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Trusting partnerships in a regulatory game: The case of suburban railway transport in Russia

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ABSTRACT

The paper addresses the existing cross-regional diversity of delivery models in the sector of suburban passenger transportation in Russia by building a formal model of endogenous organisational choice. We develop a conceptual game-theoretic framework that allows for the trusting partnership to have become equilibrium in a regulatory bargaining game with delegation. The monopoly service provider initiates a more cooperative relationship with regional authorities by offering a share in the joint venture. The latter being benevolent welfare maximiser either accepts or rejects the offer taking into account transportation market characteristics, local budget constraints, information structure, as well as socio-economic and political factors. Once the partnership is formed the private information of the parties is revealed and information rent is eliminated creating the room for welfare improvement. However, ex ante rational organisational choice to form a trusting partnership may not lead to welfare improvement ex post. In the extended model we consider how concessionary passengers and fare-dodgers affect the bargaining outcomes. Our results can be generalized to characterize the diversity of organizational choices in the public sector.

1. Introduction

In many countries suburban railway transport are running on losses and are seeking alternative delivery models to lessen the subsidy burden on local governments, and Russia is not an exception. At the regional level these services have been provided by the local divisions of the vertically integrated infrastructure monopoly 'Russian Railways' JSC (RZD) that also serves the markets for cargo and passenger rail transportation. Being regulated by the local authorities that set tariffs at the level that is deemed to be socially optimal, passenger services traditionally experience negative operating profits. What makes the financial results of railway undertakings even worse is the significant share of concessionary passengers (about 10–30%) that are only partially compensated from federal and regional budgets as well as widespread fare-evasion (another 10–30% of patronage) that is virtually unstoppable by ridiculously small fines amounting at approximately the charge for a one-way ticket to the 7th tariff zone.

Regional passenger service providers are regulated under a cost-based approach when the difference between reported costs and revenues from ticket sales is compensated through a lump-sum subsidy. However, when regional budgets have a lack of funds the transfer is insufficient to cover all the costs incurred. Moreover, the other reason for the only partial compensation of the reported losses of the monopoly is the lack of trust between the public authorities and the regulated monopoly. Specifically, by imposing strict budget constraints on the monopoly, regulators attempt to extract information rent that stems from the asymmetry of information about costs incurred by the monopoly. The standard assumption of the binding participation constraint evidently does not work in Russia where cross-subsidies of loss-making passenger transport from high-margin cargo transportation fill the gap. This is an example of a specific form of indirect income redistribution from the corporate sector that pays RZD higher infrastructure charges and tariffs for cargo transportation to public sector where RZD reports losses.

Intuitively, local authorities would always prefer such a state of affairs, since a public service is delivered at the expense of RZD and ultimately the corporate sector rather than regional budgets. However, this may not be socially optimal since price distortions in the corporate sector due to large mark-ups for transportation of high-value goods may be significant. Moreover, after the complete

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privatisation of RZD's ‘first daughter’, the First Cargo Company, the former (in the person of its ‘second daughter’, the Federal Cargo Company) faces rather fierce competition in the downstream market for wagon operations. Thus extra revenues from high-margin businesses may be skimmed by an independent rival which has no public service obligations. Hence, it is in the interest of RZD to change the status quo. Apparently, the two actors – local authorities and RZD – seem to be engaged in a bargaining game which (if played cooperatively) may create room for welfare improvement.

The rules of the game and the general strategy of passenger transportation service provisions were set by the Government that adopted a stage-by-stage approach to railway reform on May 18, 2001. The plan calls for the development of explicit Public Service Obligation (PSO) compensation contracts for the support of social requirements of suburban passenger transport. Unfortunately, adequate sources for local budgets were never clearly defined and provided. In these circumstances RZD initiated the process of establishment Suburban Passenger Companies (SPCs) in the form joint ventures with local authorities. In essence, RZD has been offering local authorities a share in the charter capital of newly created companies thus proposing a specific form trusting partnership (see Stanley & Hensher, 2008 for the definition). This form of cooperation has been proposed by RZD as an optional alternative delivery model in the sector. In turn, local authorities have been free to engage in trusting partnership depending on transportation market characteristics, local budget constraints, information structure, as well as socio-economic and political factors in the particular region.

