11TH CONFERENCE ON COMPETITION AND OWNERSHIP IN LAND PASSENGER TRANSPORT

Delft University of Technology (The Netherlands)
20-25 September 2009

WHY LOCAL AUTHORITIES PARTNER WITH REGIONAL RAILWAYS IN RUSSIA?

Andrei Dementiev
Higher School of Economics, Moscow
dementiev@icer.ru

ABSTRACT

The paper studies the process of PPP formation on the suburban passenger transport in Russia. Empirical evidence on the nature of relationship between local authorities and regional railway undertakings has been provided to rationalise basic assumptions made in the theoretical model. The theoretical findings show that PPP arrangement provides better incentives to invest in quality of services though direct welfare comparison with Compensatory Agreements is not possible due to different objectives of the parties.

INTRODUCTION

The importance of flexible institutional arrangements of effective public transport service provision has been well documented in both theoretical and empirical literature. The authorities worldwide seek for the delivery mechanisms that would tie the service provider objectives to public policy needs while maintaining incentives to innovate. A potential conflict of interests between public purchaser and private provider of transport services may at least partially be smoothed if they co-operate at the tactical level and build a partnership relationship. Among a number of requirements for such a partnering summarized by Stanley and Hensher (2008) are: common objectives, agreed governance arrangements and risk-sharing rules (see also Medda, 2007; Nisar, 2007 and Sock-Yong Phang, 2007), relationship management, trust, transparency and accountability. In practice, the idea of strategic and tactical level co-operation can be realized in the form of public-private partnership (PPP).

In this light the ongoing reform of suburban railway transport in Russia provides a relevant case study material to confront these findings with the experience of creation of Suburban Passenger Companies (SPCs) in the form of joint ventures between local authorities and regional divisions of Russian Railways (RZD). This specific form of PPP aims at internalizing the conflicting objectives of the public partner (local authorities) and RZD that is 100% state-owned joint-stock company but may be viewed as profit-maximizing private agent. The contradiction results from the fact that local authorities *de-jure* have Public Service Obligation (PSO) to provide transportation services but have very limited budgets to fully finance the purchase of such a services from the monopoly operator which is regional division of RZD. Local authorities can influence the regulator's decision to set tariffs at the 'socially acceptable' level which is often can't cover cost incurred by RZD. Moreover, numerous passengers eligible for federal and regional benefits when traveling on suburban trains enjoy concessionary fares by law. However, only 40 (as of July 2009) of 73 regions with suburban railway transport have signed the agreements to at least partially compensate RZD losses from the tariff regulation.

Such a 'Compensatory Agreements' appeared to be incomplete from the contractual point of view and poorly enforced. In the absence of clear procedures for cost structure determination on the railway transport in Russia local authorities may not trust the information on cost reported by RZD. Federal concessionary passengers started to be compensated by the Federal Agency for Healthcare and Social Development in 2005. At a local level only 14 regions agreed to fully compensate for the concessions determined locally. This form of PPP (viewed as default option) predictably resulted in the constant negotiations with low incentives to invest in the sector for both parties. Not surprisingly, the majority of regions have demonstrated low interest in sharing the losses with RZD. Agreement has been reached on at least partial local support in a few areas (Moscow and some others), but has not been reached in most areas because of a lack of funding at the local level.

The alternative to Compensatory Agreements was the establishment SPCs. 11 regions have formed SPCs with RZD so far and 4 new SPCs are to be established in the nearest future. Some of them managed to turn to profitability within two or three years after establishment, all of them improved quality of services. If such a form of PPP proves to perform better in terms of financial result and quality of services why not implement it economy wide? Are there any regional factors that make railway undertaking of any form profitable or this result is attributed to the establishment of joint venture? What theory tells us about parties' incentives to form such a partnership and why the corporate structure of created SPCs varies across regions?

To address at least part of these questions we build a model which captures the basic stylized facts of the PPP creation process in Russia to be able to make the results policy relevant. The modeling framework inherits the tradition in the growing literature on PPP (eg. Hart, 2003; Bennett and Iossa, 2006a,b; Martimort and Pouyet, 2008) by considering the possibility of bundling the investment and operational stages of public project. Providing a useful analytical tool this literature cannot give a direct answer to the questions of interest. To address these issues we first describe the relevant features of the Compensatory Agreements and PPP practices in Russian suburban rail passenger transport and built a theoretical model of PPP to compare the incentives of the partners under alternative schemes. Then we discuss the findings of the model in terms of policy recommendations that might be derived from the theoretical analysis.

THE STORY

The decade of railway passenger transport reform in Russia has witnessed a decrease by 36.5% of suburban passenger km. In 2008 about 1.2 billion trips were made by suburban rail passengers 73 Russian regions. As a result revenues from suburban passenger transportation has been decreasing for the last 4 years while costs continued to grow resulting in very unpleasant dynamics of losses which increased from 20.5 bln rubles in 2005 to 34.8 bln rubles in 2008 (see Fig.1).

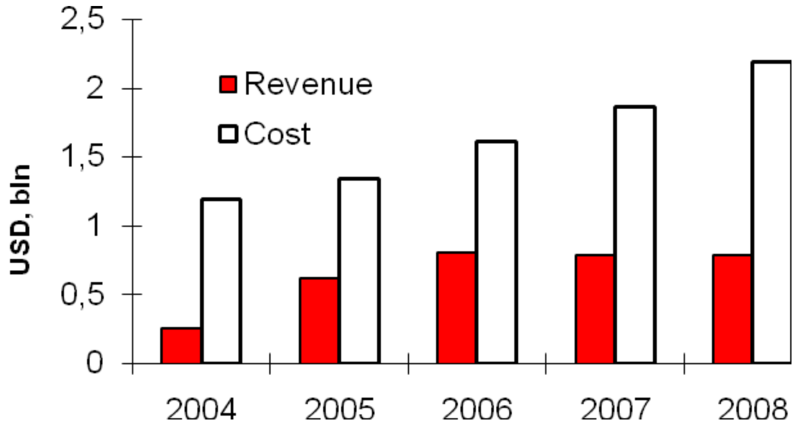

Figure 1: Financial result of suburban rail passenger transport in Russia

To large extent the very nature of suburban transportation by rail to be loss-making is inherited from the Soviet times when the Ministry of Railway Transport on behalf of the state supplied this service as a public service. Various categories of subsidized passengers were allowed to travel for free. Social attitude towards transportation as a public service coupled with very limited investment in the fare control mechanisms (ticket inspectors, entry-exit tourniquets, video cameras, etc.) resulted in the significant scope of fare evasion that ranges across regions from 10% to 40%. Moreover in 2003 in line with the structural reform plan) all the state functions (including the right of ticket inspectors to control passengers) were transferred from MPS to local authorities. Being a 100% state-owned joint stock company Russian Railways has no legal right to monitor and enforce fare collection on the route. As a result the loss-making suburban passenger transport in Russia is cross-subsidized by the freight transport.

40 regions out of 73 agreed on procedures to gradually increase at least partial compensation of reported RZD losses from their budgets. In practice so called Compensatory Agreements demonstrated very poor incentives of local authorities to comply with the signed contracts. The amount of compensation has been always a subject of constant negotiations. Since the cost structure of RZD is poorly verified local authorities may not fully trust the data provided by monopoly. For instance the scope of fare evasion may turn out to be debatable though play significant role in tariff determination at regional level. Local authorities taking into account political and social considerations can influence regional regulators' decision to set tariff at the level below cost. Such an inconsistent tariff policy may benefit short-term oriented policymakers at the local level since lower fares increase the consumption of public service and

consequently social benefit at the expense of greater losses of RZD. Naturally, RZD has been attempting to put every effort to discipline local authorities. One of the possible mechanism of enforcement developed by RZD was establishment of PPP with local authorities in the form of joint venture.

