objective]
86 competitiveness of Brazilian products diminishes ... increases	Consequences	86 > +35
91 emergence of wagon rental companies ... lack of rental companies	Consequences	91 > +57
13 government stimulates the concessions to invest ... less	Government	13 > -109
16 exempt monetary depreciation ... not	Government	16 > +13
27 lack of right-of-way and mutual traffic regulation ... effective regulation	Government	27 > -112
31 inadequate national infrastructure ... adequate	Government	31 > -75 +34
37 direct federal resources to other regions ... invest in Sao Paulo infrastructure	Government	37 > -54
66 government does not meet its obligations ... government meets its obligations	Government	66 > +68
67 government offers insufficient resources to railways ... more	Government	67 > +48 +68
73 country appreciates its needs conditioned upon its continental dimensions ... does not	Government	73 > -21 +60
92 misappropriation of CIDE resources ... no misappropriation	Government	92 > +31 -50 -13 +26 +67 +66
93 national economic fundamentals in order ... no	Government	93 > +13
97 lack of conducive investment mechanisms ... conducive investment mechanisms in place	Government	97 > +109
98 manner of attributing tax on goods and services penalizes intermodal transport ... no	Government	98 > +23 -60
99 imports of equipment are unjustifiably taxed ... more fairly taxed	Government	99 > -15
100 lack of comprehensive and durable long term planning ... no lack	Government	100 > +66 +103
101 particular corporate and sectoral interests ... national interests	Government	101 > +102

102 just a government plan ... a truly national plan	Government	102 > +100
104 reinvestment of license and leasing fees paid by concessions ... less	Government	104 > +13
105 greater slice of government budget destined for infrastructure projects ... less	Government	105 > +13
106 national development bank credit facilities deductible from license and leasing fees paid by concessions ... non-deductible	Government	106 > +13
107 safeguarding of public-private partnerships ... ineffective management of PPPs	Government	107 > +13
110 non-prejudicial recall of assets and investments ... indifferent recall	Government	110 > +13
111 assets belong to the government ... assets owned by the concessions	Government	111 > +13 +108
21 assymetrical distribution of cargo between various modes ... balanced	Intermodality	21 > +31 -52 +23
23 direct competition between rail mode road transport ... less	Intermodality	23 > +24
32 lack of expansion in available transport means ... expansion	Intermodality	32 > +31
33 lack of diversification in available transport means ... diversification	Intermodality	33 > +65 +31
57 increased participation of rail mode ... diminished	Intermodality	57 > +52 -65
60 greater modal integration ... less	Intermodality	60 > +113 -31 +61
72 increased demand for rail transport ... diminished	Intermodality	[is head/objective]
103 legislation inconsistent/incompatible with actual requirements of intermodal transport ... legislation reformed	Intermodality	103 > -60
22 low cost of freight offered by road transport ... high	Logistics	22 > +52
24 railways lose long-distance market ... win	Logistics	[is head/objective]
25 railways more economical over long distances ... less	Logistics	25 > -24
52 cost reduction in cargo transport ... no	Logistics	52 > +72
69 rail transport trustworthy ... less	Logistics	69 > +91 +72
70 rail transport fast ... not	Logistics	70 > +72

17 railway equipment has long utility life ... short	Maintenance	17 > +16
74 effective maintenance / restoration of railway lines ... ineffective	Maintenance	74 > +52 +112 +69
78 maintenance yields results ... lack of maintenance diminishes results	Maintenance	78 > +74
79 maintenance lowers costs ... lack of maintenance increases costs	Maintenance	79 > +74
80 maintenance lowers operational risks ... lack of maintenance increases operational risks	Maintenance	80 > +74
81 maintenance lowers environmental risks ... lack of maintenance increases environmental risks	Maintenance	81 > +74
84 modern maintenance technologies ... dated	Maintenance	84 > +74
85 innovative maintenance methodologies ... less innovative	Maintenance	85 > +112 +88
90 preventative maintenance ... emergency interventions	Maintenance	90 > +74
56 access to port of Santos controlled by a minority of concessions ... not	Ports	56 > -55
64 lack of port expansion ... no	Ports	64 > +31
71 inadequate port operations ... better port operations	Ports	71 > +31
94 restrictive capacity access to ports ... less	Ports	94 > +56 -112
58 less trucks on the roads ... more	Road Transport	58 > -87 +59
59 decrease in truck queues ... increase	Road Transport	[is head/objective]
62 high costs to maintain roads ... less	Road Transport	62 > +67
63 costs embedded in the maintenance of roads ... decrease in road transport auxiliary services	Road Transport	63 > +62
65 truck dependency increases ... diminishes	Road Transport	65 > +86 -60 -58
87 Brazilian roads damaged ... less	Road Transport	87 > +62
26 lack of resources for expansion and modernization of track in the short term ... more resources	Track	26 > +68
28 track trespassing ... less	Track	28 > -112
30 gauge differences ... not	Track	30 > -74 -89 +45 +44 -112

41 operational bottleneck of cargo transport in Sao Paulo metropolitan region ... bottleneck eased	Track	41 > +46
43 limited capacity of MRS concession on the slopes of Serra do Mar ... increased capacity	Track	43 > +41
44 wide gauge rack-railway of MRS ... standardized	Track	44 > +43
45 gauge differences between MRS and Ferroban's narrow gauge ... resolved	Track	45 > +41
47 lack of connectivity between diverse rights of way crossing Sao Paulo metropolitan region ... connected	Track	47 > -112 -52 +41
48 track system old ... modernized	Track	48 > -25 +30 +47
82 variable operational effectiveness of track system ... stable	Track	82 > -112 -74
96 expansion of track system to productive regions ... no	Track	96 > -31
29 through-ways in urban centers ... less	Urban Planning	29 > -112
38 infrastructure in Sao Paulo superior to national average ... equal or less	Urban Planning	38 > +37
39 high demand for cargo transport in Sao Paulo metropolitan region ... lower	Urban Planning	39 > +42
40 large majority of railways converge upon Sao Paulo metropolitan region ... less	Urban Planning	40 > -37
42 conflict with urban passenger rail transport in Sao Paulo metropolitan region ... less	Urban Planning	42 > -52 +41
49 intense flux of passenger trains in Sao Paulo metropolitan region ... less	Urban Planning	49 > +42
50 Sao Paulo urban passenger rail transport expands ... less	Urban Planning	50 > -52
53 segregate rail cargo from passenger rail transport within Sao Paulo metropolitan region ... not	Urban Planning	53 > -50 -37
54 resolve transposition problems in Sao Paulo metropolitan region ... not	Urban Planning	[is head/objective]
55 implement rail ring around Sao Paulo metropolitan region ... not	Urban Planning	55 > -42