An interview-based sociological survey conducted by the Higher School of Economics in 2010 demonstrated very low incentives for local authorities to participate in the suburban railway transport reform. Among 65 surveyed regions 17 (26%) reported that they were not involved in the reform and 28 regions (43%) played passive role. Only 8 (12%) regions saw themselves as active participants of the reform and 12 (19%) regions were likely to be involved with some reservations. Different geographical factors, socio-economic conditions as well as political and local cultural contexts across 73 Russian regions with suburban railways affected the reform pace. The observed variety of shareholding structures of 28 SPCs established so far provides the relevant factual background to pose a number of research questions: Why some regional authorities have agreed to partner with the service provider and some have not? Will trusting partnership lead to welfare improvement? What is the offered share in trusting partnership in order to be accepted? What factors affect the probability of trusting partnership creation and how?

This paper addresses the existing cross-regional diversity of delivery models in the sector of suburban passenger transportation in Russia by building a formal model of endogenous organisational choice. We develop a conceptual game-theoretic framework that allows for the trusting partnership to have become an equilibrium in a bargaining game rather than a predetermined outcome.

The building blocks of our model are as follows: First, a standard regulator's objective function which is commonly used in the literature puts a lower weight on the firm's profit reflecting certain redistribution concerns of the government. Second, we impose budget constraint on the local government and assume it to be binding reflecting the case when a lack of public funds affects organizational choice in the sector. By introducing further the asymmetry of information regarding the firm's costs we create room for bargaining between the firm and regulator. Then we define the conditions for trusting arrangements to become an equilibrium outcome in the above mentioned bargaining game.

For the sake of the tractability of the model we use a number of simplifying assumptions like linear demand function and constant unit cost of services. In the basic model the service provider is assumed to have private information about its costs. It proposes to establish a trusting partnership with local authorities to share this information in exchange for greater representation of its interest in the future partnership. Thus the information structure of the regulatory game ex ante and ex post plays a crucial role for our findings.

The rest of the paper is structured as follows. Section 2 provides a brief literature review and highlights the importance of developing a specific analytical framework to study the questions of interest. In Section 3, relevant parties of the game, their objectives, choice variables and payoffs are determined for the two different delivery models. Section 4 discusses two interesting extensions – the case of concessionary passengers and fare-dodgers. Section 5 concludes.

2. Literature review

The proposed model has been inspired by several seemingly unrelated streams of studies. We incorporate the idea of ‘selling authority’ of Lim (2012) into the standard regulatory framework of Armstrong and Sappington (2006) who emphasize the role of imperfect information in a regulatory game. We modify this approach by introducing trusting partnership as an organisational alternative that ultimately reshapes political and institutional environment of the standard regulatory game. In particular, similar to Laffont (1999, 2000) we view trusting partnership as a better informed decision maker with specific objective function. Having this option, regulator as a benevolent social welfare maximiser may or may not wish to delegate to the trusting partnership the contracting process, including tariff setting.

The idea of delegated contracting is considered by Bennett and Iossa (2006b) who treat the public-private partnership (PPP) as a joint venture between the private sector (service provider) and a public sector. Compared to a public sector entity, the PPP has a greater profit orientation and a relatively smaller concern for social benefit. Their analysis suggests that the weight placed by the PPP on social benefits is a critical factor to the success of delegated contracting. The authors point out that the formation of a corporate share structure of the PPP should be a matter of particular concern, while the existing approach to modelling PPP[1] pays little attention to the process of ex ante bargaining over PPP structure. We depart from this literature by making the very process of delegation endogenous and developing a specific political economy framework for the analysis of PPP creation in the sector of suburban passenger transportation in Russia.

Our approach can be generalized to the study of political feasibility of institutional reform in public sector (see Boardman & Vining, 2012 for the discussion of political economy perspective on PPPs and Chong, Huet, Saussier, & Steiner, 2006 for the empirical study of the endogenous nature of organisational choice). As pointed out by Maskin and Tirole (2008) there is substantial evidence that political project choices are influenced significantly by the desire to please constituencies and by budgetary constraints. We believe our model provides for a tractable way to see the role of redistribution concerns and budget limits in organisational choice. Still we assume that the private partner does not capture the procurement process by colluding with the government and that government retains its benevolence.[2]

Practical developments of trusting partnerships in public transport have run ahead of academic analysis. Among a number of

[1] Bennett and Iossa (2006a), Martimort and Pouyet (2008), Carmona (2010), Iossa and Martimort (2012) etc. are examples.