The process of creation of joint venture companies for operating suburban and regional rail passenger undertakings was started in 1998 when ongoing structural railway reform had not been initiated (the three-stage reform plan was officially approved in May 2001). In March 2006 the Federal Government established the licensing procedures for these or any new companies to become operators. By the end of 2008 11 SPCs in 73 regions were established in the form of joint venture between RZD and local and regional authorities. The corporate structure (see Table 1) of these companies varies across regions but the dominant role of RZD prevails in the majority of them.

Table 1: Share structure of suburban passenger companies in Russia

No.	Year of establish.	Company Name	Share Structure
1	1998	Express-Prigorod	RZD (51%), Novosibirsk region (39,8%), Novosibirsk city (9,2%)
2	2003	Kuzbass-Prigorod	RZD (51%), Kemerovo region (49%)
3	2003	Omsk-Prigorod	RZD (51%), Omsk region (49%)
4	2003	Altay-Prigorod	RZD (51%), Altayskiy Kray (49%)
5	2005	Central SPC	RZD (49,34) Moscow City (25,33%), Moscow region (25,33%)
6	2005	Krasprigorod	RZD (51%), SOE "Center for transport logistic" (49%)
7	2005	Express Primoriya	RZD (51%), Primorskiy Kray (49%)
8	2005	Sverdlovsk SPC	RZD (51%), Sverdlovsk region (49%)
9	2006	Nord-West SPC	RZD (75% - 1share), St. Petersburg (25% + 1share)
10	2006	Volgogradtransprigorod	RZD (51%), Volgograd region (49%)
11	2006	Don-Prigorod	RZD (75% - 1share), SOE "Rostovdorsnab"" (25% + 1 share)
12	2009*	Moscow-Tver SPC	RZD (50% - 2 shares), JSC «Delta-Trans-Invest» (25% + 1share), Tver region (25% + 1share)
13	2009*	Volgo-Vyatskaya SPC	RZD (50% - 2 shares), Nizhny Novgorod region (25% + 1share)and Kirov region (25% + 1share)
14	2009*	Permskaya SPC	RZD (51%), Permskiy kray (49%)
15	2009*	Sodrugestvo	RZD (50% - 2 shares), Republic of Tatarstan (25% + 1share) and Udmurtiya (25% + 1share)

The following section presents a formal model where the idea of PPP creation is captured by the different objective functions of the partners under two alternative schemes: Compensatory Agreement and PPP. The later attempts at internalizing the conflict between local authorities and RZD that would be a pre-requisite for the further development of their relationship towards trysting partnership.

THE MODEL

Social Benefit

The gross benefit of the society is modeled by the function: $B = B_0(q) + u(a) + v(e)$, where $B_0(q)$ states for consumer surplus indicating passengers utility derived from suburban transportation. To capture the idea that society is better-off when more passengers are transported by rail we assume the scalability of this public project. In particular we extend the functional form of B used in Bennett and Iossa (2006) and require that greater demand increases social benefits, $\partial B_0 / \partial q > 0$, but at a decreasing rate, $\partial^2 B_0 / \partial q^2 < 0$.

We also borrow from PPP literature the idea that quality of public services positively affects social welfare while the quality itself may be improved by greater investment in infrastructure, a, and/or by more efforts, e, exerted at the operational level. We normalize the cost of one unit of a or e as unity; and can speak of them as 'technological' and 'organizational' innovations correspondingly. One might think of a as investment in modern, more comfortable and faster rolling stock; modernization of railroad stations; etc. In turn, higher efforts of an agent operating the project may, for instance, result in cleaner stations, better ticketing service, availability of ancillary businesses (like selling food/newspapers to passengers or retailing at railroad stations), etc. Thus, the social value of quality improvement would be $u(a) + v(e)$.

Cost structure

The project cost function $C = C_0(q,e) + \phi(a) + \psi(e)$ can be divided into two parts: the first one $C_0(q,e)$ represents variable cost, that rises with quantity at an increasing rate: $\partial C_0 / \partial q > 0$, $\partial^2 C_0 / \partial q^2 > 0$, while the second one $\phi(a) + \psi(e)$ can be perceived as operational cost of quality improvement. We follow Laffont and Tirole (1993) to assume that efforts (or organizational innovations) can decrease variable cost, $\partial C_0 / \partial e < 0$, at the expense of fixed costs. Namely $\psi(e)$ is associated with disutility of efforts for managers; the standard assumptions here imply $\psi(0) = 0$, $d\psi / de > 0$, $d^2\psi / de^2 < 0$. Infrastructural investment $\phi(a)$ is modeled by concave function with $d\phi / da > 0$, $d^2\phi / da^2 < 0$.

Let $AC = \dfrac{C_0(q,e) + \phi(a) + \psi(e)}{q}$ be the average cost of the project.

To capture the idea that the projects deals with regional natural monopoly we consider only the downward sloping part of the average cost function with $\partial AC/\partial q < 0$ and $\partial^2 AC/\partial q^2 > 0$.

Demand function

To account for the heterogeneity of passengers and be able to study possible distributional effects we consider three different groups: obedient, fare-dodgers and concessionary passengers. Passengers from the first group perceive that the probability of being caught if they travel for free is high. Being risk-averse and homogeneous within the group they pay tariff T and if it doesn't exceed their reservation price, otherwise they choose alternative transportation mode. The second group apparently comprises of risk-lovers with propensity to travel for free equal to γ who don't pay for tickets. They perceive that expected penalty levied by ticket inspector if they are caught is low and prefer to play such a lottery with the state.

The propensity to free-ride γ appears to be a composite characteristic reflecting risk-aversion of the population to free-ride. Higher level of supervision by ticket inspectors decreases γ (the inclination to travel for free), as well as higher penalties and public intolerance towards ticketless passengers. Lower propensity to travel for free decreases the pool of fare dodgers who may either join the first group or switch to another mode of transportation (where such a lottery is not that costly). We model this idea by assuming the following functional form: $q_1(1-\gamma,T)+q_2(\gamma,0)$, where $q_1(1-\gamma,T)$ is demand of obedient passengers and $q_2(\gamma,0)$ is demand of free-riders.

The third group of concessionary passengers (war veterans, children, students, etc.) have socially based ticket privileges and pay $(1-\beta)T$ for their trip, where β is the size of concession. We also assume that discount β is sufficient to guarantee that concessionary passengers have no incentives to free-ride (and have $\gamma = 0$). Thus the total demand can be expressed as: $q = q_1(1-\gamma,T)+q_2(\gamma,0)+q_3(0,(1-\beta)T)$. Obviously

$$\frac{\partial q}{\partial \gamma} = -\frac{\partial q_1(1-\gamma,T)}{\partial(1-\gamma)} + \frac{\partial q_2(\gamma,0)}{\partial \gamma} > 0,$$

that is higher propensity to travel for free increases total demand and, as will be shown below, increases social benefit.

We suppose that improvements in the quality of services resulted in either technological or organizational innovations may attract extra passengers on the railroad. Therefore the demand of each group of passengers is assumed to be quality sensitive:

$$\frac{\partial q_1}{\partial e},\frac{\partial q_2}{\partial e},\frac{\partial q_3}{\partial e} > 0;\ \frac{\partial q_1}{\partial a},\frac{\partial q_2}{\partial a},\frac{\partial q_3}{\partial a} > 0.$$

Strategic variables

The government (or local authorities) may wish to impose a certain level of control to increase the probability of fare-dodgers detection. The government expenditure on hiring k ticket inspectors is $G(k)$, where $dG/dk > 0$. Naturally, the propensity to free ride decreases with the level of supervision $\partial\gamma/\partial k < 0$. Since passengers from the first and the third groups only pay for their tickets additional number of ticket inspectors may ring about an increase in total revenues but total demand for transportation will be lower: $\frac{\partial q}{\partial k} = \frac{\partial q}{\partial \gamma} \times \frac{\partial \gamma}{\partial k} < 0$.

Another strategic variable, investment, is controlled by the operator. It consists of two parts: $I = I_0 + a$, where I_0 is viewed at this stage as positive constant and considered to be sunk. We incorporate this variable to model the strategic behavior under binding budget constraint. As described above a stands for investment in quality.

First-best

Social welfare can be viewed as unweighted sum of consumer and producer surpluses. When we abstract from the shadow cost of public funds the social optimum is derived from the following maximization problem: $\max_{a,e,k}(B - C - I - G)$

The first-best optimum level of control variables are as follows: $k_{FB} = 0$, $e_{FB} > 0$, and $a_{FB} > 0$ (hereinafter the proof of all propositions is derived in the Appendix).

Compensatory agreements

To model current situation described above as ‘compensatory agreement’ which obviously lacks basic features of trusting partnership we need to assume specific principal–agent relations between local authorities (who also have a certain regulatory power) and operator (who’s cost cannot be verified in a reliable manner).

Tariff setting

The current regulatory approach to setting tariffs for the suburban rail transport is mainly cost-based. In particular, local authorities set such a tariff to cover average cost. However, since they cannot perfectly estimate the number of fare-dodgers they may be reluctant to cover the costs associated with the transportation of this group of passengers. In other words the immanent information asymmetry between regulator and operator prevents the principal from setting economically sound tariff.

We don’t focus in this paper on regulatory issues and are not looking for the optimal tariff. The crucial point here is that neither tariff alone nor tariff plus compensation M can fully cover the operator’s cost. We capture this idea by the following specification. The tariff is set by the regulator without taking into account costs incurred by the operator when supplying services to free-riders:

$Tq_1 + (1-\beta)Tq_3 + M = C(q_1 + q_3)$, where the compensation for concessionary passengers is calculated as $M = \beta \cdot T \cdot q_3$. That is

$$T = AC(q_p) = AC(q_1(1-\gamma, T) + q_3(0, (1-\beta)T)).$$

Players' objectives

The *status-quo* can be characterized by two different objective functions that local authorities (the principal) and operator have. It is common for the regulatory literature to assume that the principal may wish to put lower weight $0 \le \mu \le 1$ on the producer's surplus. All infrastructure investments are made by the operator (the agent) and financed from non-budgetary sources. So the principal put zero weight on I. On the contrary, all the controlling functions (and associated expenditures G) are fully attributed to the principal. As a result we have the following specification:

The principal's objective is: $\max_k (B - (Tq_1 + (1-\beta)Tq_3) - M + \mu(\pi + M) - G)$, where $B - (Tq_1 + (1-\beta)Tq_3)$ is the net consumer benefit, $\pi = Tq_1 + (1-\beta)Tq_3 - C$ is the net producer surplus, and M is the size of compensation that operator receives from the local government to cover the cost of transportation of concessionary passengers.

The agent's objective is: $\max_{a,e} (\pi + M - I) = -C(q_p + q_2) + C(q_p) - I_0 - a < 0$, which is equivalent to $\min_{a,e} C(q_p + q_2) - C(q_p) + I_0 + a$.

Private-public partnership

We consider the particular type of Public-Private-Partnership which takes the form of joint venture between local authorities and operator. The corporate structure of the company reflects the bargaining power of the parties. Namely, share λ belongs to local authorities and $(1-\lambda)$ is controlled by the operator.

Tariff setting

Since information asymmetry between the parties (who cooperate now) is lower the total demand (and probably total cost) can be observed by local authorities directly. Indeed, both ticket sellers and ticket inspectors which can be legally hired now by PPP may increases the local authorities' awareness of the scope of free-riding. Having regulatory power they have now more reasons to set tariff that covers total operational cost (but not investment or other strategic expenditures). So, tariff setting rule is now: $T = AC(q) = AC(q_1 + q_2 + q_3)$.

Common objectives

The objective function of established PPP accounts for the fact that local authorities care about consumer surplus, $B - T(q_1 + (1-\beta)q_3) - M$, while operator votes for higher profit and full compensation for the concessionary passengers, $\pi + M$. Both parties are assumed now to control strategic variables $G(k)$ and I, so the aggregate objective function becomes: $\max_{k,a,e}\{\lambda(B - T(q_1 + (1-\beta)q_3) - M) + (1-\lambda)(\pi + M) - I - G\}$,

$$\pi = Tq_1 + (1-\beta)Tq_3 - C(q) = AC(q)(q_1 + (1-\beta)q_3 - q_1 - q_2 - q_3) = -AC(q)(q_2 + \beta q_3).$$

The size of compensation that government pays to operator for concessionary passengers $M = \beta \cdot T \cdot q_3 = \beta \cdot AC(q) \cdot q_3$. Hence, $\pi + M = -q_2 \cdot AC(q)$.

Thus the common objective function of PPP becomes:

$$\max_{k,a,e}(\lambda(B - (\pi + M + C)) + (1-\lambda)(\pi + M) - I - G) =$$
$$= \max_{k,a,e}(\lambda(B - C) + (1-2\lambda)(\pi + M) - I - G) = \max(\lambda(B - C) - (1-2\lambda) \cdot q_2 \cdot AC(q) - I - G)$$

When the share of local authorities in PPP $\lambda < 0.5$, $1 - 2\lambda > 0$, that is if PPP is controlled by the operator minimization of the scope of free-riding q_2 becomes an important factor for the PPP strategy.

DISCUSSION

Organizational and technological innovations

Apparently the alternative organizational structures cannot be directly compared in terms of social welfare criterion because players change their objective functions when PPP is formed. However, one may be interested in the incentives to make organizational and technological innovations by comparing optimum $\{e, a\}$ under alternative institutional arrangements and the first best benchmark case $\{e_{FB}, a_{FB}\}$. Several propositions follow from the model described in the previous section.

Proposition 1. Compensatory agreements imply lower level of organizational and technological innovations than PPP which in turn below socially optimum level.

Minimum level of innovations may be normalized to zero, though in practice there may be some lower bound that is guaranteed by minimum quality standards. The idea here is that compensatory agreements provide no incentives for agent to put any effort above this level. Since the quality of services in the model is determined by the level innovations establishment of PPP may lead to better quality of services. At the same time socially optimal level of organizational and infrastructure innovations is not achieved under PPP structure.

Empirical evidence of PPP creation in the form of joint ventures between local authorities and RZD supports this finding. For instance, Central SPC in Moscow region invested in new rolling stock, railway stations, etc. and demonstrated average annual growth of passengers of 9% for the last 4 years.

Investment in law enforcement

The scope of fare evasion on the suburban passenger transport in Russian makes the consideration of investment in law enforcement technologies (modeled for simplicity sake as a number of ticket inspectors on the railroad) very important. Under compensatory agreements local authorities may have mixed incentives concerning implementation of the level of control. On the one hand, increase in the level of control means that a number of obedient passengers increases as well. However the effect on the total demand and as a consequence on the gross welfare is negative. We begin with the analysis of how change in the level of control affects tariffs.