[2] see Laffont and Martimort (1999), Martimort (1999) for the case of non-benevolent or captured government agencies.

requirements for successful partnering in the sector summarized by Stanley and Hensher (2008) are: common objectives of the parties, agreed governance arrangements and risk-sharing rules (see also Medda, 2007; Phang, 2007), relationship management, trust, transparency and accountability. This insight is incorporated in the proposed model below.

3. The model

In this section we describe the basic regulatory model that will be further modified and extended. As a benchmark and a basis for welfare comparison, we use the case of the status quo when local authorities (the regulator) are obliged to undertake a public service project (suburban transportation by rail) which is viewed as being socially beneficial. The regulator can employ two delivery models: 1) centralised contracting in the form of a Public Service Obligation (PSO) when a monopoly service provider is regulated through tariffs and lump-sum transfers, and 2) delegated contracting when tariff setting is determined by the joint venture between public and private sector agents. The joint venture is voluntary established in the form of trusting partnership with the objective to maximize a linear combination of social welfare and profit.

3.1. Public service obligation

3.1.1. Agents' objectives and choice variables

PSO is modelled as a regulated contract for transport service provision. The monopoly service provider is obligated to serve all customers at the regulated unit price, P. The demand curve for the single homogenous product is common knowledge and assumed to be linear $Q(P) = a - bP$. The firm is assumed to incur unit cost of production θ and no fixed cost.[3] The regulator sets both unit price, P, and determines a lump-sum transfer payment, T_{RS}, from taxpayers to the firm.

The firm maximises its profit $\pi = Q(P)\cdot[P-\theta] + T_{RS}$ while the benevolent regulator pursues the goal of maximizing the expected value of social welfare, $W = V(P) - [1+\lambda]T_{RS} + \alpha\pi$, where $V(P)$ denotes consumer surplus, which is reduced by the transfer payment $[1+\lambda]T_{RS}$ estimated at the social cost of public funds, $\lambda \geq 0$. Regulators often have implicit distributional concerns and value the consumer surplus less than the producer surplus, i.e. $\alpha \leq 1$. This parameter plays a crucial role in our further analysis.

3.1.2. Hard budget and soft participation constraints

When the benevolent regulator, being the social welfare maximiser, values consumer welfare at least as highly as the welfare of the firm's shareholders, the tariff setting itself accompanied by the provision of a lump-sum transfer implies a certain redistribution policy between transport end-users and taxpayers on the one hand and the public and the private sector on the other hand. Along with political and socio-economic factors affecting preferences for redistribution, the ownership structure of the service provider matters. In fact, when α is relatively low (thus the tariff is set at a low level which is socially optimal due to redistribution concerns) and transfer T_{RS} is restricted by the hard budget constraint, $T_{RS} \leq T$ (where local budget limit T is assumed to be exogenous at the regional level), the firm may find itself operating at a loss.

The standard participation constraint of the regulated firm is then violated. However, in certain institutional environments the regulated monopoly may not be able to escape from providing the service – the winner's curse is an example. Another example of so-called *soft participation constraint* would be the case of a multiproduct monopoly being regulated separately in different markets. For instance, loss-making passenger transportation in Russia is cross-subsidised by high-margin cargo transportation. This is also an illustration of a specific form of indirect income redistribution from the corporate sector that pays RZD higher infrastructure charges and tariffs for cargo transportation to the public sector where RZD reports losses.

In these circumstances, local authorities that suffer from budget centralisation and a short of funds, and therefore unable to fully compensate the cost of service provision at a regional level. However, at the federal level RZD is regulated in such a way as to secure overall profitability. RZD's operating profit before subsidies from federal and municipal budgets decreased from 102.1 bln ruble in 2012 to 72.0 bln ruble in 2013 but nonetheless remains significantly positive. Effectively, RZD benefits from *de facto* implementation of the Ramsey pricing principle for infrastructure access charge regulation in Russia. However, the question of optimality of such an approach to tariff regulation is beyond the scope of this paper. What matters is that regional passenger divisions of RZD, being monopoly service providers in the local transportation markets, can operate on systemic losses covered from corporate sources rather than public funds. Thus the following assumptions can be justified.

Assumption 1. For the multiproduct monopoly regulated separately in different markets, participation constraint in a single market may not be binding, so the firm may operate with losses in this market.

Assumption 2. Lump-sum transfer, T_{RS}, from the regulator to the firm is insufficient to fully compensate for operating losses of the firm so the hard budget constraint $T_{RS} \leq T$ becomes binding.