Proposition 2. Under Compensatory Agreements tariffs decrease with the level of control. On the contrary under PPP arrangement, greater control leads to greater tariffs.

The first part of this proposition states that under Compensatory Agreements tariff and the level of control move in different directions. This result is explained by two facts. First of all, fare-dodgers are not included into tariff determination therefore the quantity which is perceived by the government as an actual quantity for the tariff determination increases since part of free-riders move into the obedient subgroup. Secondly, suburban transport is natural monopoly therefore AC decreases with increasing quantity.

The second part of the proposition examines tariff's behavior under PPP regime. It is opposite to the result for the Compensatory Agreements that is explained by the fact that now fare-dodgers are accounted for tariff determination and increase in control negatively affects their number. This result seems to be interesting because it basically states that given the average cost pricing rule more accurate determination of total number of passengers leads to change in response of tariff to the level of control. Now we move to determination of optimal level of control under different regimes.

Proposition 3. Under Compensatory Agreements the optimal level of control is zero and equal to the first-best level of control. Under PPP arrangement the level of control decreases with the share of local authorities in PPP.

The first part of this proposition basically states that under Compensatory Agreements principal has no incentives to implement positive level of control since it decreases demand and therefore decreases consumer's benefits as well as welfare function since the consumer surplus is weighted with higher weight than producer surplus.

The second part of this proposition states that bargaining power of local authorities to maximize net consumer benefits under PPP regime increases with their share in PPP. On the contrary RZD has incentives to increase level of control and PPP arrangement could allow it to vote for such a policy at the shareholders' meeting.

As was mentioned above the direct welfare comparison of Compensatory Agreements and PPP is not possible due to different objective functions of the agents. However, some conclusions can be reached regarding the incentives of local authorities to create PPP.

Proposition 4. Local authorities can either benefit or lose when switching from Compensatory Agreements to PPP. Regional railways win from PPP creation in any case.

Consumers' welfare can change in either direction after PPP creation because PPP creation does not only lead to increase in quality of services but also implies change in tariffs and movement of consumers from one subgroup to another (e.g. fare-dodgers start to pay for their tickets) and increase in tariffs.

CONCLUDING REMARKS

The paper studies the effect that the establishment of a specific form of partnership between local authorities and regional railways. The main focus of this research was to understand how change of institutional arrangements affects the economic incentives to innovate. Firstly, this paper concludes that under Compensatory Agreements RZD minimizes technological and organizational innovations, because efforts create disutility for RZD and also increases quantity demanded. At the same time, tariffs are lower than economically sound therefore RZD has no incentives to encourage the demand for transportation by quality improvement. Under PPP arrangement both levels of technological and organizational innovations become positive resulting in better quality of services.

Under Compensational Agreements the increase in the level of control (greater number of ticket inspectors) decreases the tariff because higher level of control implies higher demand from obedient passengers. Since suburban transport is a natural monopoly, average cost decreases therefore the tariff (which is set at the level of average cost) decreases. Under PPP arrangement greater level of control leads to greater tariff.

The incentives of local authorities to partner with regional railways depend on a number of factors, such as: state of the regional budget, rail mode share in suburban transportation marker, preferences of the passengers (in particular how they value the quality of services) that also varies across regions.

Among possible extensions of the analysis there are: incorporation of the shadow cost of public funds, cost asymmetry and budget constraints.

REFERENCES

Bennett J., Iossa E. (2006a). Building and managing facilities for public services. *Journal of Public Economics*, **90**, 2143-2160.

Bennett J., Iossa E. (2006b). Delegation of contracting in private provision of public services. *Review of Industrial Organization*, **29**, 75-92.

Besley T., Ghatak M. (2001). Government versus private ownership of public goods. *The Quarterly Journal of Economics*, Vol. 116, No. 4, 1343-1372.

Bettignies J.E., Ross T.W. (2004). The economics of public-private partnerships. *Canadian Public Policy – Analyse de Politiques*, vol. XXX, No. 2, 135-154.

Davis K. (2005) PPPs and infrastructural investment. *The Australian Economic Review*, vol. 38, No.4, 439-444.

Hart O. (2003). Incomplete contracts and public ownership: remarks, and an application to public-private partnerships. *The Economic Journal*, **113**, 69-76.

Laffont J.J. and Martimort D. (2002). *The Theory of Incentives: the Principal-Agent Model*. Princeton University Press.

Laffont J.J. and Tirole J. (1993). *The Theory of Incentives in Procurement and Regulation*. MIT press.

Martimort D., Pouyet J. (2008). To build or not to build: Normative and positive theories of public-private partnerships. *International Journal of Industrial Organization*, **26**, 393-411.

Maskin E., Tirole J. (2008). Public-private partnerships and government spending limits. *International Journal of Industrial Organization*, **26**, 412-420.

Medda F. (2007). A game theory approach for the allocation of risks in transport public private partnerships. *International Journal of Project Management*, **25**, 213-218.

Sock-Yong Phang (2007). Urban Rail Transit PPPs: Survey and risk assessment of recent strategies. *Transport Policy*, **14**, 214-231.

Spackman M. (2002). Public-Private partnerships: lessons from the British approach. *Economic Systems*, **26**, 283-301.

Stanley J., Hensher D.A. (2008). Delivering partnerships for route bus services: a Melbourne case study. *Transportation Research Part A*, **42**, 1295-1301.

Nisar T.M. (2007). Risk management in public-private partnership contracts. *Public Organization Review*, **7**, 1-19.

APPENDIX

First-best

Let's find first-best conditions. They are characterized by $\max\limits_{a,e,k}(B-C-I-G)$. There are three control variables here a, e, k. So, FOCs are:

$$\frac{\partial(B-C-I-G)}{\partial k}=\frac{\partial(B_0(q)+u(a)+v(e)-C_0(q,e)+\phi(a)-\psi(e)-I_0-a-G(k)}{\partial k}=$$
$$=\frac{\partial(B_0(q)-C_0(q,e)-G(k)}{\partial k}=\frac{\partial(B_0(q)-C_0(q,e))}{\partial k}-\frac{dG}{dk}=\frac{\partial B_0(q)}{\partial q}\times\frac{\partial q}{\partial k}-\frac{\partial C_0}{\partial q}\times\frac{\partial q}{\partial k}-\frac{dG}{dk}=$$
$$=(\frac{\partial B_0(q)}{\partial q}-\frac{\partial C_0}{\partial q})\times\frac{\partial q}{\partial k}-\frac{dG}{dk}=(\frac{\partial B_0(q)}{\partial q}-\frac{\partial C_0}{\partial q})\times\frac{\partial q}{\partial \gamma}\times\frac{\partial \gamma}{\partial k}-\frac{dG}{dk}$$

Obviously, $\frac{\partial B_0(q)}{\partial q}-\frac{\partial C_0}{\partial q}\geq 0$. Since $\frac{\partial q}{\partial \gamma}>0$ the optimal k is 0 because $\frac{dG}{dk}>0$. QED

Consider optimal level of efforts:

$$\frac{\partial(B-C-I-G)}{\partial e}=\frac{\partial(B_0(q)+u(a)+v(e)-C_0(q,e)+\phi(a)-\psi(e)-I_0-a-G(k))}{\partial e}=$$
$$=\frac{\partial(B_0(q)+v(e)-C_0(q,e)-\psi(e))}{\partial e}=\frac{\partial B_0}{\partial q}\times\frac{\partial q}{\partial e}+\frac{dv}{de}-\frac{\partial C_0}{\partial q}\times\frac{\partial q}{\partial e}-\frac{\partial C_0}{\partial e}-\frac{d\psi}{de}=0$$

Thus the optimum level of e is implied by:

$\frac{\partial B_0}{\partial q}\times\frac{\partial q}{\partial e}+\frac{dv}{de}=\frac{\partial C_0}{\partial q}\times\frac{\partial q}{\partial e}+\frac{\partial C_0}{\partial e}+\frac{d\psi}{de}$ or $(\frac{\partial B_0}{\partial q}-\frac{\partial C_0}{\partial q})\times\frac{\partial q}{\partial e}+\frac{dv}{de}=\frac{\partial C_0}{\partial e}+\frac{d\psi}{de}$. Given the functional forms we assumed e should be strictly positive. QED.

Consider optimal level of infrastructure investment:

$$\frac{\partial(B-C-I-G)}{\partial a}=\frac{\partial(B_0(q)+u(a)+v(e)-C_0(q,e)-\phi(a)-\psi(e)-I_0-a-G(k)}{\partial a}=$$
$$=\frac{\partial(B_0(q)+u(a)-C_0(q,e)-\phi(a)-a)}{\partial a}=\frac{\partial B_0}{\partial q}\times\frac{\partial q}{\partial a}+\frac{du}{da}-\frac{\partial C_0}{\partial q}\times\frac{\partial q}{\partial a}-\frac{d\phi}{da}-1=0$$

Thus

$\frac{\partial B_0}{\partial q}\times\frac{\partial q}{\partial a}+\frac{du}{da}=\frac{\partial C_0}{\partial q}\times\frac{\partial q}{\partial a}+\frac{d\phi}{da}+1$ or $(\frac{\partial B_0}{\partial q}-\frac{\partial C_0}{\partial q})\times\frac{\partial q}{\partial a}+\frac{du}{da}=1+\frac{d\phi}{da}$. Thus $a>0$. QED.

Proof of Proposition 1

Organizational innovations

Consider the agent's objective function under compensatory scheme.

$\pi + M - I = -C(q_p + q_2) + C(q_p) - I_0 - a < 0$, where q_p - demand of the first and the third group of passengers. The agent's objective function is equivalent to $\min C(q_p + q_2) - C(q_p) + I_0 + a$. By differentiating with respect to e we obtain:

$$\frac{\partial(C(q_p + q_2) - C(q_p) + I_0 + a)}{\partial e} = \frac{\partial(C(q_p + q_2) - C(q_p))}{\partial e} =$$
$$= \frac{\partial(C_0(q_p + q_2) + \phi(a) + \psi(e) - C_0(q_p) - \phi(a) - \psi(e))}{\partial e} =$$
$$= \frac{\partial C_0(q_1 + q_2 + q_3)}{\partial(q_1 + q_2 + q_3)} \times \frac{\partial(q_1 + q_2 + q_3)}{\partial e} - \frac{\partial C_0(q_1 + q_3)}{\partial(q_1 + q_3)} \times \frac{\partial(q_1 + q_3)}{\partial e} =$$
$$= \left(\frac{\partial C(q_1 + q_2 + q_3)}{\partial(q_1 + q_2 + q_3)} - \frac{\partial C_0(q_1 + q_3)}{\partial(q_1 + q_3)}\right) \times \left(\frac{\partial q_1}{\partial e} + \frac{\partial q_3}{\partial e}\right) +$$
$$+ \frac{\partial C(q_1 + q_2 + q_3)}{\partial(q_1 + q_2 + q_3)} \times \frac{\partial q_2}{\partial e}$$

As $\partial^2 C_0 / \partial q^2 > 0$, $q_1 + q_2 + q_3 > q_1 + q_3 \equiv q_p$, and having in mind that $\partial C_0 / \partial q > 0$, $\partial^2 C_0 / \partial q^2 > 0$, $\forall \frac{\partial q_1}{\partial e}, \frac{\partial q_2}{\partial e}, \frac{\partial q_3}{\partial e} > 0$, we obtain:

$$\frac{\partial C(q_1 + q_2 + q_3)}{\partial(q_1 + q_2 + q_3)} - \frac{\partial C(q_1 + q_3)}{\partial(q_1 + q_3)} > 0, \text{ thus } \frac{\partial(C(q_p + q_2) - C(q_p) + I_0 + a)}{\partial e} > 0$$

Note that first-best level of efforts is determined by equation:

$$\left(\frac{\partial B_0}{\partial q} - \frac{\partial C_0}{\partial q}\right) \times \frac{\partial q}{\partial e} + \frac{dv}{de} = \frac{\partial C_0}{\partial e} + \frac{d\psi}{de}.$$

Obviously the first-best e is positive. Therefore under compensatory scheme agent puts less effort than socially optimal.

Now consider the optimum level of efforts for the PPP structure.

The objective of PPP can be written as $\max(\lambda(B - C) - (1 - 2\lambda) \cdot q_2 \cdot AC(q) - I - G)$

Let's differentiate this function with respect to e:

$$\frac{\partial(\lambda(B - C) - (1 - 2\lambda) \times q_2 \times AC(q) - I - G)}{\partial e} = \lambda \times \frac{\partial(B - C)}{\partial e} - (1 - 2\lambda) \times \frac{\partial(q_2 \times AC(q))}{\partial e} =$$
$$= \lambda \frac{\partial(B - C)}{\partial e} - (1 - 2\lambda) \times \left(AC(q) \times \frac{\partial q_2}{\partial e} + q_2 \times \frac{\partial AC(q)}{\partial e}\right)$$

Consider

$$AC(q)\times\frac{\partial q_2}{\partial e}+q_2\times\frac{\partial AC(q)}{\partial e}=AC(q)\times\frac{\partial q_2}{\partial e}+q_2\times\frac{\partial AC(q)}{\partial q}\times\frac{\partial q}{\partial e}=(AC(q)+q\times\frac{\partial AC(q)}{\partial q})\times\frac{\partial q_2}{\partial e}+$$
$$+q_2\times\frac{\partial AC(q)}{\partial q}\times\frac{\partial(q_1+q_3)}{\partial e}-(q_1+q_3)\times\frac{\partial AC(q)}{\partial q}\times\frac{\partial q_2}{\partial e}=(AC(q)+q\times\frac{\partial AC(q)}{\partial q})\times\frac{\partial q_2}{\partial e}+$$
$$+\frac{\partial AC(q)}{\partial q}\times(q_2\times\frac{\partial(q_1+q_3)}{\partial e}-(q_1+q_3)\times\frac{\partial q_2}{\partial e})$$

Consider $\frac{\partial AC(q)}{\partial q}=\frac{\partial(C(q)/q)}{\partial q}=\frac{MC(q)\times q-C(q)}{q^2}=\frac{MC(q)-AC(q)}{q}$. Thus,

$$(AC(q)+q\times\frac{\partial AC(q)}{\partial q})\times\frac{\partial q_2}{\partial e}+\frac{\partial AC(q)}{\partial q}\times(q_2\times\frac{\partial(q_1+q_3)}{\partial e}-(q_1+q_3)\times\frac{\partial q_2}{\partial e})=$$
$$=(AC+q\times\frac{MC(q)-AC(q)}{q})\times\frac{\partial q_2}{\partial e}+\frac{\partial AC(q)}{\partial q}\times(q_2\times\frac{\partial(q_1+q_3)}{\partial e}-(q_1+q_3)\times\frac{\partial q_2}{\partial e})=$$
$$=\frac{\partial C(q)}{\partial q}\times\frac{\partial q_2}{\partial e}+\frac{\partial AC(q)}{\partial q}\times(q_2\times\frac{\partial(q_1+q_3)}{\partial e}-(q_1+q_3)\times\frac{\partial q_2}{\partial e})$$

$\forall\frac{\partial C(q)}{\partial q},\frac{\partial q_2}{\partial e}>0$, so $\frac{\partial C(q)}{\partial q}\times\frac{\partial q_2}{\partial e}$

However, $\frac{\partial AC(q)}{\partial q}<0$ and the sign of $q_2\times\frac{\partial(q_1+q_3)}{\partial e}-(q_1+q_3)\times\frac{\partial q_2}{\partial e}$ can be either negative or positive. So, the sign of $AC(q)\times\frac{\partial q_2}{\partial e}+q_2\times\frac{\partial AC(q)}{\partial e}$ can't be determined analytically and depends on concrete functions of q_1,q_2,q_3.