A starting point for further analysis is the case when unit cost of production θ is known. Subsequently, we relax this assumption and directly compare the welfare in case of complete and asymmetric information.

3.1.3. Payoffs under complete information

When Assumptions 1 and 2 hold, the welfare optimisation problem of the benevolent regulator can be written as:

$$W = V(P) - [1+\lambda]T_{RS} + \alpha[Q(P)\cdot[P-\theta] + T_{RS}] \overset{P\geq 0}{\rightarrow} \max \ \ s.t. \ T_{RS} \leq T$$

Socially optimal tariff $P = (a - \alpha b\theta - \alpha a)/b(1-2\alpha)$ is positive when $\alpha > 1/2$ (see the proof of this and other formulas in the Appendix). Intuitively, when the relative weight of the producer surplus in the social welfare function is too low the regulator effectively defends consumers' interest who are always seeking a ‘free-lunch’. This is obviously not the case under consideration. Indeed, one can prove that Lemma 1 holds:

Lemma 1. In a complete information framework, socially optimal tariff increases with the relative weight put on the producer's surplus in the social welfare function, i.e. $\partial P/\partial\alpha > 0$.

Still, a positive tariff does not guarantee the firm will breakeven if it is below the marginal cost and the lump-sum transfer from the budget is insufficient to compensate for the negative margin. The regulator's specific preferences for redistribution make it optimal to set the welfare maximising tariff at the level below the economically sound one. Thus, Lemma 2 holds:

[3] The assumption of no fixed cost is common to the literature on optimal regulation. Moreover, existing regulatory stimulus in the passenger railway transport in Russia allows Suburban Passenger Companies to pay symbolic 1% of the infrastructure access charge and save up to 50% of their total cost. Thus the assumption of fixed costs to be virtually zero is also relevant for the case studied.

Lemma 2. When $1/2 < \alpha < 1$ the socially optimal tariff is set at the level below marginal cost, $0 < P < \theta$.

It is vital for the regulated firm to be adequately compensated through the mechanism of lump-sum transfer once tariff revenues are insufficient to fully cover all the costs incurred. When local budgets lack funds, the regulated firm operates at a loss (see Eq. (A.1) in the Appendix), so Assumptions 1 and 2 are fully justified in the case of complete information.

A closed form solution can be useful for the welfare function in the case of a PSO, with complete information as a criterion for a comparison of social welfare among different organisational alternatives. When the budget constraint becomes binding and the lump-sum transfer from the regulator to the firm amounts at the budget cap, T, the social welfare under public service obligation looks as follows:

$$W^{PSO} = V(P) - [1+\lambda]T + \alpha\pi$$
$$= -\alpha^2(a-b\theta)^2 \Big/ 2b(1-2\alpha) - (1+\lambda-\alpha)T \quad (1)$$

The analysis of the PSO case with full information shows that the relative size of the redistribution parameter α and the shadow cost of public funds λ have a direct welfare implication. In particular, when welfare losses caused by distortionary taxation pose a serious problem for the economy (λ is high), and redistribution concerns are very pronounced (α is low), condition $\lambda > \alpha$ is likely to hold, meaning that compensatory transfers from the local budgets to the firm are not desirable from the social perspective.

3.1.4. Payoffs under asymmetric information

When cost can not be directly observed by the regulator, though the density function $f(\theta)$ at the support $[\underline{\theta}, \overline{\theta}]$ is known, the regulator's problem gives the same solution for the optimal tariff in expected terms: $P = (a - \alpha bE\theta - \alpha a)/b(1-2\alpha)$, where the cost parameter, θ is substituted by its expected value: $E\theta \equiv \int_{\underline{\theta}}^{\overline{\theta}} \theta f(\theta) d\theta$.

Again, optimal tariff can be set at the level below marginal cost, $0 < P < \theta$, when the relative weight of profit in the welfare function is larger than that of consumers: $1/2 < \alpha < 1 - \frac{b(E\theta-\theta)}{a-b\theta+b(E\theta-\theta)}$ (see Eq. (A.2)).

Theoretically, when the regulator is poorly informed about the firm's true cost parameterθ, the optimal tariff that solves the social welfare maximization problem under asymmetric information can turn out to be too high. In the context of very efficient firm, when revealed cost is below its expected level, $\theta < E\theta$, the tariff may exceed its monopolistic level: $\theta < \frac{a-2\alpha bE\theta}{b(1-2\alpha)}$ (see Eq. (A.3)). Hence, a cost efficient firm benefits from revealing its cost to the regulator.

Generally speaking, asymmetric information creates distortions which lead to lower social welfare, W_0^{PSO}. Once such an asymmetry is mitigated (as in the case of trusting partnership) the firm's profit and social welfare can be improved:

$$\pi_0^{PSO} = \pi^{PSO} - \left(\alpha(a-b\theta)(\theta-E\theta) + \alpha^2 b(\theta-E\theta)^2\right) \Big/ (1-2\alpha)^2 \quad (2)$$

$$W_0^{PSO} = W^{PSO} + \alpha^2 b(\theta - E\theta)^2 \Big/ 2(1-2\alpha) < W^{PSO} \quad (3)$$

The expressions (2) for profit and (3) for the welfare function are identical to the case of complete information subject to θ is substituted by its expected value, $E\theta$.

3.2. Trusting partnership

3.2.1. Agents, their objectives and choice variables

Trusting partnership arises when public and private agents mutually agree to delegate the decision-making process to a legal entity with a specific corporate structure that reflects the mix of the benevolent regulator's objective function and the firm's profit. Bennett and Iossa (2006b) develop this idea in the context of public-private partnership, so we use the notation PPP for trusting partnership hereinafter. The objective function of a trusting partnership, U_{PPP}, is a linear combination of social welfare and monopoly profit: $U_{PPP} = \omega W + (1-\omega)\pi$, where ω represents the relative weight of the regulator's interest in the PPP's objective function. These weights reflect the share structure of the joint venture that the regulator may agree to establish based on the initiative of the service provider. The firm's profit maximisation problem remains unaffected in the absence of a profit distribution concerns or dividend sharing rule.

3.2.2. Payoffs under trusting partnership

We consider a ‘regulatory bargaining game with a delegation’ with the following timing of the negotiation process. First, the firm makes an offer regarding ω; second, the regulator decides whether it accept or reject the offer. If the offer is accepted, a trusting partnership is formed (thus greater weight is placed on the firm's profit) and information about the firm's cost is revealed. Finally, tariff is determined according to the new weights in the joint objective function. If the offer to form the trusting partnership is rejected, tariff setting is not delegated to PPP, so regulator's objective function remains intact but information about the firm's cost is undisclosed. Intuitively, other things being equal, social welfare decreases with ω, while elimination of information asymmetry (as shown in (3)) proves to be ex ante welfare improving. Thus, there exists a non-empty set of possible values of ω, $\omega \in [\underline{\omega}, 1]$, when the regulator perceives the establishment of the partnership as an improvement of social welfare, and the firm's offer is accepted.

A relatively cost efficient firm has incentive to offer a greater share in a trusting partnership since it has to sacrifice its profit when its cost parameter is revealed. There is thus a range of possible levels of ω, $\omega \in [0, \overline{\omega}]$, when the firm is worse off as a result of a trusting partnership. Consequently, the offer can either be withdrawn or rejected by the regulator, so the status quo is retained. Relatively inefficient firms always benefit from the elimination of information asymmetry and would always offer a positive share in the trusting partnership to regulator.

Naturally, a partnership's objective function represents the monotonic transformation of the regulator's objective function where the relative weight of the firm's profit, α, is replaced by the new weight, $\psi = (1-\omega(1-\alpha))/\omega = \alpha + ((1/\omega) - 1)$. Hence, the expression for the optimal tariff can be rewritten by plugging $\psi \geq \alpha$ instead of α in the previous formula: $P = (a - \psi(b\theta + a))/(b - 2\psi b)$. The firm's profit under trusting partnership arrangement, $\pi_{PPP} = -\psi(a-b\theta)^2(1-\psi)/b(1-2\psi)^2 + T$, decreases with ω, so $\partial\pi_{PPP}/\partial\omega < 0$ (see Eq. (A.5)). Thus the firm would offer the lowest possible share ω in the partnership that is accepted by the regulator. Ultimately, whether the partnership is formed depends on the decision of the regulator.