Let's put the first-best level of efforts into the derivative of the PPP's objective function with respect to the level of efforts.

$$\frac{\partial(\lambda(B-C)-(1-2\lambda)\times q_2\times AC(q)-I-G)}{\partial e}\bigg|_{e_{FB}}=$$
$$=\lambda\frac{\partial(B-C)}{\partial e}\bigg|_{e_{FB}}-(1-2\lambda)\times(AC(q)\times\frac{\partial q_2}{\partial e}+q_2\times\frac{\partial AC(q)}{\partial e})\bigg|_{e_{FB}}$$

From the analyses of first-best conditions we know that $\lambda\frac{\partial(B-C)}{\partial e}\Big|_{e_{FB}}=0$. Hence,

$$\lambda\frac{\partial(B-C)}{\partial e}\bigg|_{e_{FB}}-(1-2\lambda)\times(AC(q)\times\frac{\partial q_2}{\partial e}+q_2\times\frac{\partial AC(q)}{\partial e})\bigg|_{e_{FB}}=$$
$$=-(1-2\lambda)\times(AC(q)\times\frac{\partial q_2}{\partial e}+q_2\times\frac{\partial AC(q)}{\partial e})\bigg|_{e_{FB}}$$

and can have any sign. Under certain assumptions, the level of efforts under PPP regime e_{PPP} corresponds to the first-best level e_{FB}. In general, $\lambda\frac{\partial(B-C)}{\partial e}-(1-2\lambda)\times(AC(q)\times\frac{\partial q_2}{\partial e}+q_2\times\frac{\partial AC(q)}{\partial e})$ is expected to be positive while there may be the case where it is negative for any e. Thus it can be concluded that e_{PPP} may be either positive or zero.

Technological innovations

Let's take the first derivative of this function with respect to a. Analogically, we get

$$\frac{\partial(C(q_p+q_2)-C(q_p)+I_0+a)}{\partial a}=(\frac{\partial C(q_1+q_2+q_3)}{\partial(q_1+q_2+q_3)}-\frac{\partial C(q_1+q_3)}{\partial(q_1+q_3)})\times$$

$$\times(\frac{\partial q_1}{\partial a}+\frac{\partial q_3}{\partial a})+\frac{\partial C(q_1+q_2+q_3)}{\partial(q_1+q_2+q_3)}\times\frac{\partial q_2}{\partial a}+1>0$$

As $\partial AC/\partial q<0$, $\partial C_0/\partial q>0$, $\partial^2 C_0/\partial q^2>0$, $\forall\frac{\partial q_1}{\partial a},\frac{\partial q_2}{\partial a},\frac{\partial q_3}{\partial a}>0$.

So optimal for agent level of infrastructure investment is 0.

Note that equation that determines the socially optimal level of infrastructure investments - $(\frac{\partial B_0}{\partial q}-\frac{\partial C_0}{\partial q})\times\frac{\partial q}{\partial a}+\frac{du}{da}=1+\frac{d\phi}{da}$ implies that socially optimal level of a is positive. So, under current situation agent under invests in infrastructure investments.

Now consider PPP regime.

$$\frac{\partial(\lambda(B-C)-(1-2\lambda)\times q_2\times AC(q)-I-G)}{\partial a}=\lambda\times\frac{\partial(B-C)}{\partial a}-(1-2\lambda)\times\frac{\partial(q_2\times AC(q))}{\partial a}-1=$$

$$=\lambda\frac{\partial(B-C)}{\partial a}-(1-2\lambda)\times(AC(q)\times\frac{\partial q_2}{\partial a}+q_2\times\frac{\partial AC(q)}{\partial a})-1$$

The sign of expression below is ambiguous:

$$(AC(q)+q\times\frac{\partial AC(q)}{\partial q})\times\frac{\partial q_2}{\partial a}+\frac{\partial AC(q)}{\partial q}\times(q_2\times\frac{\partial(q_1+q_3)}{\partial a}-(q_1+q_3)\times\frac{\partial q_2}{\partial a})=$$

$$=\frac{\partial C(q)}{\partial q}\times\frac{\partial q_2}{\partial a}+\frac{\partial AC(q)}{\partial q}\times(q_2\times\frac{\partial(q_1+q_3)}{\partial a}-(q_1+q_3)\times\frac{\partial q_2}{\partial a})$$

therefore the expression $\frac{\partial(\lambda(B-C)-(1-2\lambda)\times q_2\times AC(q)-I-G)}{\partial a}$ can be either negative for any a or can be positive for certain levels of a. Furthermore,

$$\left.\frac{\partial(\lambda(B-C)-(1-2\lambda)\times q_2\times AC(q)-I-G)}{\partial a}\right|a_{FB}=$$

$$=\lambda\left.\frac{\partial(B-C)}{\partial a}\right|a_{FB}-1-(1-2\lambda)\times\left.(AC(q)\times\frac{\partial q_2}{\partial a}+q_2\times\frac{\partial AC(q)}{\partial a})\right|a_{FB}=$$

$$=-(1-2\lambda)\times\left.(AC(q)\times\frac{\partial q_2}{\partial a}+q_2\times\frac{\partial AC(q)}{\partial a})\right|a_{FB}$$

can be either positive or negative therefore a_{PPP} can correspond to a_{FB} in any way.

Proof of Proposition 2

By differentiating *q* and *T* with respect to *k* we obtain:

$$\frac{\partial q}{\partial k} = \frac{\partial q}{\partial \gamma} \cdot \frac{\partial \gamma}{\partial k} < 0 .$$

$$\frac{\partial T}{\partial k} = \frac{\partial AC(q_1+q_3)}{\partial k} = \frac{\partial AC(q_1+q_3)}{\partial(q_1+q_3)} \times \frac{\partial q_1}{\partial k} + \frac{\partial AC(q_1+q_3)}{\partial(q_1+q_3)} \times \frac{\partial q_3}{\partial k} = \frac{\partial AC(q_1+q_3)}{\partial(q_1+q_3)} \times \frac{\partial q_1}{\partial \gamma} \times \frac{\partial \gamma}{\partial k} +$$
$$+ \frac{\partial AC(q_1+q_3)}{\partial(q_1+q_3)} \times \frac{\partial q_3}{\partial \gamma} \times \frac{\partial \gamma}{\partial k} = \frac{\partial AC(q_1+q_3)}{\partial(q_1+q_3)} \times \frac{\partial q_1}{\partial \gamma} \times \frac{\partial \gamma}{\partial k} = \frac{\partial AC(q_1+q_3)}{\partial(q_1+q_3)} \times (-\frac{\partial q_1(1-\gamma,T)}{\partial 1-\gamma}) \times \frac{\partial \gamma}{\partial k} =$$
$$= -\frac{\partial AC(q_1+q_3)}{\partial(q_1+q_3)} \times \frac{\partial q_1(1-\gamma,T)}{\partial 1-\gamma} \times \frac{\partial \gamma}{\partial k} < 0$$