3.3. The regulator's choice

The timing of the model implies that the firm's offer to establish a partnership is considered by the regulator prior to information disclosure. Elimination of information asymmetry would increase social welfare, since $EW(P(\theta)) > W(P(E\theta))$. The scope of information asymmetry is measured by the standard deviation of the unit cost, σ_θ. It's important to emphasize here that the regulator makes the organisational choice on the basis of the expected values of the cost parameter and compares the following the social welfare functions under asymmetric information (W_0^{PSO}) with the expected welfare function under a partnership (EU^{PPP}):

$$W_0^{\text{PSO}} = \frac{-\alpha^2(a-bE\theta)^2}{2b(1-2\alpha)} - (1+\lambda-\alpha)T \vee \omega\left(\frac{-\psi^2\left[b^2\sigma_\theta^2 + (a-bE\theta)^2\right]}{2b(1-2\psi)} - (1+\lambda-\psi)T\right) = EU_{\text{PPP}}$$

In order to study the welfare implications of trusting partnership, one should compare the benchmark case for the actual social welfare under complete information before the establishment of a partnership (W^{PSO}) and social welfare under complete information after the establishment of a trusting partnership (U^{PPP}):

$$W^{\text{PSO}} = \frac{-\alpha^2(a-b\theta)^2}{2b(1-2\alpha)} - (1+\lambda-\alpha)T + \frac{\alpha^2 b(\theta-E\theta)^2}{2(1-2\alpha)} \vee \omega\left(\frac{-\psi^2(a-b\theta)^2}{2b(1-2\psi)} - (1+\lambda-\psi)T\right) = U_{\text{PPP}}.$$

4. Extensions

4.1. Concessionary passengers

Concessionary passengers are deemed to have socially based privileges and pay lower charge for travel. Without loss of generality, we can normalise this charge to zero thus assuming that by providing the service to this group the monopoly receives no revenue from ticket sales and has to be compensated by lump-sum transfer from the budget. The previously studied transfer T_{RS} is normalized to zero since it does not have qualitative implications. The focus here is on the transfer from the local budget to compensate the firm's cost of providing services to concessionary passengers. Initially, we assume that public funds are always available for this purpose, and further we relax this assumption and introduce a budget limit which is not known ex ante to the firm.

4.1.1. Public service obligation

Let's denote the number of concessionary passengers by $\tilde{a}$ who travel for free and derive a certain utility U_{CP} from being served. Consider the case with no externalities when U_{CP} is simply added to the social welfare function. Though the regulator may be perfectly aware of the maximum number of passengers with the legal right to travel for free, it is the firm that has confidential information about actual demand for transportation from the concessionary passengers. So, $\tilde{a}$ is not known to the regulator who is bound to compensate the service provider on the basis of expected demand from concessionary passengers $E\tilde{a}$ which is also assumed to be inelastic since these passengers are fully compensated[4]: $W = \text{CS}(P) + U_{\text{CP}} - [1+\lambda]T + \alpha[\pi(P) + T]$, where $\text{CS}(P)$ is a consumer surplus of the regular passengers and $T = \theta E\tilde{a}$ is a budget transfer to compensate only the cost of concessionary passengers' transportation. For the sake of tractability of the model we consider the situation when the only source of information asymmetry is the demand parameter$\tilde{a}$, while unit cost of the firm θ is assumed to be known to the regulator. Socially optimal tariff thus would be the same $P = (a - \alpha b\theta - \alpha a)/b(1-2\alpha)$ while social welfare function is altered:

$$W = \left[\frac{(a-bP)^2}{2b} + U_{\text{CP}} + \alpha((P-\theta)(a-bP) - \theta\tilde{a})\right] - (1+\lambda-\alpha)\theta E\tilde{a}$$

The expected number of concessionary passengers defines the transfer but not the tariff. Evidently, due to the social cost of public funds and lower relative weight on producer surplus, the society benefits from the lower transfer from the budget based on the total number of concessionary passengers. When the firm is obligated to deliver this public service the local authorities have incentives to minimise financial support of the sector causing unsustainable situation.

4.1.2. Trusting partnership

As in the benchmark case, the delegation of tariff setting to a trusting partnership results in tariff increase on the one hand and information rent elimination on the other hand. The total effect of the establishment of trusting partnership is thus unambiguous. The transfer is determined prior to the partnership establishment and may be constrained by the availability of public funds. Once the actual number of concessionary passengers is revealed, the firm obtains the transfer $\theta\tilde{a}$. The level of the expected transfer is based on the actual number of concessionary passengers and equals to $\text{ET} = E(\theta\tilde{a}) = \theta E\tilde{a}$. Thus we consider two cases.

Case 1. Under no budget constraint for compensation of concessionary passengers' transportation, social welfare is unaffected by the elimination of information asymmetry. (see Appendix for the proof). Thus, the regulator would never agree to form a trusting partnership and hence set suboptimal levels of tariff in this case.

Case 2. When the budget for compensation of concessions is limited to an exogenous level, A, and the number of concessionary passengers is random variable on the support $[\tilde{a}_{\text{LOW}}, \tilde{a}_{\text{HIGH}}]$ with known density function $g(\tilde{a})$.

In Case 2, the transfer based on the expected number of concessionary passengers is higher than the expected transfer based on the actual number. Indeed, transfer represents a concave function of the number of concessionary passengers (Fig. 1(b)). This means that the partnership establishment is associated with expected reduction in transfer. Yet, as shown above, the lower the transfer, the higher the social welfare. Thus, the regulator is more likely to agree on a partnership establishment for the expected positive welfare effect of information rent elimination.

This effect is expected to be positive whatever the proposed ownership structure. There must exist a non-empty set of possible values of, $\omega \in [\underline{\omega}, 1]$, under which the regulator perceives a partnership establishment as social welfare improving. Hence, when a budget constraint is binding (as in Case 2), there exists room for endogenous establishment of a trusting partnership.

There are two effects of trusting partnership establishment on the firm as well. One arises from the delegation of tariff setting to the agent who places greater relative weight on producer surplus than the regulator, and it affects the firm's profit positively, as has been proved in Section 3. When the actual number of concessionary passengers is higher than what is compensated by the regulator under PSO, the firm is worse off from the elimination of information asymmetry. Thus the firm would wish to offer a certain share in a partnership ω, $\omega \in [0, \overline{\omega}]$ to offset the loss. The set of possible shares in a partnership could be empty, and the firm makes no offer to the regulator in this case. When the actual number of

[4] We avoid the problem of regulator defining optimal tariff within incomplete information framework as the utility of concessionary passengers is fixed and does not enter FOC.

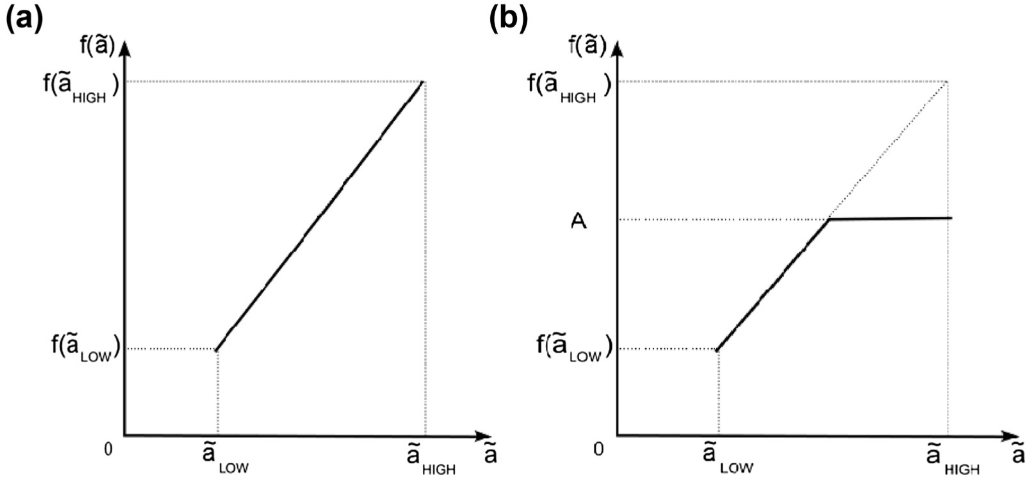

Fig. 1. (a).The transfer as a function of the number of concessionary passengers with no budget limits. (b). The transfer as a function of the number of concessionary passengers with budget limit $A < \theta\tilde{a}_{\mathrm{HIGH}}$.

concessionary passengers is lower, the firm benefits from the information rent elimination and is indifferent about the share structure of a partnership once it is established.

The role of hard budget constraint is considered in the setup when the budget limit A is not known to the service provider a prior. If A is overestimated, the firm would miss the opportunity to offer a higher share in a partnership that would secure maximum profit. If A is underestimated the offer to form a partnership may be rejected by the regulator. Thus we can formulate the following propositions.

Proposition 1. Uncertain demand of concessionary passengers makes the organisational choice of trusting partnership less likely.

Proposition 2. Tougher budget constraint for compensation of concessionary passengers makes the organisational choice of trusting partnership more likely.