Since $\frac{\partial q_1(1-\gamma,T)}{\partial 1-\gamma} > 0$, $\frac{\partial \gamma}{\partial k} < 0$, , $\frac{\partial q_3}{\partial \gamma} = 0$

Now consider the PPP case.

$$\frac{\partial T}{\partial k} = \frac{\partial AC(q_1+q_2+q_3)}{\partial k} = \frac{\partial AC(q)}{\partial q} \times \frac{\partial q}{\partial k} > 0 \text{ since } \forall \frac{\partial AC(q)}{\partial q}, \frac{\partial q}{\partial k} < 0$$

Proof of Proposition 3

Consider the principal objective function in current situation.

$$B(q) - (Tq_1 + (1-\beta)Tq_3) - M + \mu(\pi + M) - G = B(q) - G - (Tq_1 + (1-\beta)Tq_3 + \beta Tq_3) +$$
$$+ \mu(\pi + M) = B(q) - G - T(q_1 + q_3) + \mu(\pi + M) = B(q) - G - AC(q_1 + q_3) \times (q_1 + q_3) +$$
$$+ \mu(\pi + M) = B(q) - G - C(q_p) + \mu(C(q_p) - C(q)) = B(q) - G - (1-\mu)C(q_p) - \mu C(q) =$$
$$= B(q) - G - C(q) + C(q) - (1-\mu)C(q_p) - \mu C(q) = B(q) - G - C(q) + (1-\mu)(C(q) - C(q_p))$$

Let’s find the optimal for principal level k in current situation. For the later analyses let’s denote optimal for current situation level of control as k_C

Now consider $C(q) - C(q_p)$. Let’s differentiate this expression with respect to k.

$$\frac{\partial(C(q_1+q_2+q_3)-C(q_1+q_3))}{\partial k}=\frac{\partial C(q_1+q_2+q_3)}{\partial(q_1+q_2+q_3)}\times\frac{\partial(q_1+q_2+q_3)}{\partial k}-$$

$$-\frac{\partial C(q_1+q_3)}{\partial(q_1+q_3)}\times\frac{\partial(q_1+q_3)}{\partial k}=\frac{\partial C(q_1+q_2+q_3)}{\partial(q_1+q_2+q_3)}\times(\frac{\partial q_1}{\partial k}+\frac{\partial q_2}{\partial k}+\frac{\partial q_3}{\partial k})-\frac{\partial C(q_1+q_3)}{\partial(q_1+q_3)}\times(\frac{\partial q_1}{\partial k}+\frac{\partial q_3}{\partial k})=$$

$$=\frac{\partial C(q_1+q_2+q_3)}{\partial(q_1+q_2+q_3)}\times(\frac{\partial q_1}{\partial k}+\frac{\partial q_2}{\partial k})-\frac{\partial C(q_1+q_3)}{\partial(q_1+q_3)}\times\frac{\partial q_1}{\partial k}=(\frac{\partial C(q_1+q_2+q_3)}{\partial(q_1+q_2+q_3)}-\frac{\partial C(q_1+q_3)}{\partial(q_1+q_3)})\times$$

$$\times(\frac{\partial q_1}{\partial k}+\frac{\partial q_3}{\partial k})+\frac{\partial C(q_1+q_2+q_3)}{\partial(q_1+q_2+q_3)}\times\frac{\partial q_2}{\partial k}=(\frac{\partial C(q_1+q_2+q_3)}{\partial(q_1+q_2+q_3)}-\frac{\partial C(q_1+q_3)}{\partial(q_1+q_3)})\times\frac{\partial q_1}{\partial k}+$$

$$+\frac{\partial C(q_1+q_2+q_3)}{\partial(q_1+q_2+q_3)}\times\frac{\partial q_2}{\partial k}=(\frac{\partial C(q)}{\partial q}-\frac{\partial C(q_p)}{\partial q_p})\times\frac{\partial q_1}{\partial k}+\frac{\partial C(q)}{\partial q}\times\frac{\partial q_2}{\partial k}=$$

$$=((\frac{\partial C(q)}{\partial q}-\frac{\partial C(q_p)}{\partial q_p})\times\frac{\partial q_1}{\partial \gamma}+\frac{\partial C(q)}{\partial q}\times\frac{\partial q_2}{\partial \gamma})\times\frac{\partial \gamma}{\partial k}$$

As $\partial^2 C_0 / \partial q^2 > 0$ then $\frac{\partial C(q)}{\partial q}-\frac{\partial C(q_p)}{\partial q_p}>0$ hence $(\frac{\partial C(q)}{\partial q}-\frac{\partial C(q_p)}{\partial q_p})\times\frac{\partial q_1}{\partial \gamma}<0$

From the analyses above we know that $\frac{\partial q}{\partial \gamma}=\frac{\partial q_1}{\partial \gamma}+\frac{\partial q_2}{\partial \gamma}>0$ therefore $\frac{\partial q_2}{\partial \gamma}>-\frac{\partial q_1}{\partial \gamma}>0$.

Furthermore, $\frac{\partial C(q)}{\partial q}>(\frac{\partial C(q)}{\partial q}-\frac{\partial C(q_p)}{\partial q_p})>0$. These two inequalities lead to the fact that $\frac{\partial q_2}{\partial \gamma}\times\frac{\partial C(q)}{\partial q}>(\frac{\partial C(q)}{\partial q}-\frac{\partial C(q_p)}{\partial q_p})\times(-\frac{\partial q_1}{\partial \gamma})$ hence $(\frac{\partial C(q)}{\partial q}-\frac{\partial C(q_p)}{\partial q_p})\times\frac{\partial q_1}{\partial \gamma}+\frac{\partial C(q)}{\partial q}\times\frac{\partial q_2}{\partial \gamma}>0$ therefore $((\frac{\partial C(q)}{\partial q}-\frac{\partial C(q_p)}{\partial q_p})\times\frac{\partial q_1}{\partial \gamma}+\frac{\partial C(q)}{\partial q}\times\frac{\partial q_2}{\partial \gamma})\times\frac{\partial \gamma}{\partial k}<0$.

Let’s differentiate the objective function with respect to k.

$$\frac{\partial(B(q)-G-C(q)+(1-\mu)\times(C(q)-C(q_p)))}{\partial k}=\frac{\partial(B(q)-C(q))}{\partial k}+(1-\mu)\times\frac{\partial(C(q)-C(q_p))}{\partial k}-\frac{dG}{dk}=$$

$$=\frac{\partial(B(q)-C(q))}{\partial q}\times\frac{\partial q}{\partial k}+(1-\mu)\times\frac{\partial(C(q)-C(q_p))}{\partial k}-\frac{dG}{dk}$$

From the analyses of first-best, $\frac{\partial(B(q)-C(q))}{\partial q}\times\frac{\partial q}{\partial k}<0$

By definition $\frac{dG}{dk}>0$.

From the analyses above, $(1-\mu)\times\frac{\partial(C(q)-C(q_p))}{\partial k}<0$

Thus, $\frac{\partial(B(q)-G-C(q)+(1-\mu)\times(C(q)-C(q_p)))}{\partial k}<0$ hence $k_C=k_{FB}=0$

Consider the optimal for PPP level of control.

Let’s differentiate the objective function of PPP with respect to k.

$$\frac{\partial(\lambda(B-C)-(1-2\lambda)\times q_2\times AC(q)-I-G)}{\partial k}=\lambda\times\frac{\partial(B-C-G)}{\partial k}-(1-2\lambda)\times\frac{\partial(q_2\times AC(q))}{\partial k}=$$
$$=\lambda\frac{\partial(B-C-G)}{\partial k}-(1-2\lambda)\times(AC(q)\times\frac{\partial q_2}{\partial k}+q_2\times\frac{\partial AC(q)}{\partial q}\times\frac{\partial q}{\partial k})$$

Consider $AC(q)\times\frac{\partial q_2}{\partial k}+q_2\times\frac{\partial AC(q)}{\partial q}\times\frac{\partial q}{\partial k}$. $\forall\frac{\partial q_2}{\partial k},\frac{\partial AC(q)}{\partial q}<0$, $\forall AC(q),q_2,\frac{\partial q}{\partial k}>0$ hence $AC(q)\times\frac{\partial q_2}{\partial k}+q_2\times\frac{\partial AC(q)}{\partial q}\times\frac{\partial q}{\partial k}<0$.

From the analyses of first-best, $\frac{\partial(B-C-G)}{\partial k}<0$. Hence there may be 2 cases. The first case is where $\frac{\partial(B-C-G)}{\partial k}>\frac{1-2\lambda}{\lambda}\times(AC(q)\times\frac{\partial q_2}{\partial k}+q_2\times\frac{\partial AC(q)}{\partial q}\times\frac{\partial q}{\partial k})$ for some k. In this case $k_{PPP}>k_{FB}=0$. The second case is where $\frac{\partial(B-C-G)}{\partial k}<\frac{1-2\lambda}{\lambda}\times(AC(q)\times\frac{\partial q_2}{\partial k}+q_2\times\frac{\partial AC(q)}{\partial q}\times\frac{\partial q}{\partial k})$ for all k. In this case $k_{PPP}=k_{FB}=0$. We do not consider the third case where $\frac{\partial(B-C-G)}{\partial k}>\frac{1-2\lambda}{\lambda}\times(AC(q)\times\frac{\partial q_2}{\partial k}+q_2\times\frac{\partial AC(q)}{\partial q}\times\frac{\partial q}{\partial k})$ for all k because of assumptions on the behavior of functions which are used in this expression.

To sum up, under PPP regime the optimal level of control may be positive or zero depending on concrete functions.

An interesting observation concerning the share of principal in PPP.

$$\frac{\partial(\lambda\frac{\partial(B-C-G)}{\partial k}-(1-2\lambda)\times(AC(q)\times\frac{\partial q_2}{\partial k}+q_2\times\frac{\partial AC(q)}{\partial q}\times\frac{\partial q}{\partial k}))}{\partial\lambda}=$$
$$=\frac{\partial(B-C-G)}{\partial k}+2(AC(q)\times\frac{\partial q_2}{\partial k}+q_2\times\frac{\partial AC(q)}{\partial q}\times\frac{\partial q}{\partial k})<0$$

So, with increase in λ the derivative of the objective function of PPP with respect to k decreases. To put it in other words, with increase of share of LA in PPP the chance of positive optimal k decreases (that is the chance of $\lambda\frac{\partial(B-C-G)}{\partial k}-(1-2\lambda)\times(AC(q)\times\frac{\partial q_2}{\partial k}+q_2\times\frac{\partial AC(q)}{\partial q}\times\frac{\partial q}{\partial k})$ being positive decreases).

Proof of Proposition 4.

Analyses of consumers preferences.

Consumer's preferences area is represented by the benefits function.

$B=B_0(q)+u(a)+v(e)-T(q_1+(1-\beta)q_3)$

Let's find the difference between the net consumer's surplus in PPP and Compensatory Arrangements.

$\Delta B = (B_0(q_{PPP}) - B_0(q_{CS})) + (u(a_{PPP}) - u(a_{CS})) + (v(e_{PPP}) - v(e_{CS})) -$
$-(T_{PPP}(q_{1PPP} + (1-\beta)q_{3PPP}) - T_{CS}(q_{1CS} + (1-\beta)q_{3CS})) =$
$= (B_0(q_{PPP}) - (T_{PPP}(q_{1PPP} + (1-\beta)q_{3PPP})) - (B_0(q_{CS}) - T_{CS}(q_{1CS} + (1-\beta)q_{3CS})) +$
$+ (u(a_{PPP}) - u(a_{CS})) + (v(e_{PPP}) - v(e_{CS}))$

$u(a_{PPP}) \geq u(a_{CS})$ since $a_{PPP} \geq a_{CS}$. Analogically $v(e_{PPP}) \geq v(e_{CS})$ since $e_{PPP} \geq e_{CS}$.
Consider total differential of quantity when we move from Compensatory Arrangements to PPP regime $dq = \frac{\partial q}{\partial e} \times de + \frac{\partial q}{\partial a} \times da + \frac{\partial q}{\partial k} \times dk$.

Note that $\forall \frac{\partial q}{\partial e}, \frac{\partial q}{\partial a} > 0$, $\frac{\partial q}{\partial k} < 0$ and $\forall de, da, dk \geq 0$ since $e_{PPP} \geq e_{CS}$, $a_{PPP} \geq a_{CS}$, $k_{PPP} \geq k_{CS}$. So, dq can be either positive or negative depending on the concrete functions. It can be shown that $\forall dq_1, dq_2, dq_3$ has the same sign as dq. Furthermore, $B_0(q_{PPP}) - B_0(q_{CS})$ has the same sign as dq since $B_0(q)$ increases.
This leads us to conclusion that the gain of consumers from creating PPP is ambiguous and depends on the concrete functions.

The trade-off between Compensatory Agreement and PPP

Let’s find out how LA and RZD decide whether or not to enter PPP.
Let’s make some notations.
$\prod_1 = \pi_1 + M_1 - I_1$ is what agent gets under Compensatory Arrangements, where

$\pi = Tq_1 + (1-\beta)Tq_3 - C(q_f)$

$M = C(q_p - \varsigma q_3) - T \times q_p + \beta T q_3 = C(q_p - \varsigma q_3) - T \times (q_p - \beta q_3)$

$\prod_2 = \pi_2 + M_2$ is what agent gets under PPP regime (π_2 and M_2 are different from π_1 and M_1)
It is easily seen from the previous analyses that $\prod_2 > \prod_1$
Now consider objective function of principal under Compensatory Arrangements.

$B - Tq + \mu(\pi + M) - M - G$

Let’s denote the outcome (i.e. the value of this function after agent sets both levels of efforts and investments and principal sets level of control) as $SW_1(e_{CS}, a_{CS}, k_{CS})$
The choice of “Compensatory Scheme versus PPP creation” presents a two options between the principal: leave the Compensatory Arrangements and get $SW_1(e_{CS}, a_{CS}, k_{CS})$ or accept the PPP structure and get new variables of a, e and k. Since when principal decides whether or not to construct the joint venture with RZD it uses objective function from current situation then the outcome that matters for principal is $SW_2(e_{PPP}, a_{PPP}, k_{PPP}) = (B + \mu(\pi + M) - M - G)\big|_{e_{PPP}, a_{PPP}, k_{PPP}}$
From analyzing of consumers’ situation we can analogically conclude that the change from Compensatory Arrangements to PPP is ambiguous from society’s point of view, nothing can be predicted without knowledge of the actual strategic functions.