It should be noted that the firm is always better off when the actual number of concessionary passengers is unknown to the regulator ex ante. An illustration would be the case of so called monetization reform in the suburban railway passenger sector. Non-monetary benefits in the form of various concessions were substituted by explicit compensatory schemes in 2006 that revealed actual demand for public transport by almost all the categories of privileged passengers. Still a significant part of the demand for transportation (especially from numerous railway workers who travel for free) remains uncertain prior to the establishment of trusting partnership.

Note that monetization reform offers a possibility to eliminate asymmetry of information on behalf of the regulator at no cost. When the local budget is limited, monetization turns out to be purely beneficial for the society in expected terms. With SPCs creation, information asymmetry is eliminated while the society suffers from the suboptimal level of tariff. Consequently, other things being equal the future plans about monetization reform could have affected the pace of the organisational transformation in the sector which is observed in the data, slowing down the process of establishment trusting partnerships on the eve of reform in Russia in 2006.

4.2. Fare-dodgers

An additional factor that provides the reason for trusting partnership creation even in the absence of of information asymmetry is the scope of fare evasion on transport and the presence of fare dodgers. For the illustrative purposes we now make the assumption that the total demand for the service comprises of the two components: $Q_{OP}(P) = a_1 - b_1P$ and $Q_{FR}(P) = a_2 + b_2P$, where $Q_{OP}(P)$ stands for the demand of obedient passengers and $Q_{FR}(P)$ stands for the demand of free-riders, and $a_1,\ a_2, b_1, b_2 > 0$.

Note that while demand of obedient passengers is downward sloping as usual, demand of fare-dodgers is upward-sloping reflecting the positive relationship between the tariff charged for the service and the number of free-riders. The assumption $b_2 < b_1$ captures the idea that demand of obedient passengers decreases in tariff, since part of the passengers become free-riders and another part switch to other means of transport. Consequently, the overall demand for the service is downward-sloping yet steeper than the demand of obedient passengers alone: $Q(P) = (a_1 + a_2) - (b_1 - b_2)P$.

4.2.1. Public services obligation

The existence of free-riders affects the social welfare in two ways. First, it decreases producer surplus since the firm collects no revenues from them. Second, it increases consumer surplus due to higher patronage. The optimal tariff in the absence of information asymmetry would be: $P = \frac{-(a_1+a_2)+\alpha(a_1+\theta(b_1-b_2))}{-(b_1-b_2)+2\alpha b_1}$.

The problem of fare evasion is of particularly severe in Russia, where about 10–30% of users systematically do not pay for their travel (see Table 1). Ironically, RZD as a commercial firm has no legal right to penalise fare dodgers according to existing legislation, and only local authorities are entitled to collect fines. Moreover, as Dementiev's (2013) study on social capital in the sector of suburban railway transport in Russia has revealed, the fare-evasion in Russia does not depend on the size of fines and on-route ticket inspection

Table 1
The scope of fare-evasion in suburban railway transport sector in Russia.

Suburban passenger company	Estimated percentage of fare-dodgers, (data)	Average monthly wage (RUR) in Russian regions in 2010
Sverdlovskaya	3 (09. 2012)	19 675
Yuzhno-Uralskaya	7–13 (09. 2012)	17 388
Moskovsko-Tverskaya	22 (10. 2012)	25 502
Central	10–30 (05. 2012)	40 479
Nord-West	15–35 (03.2012)	27 618
Saratovskaya	15–25 (06. 2012)	14 592
North	5–7 (09. 2012)	21 263

Source: the Federal State Statistics Service.

intensity. In fact, the only effective measure that triggers passengers' behaviour and forces them to pay for the journey proves to be an access prevention measure such as tourniquets.

That is, the problem of fare-evasion in Russia requires complex and costly solution and hardly can be tackled with incremental policy innovations, such as greater number of ticket inspectors or on route higher fines. Thus we introduce a certain threshold control variable, F that can be interpreted as some fixed investment in enforcement technologies such as tourniquets, that can effectively change the situation with fare evasion and serve as a precondition for establishment of a trusting partnership (other things being equal). So we assume that if F is sufficiently large the access of free-riders to the service is completely blocked. Hence, the optimal tariff can be raised to the level that at least partially compensates for the sunk investment disbursed:

$P = \frac{-(a_1+a_2)+\alpha((a_1+a_2)+\theta(b_1-b_2))}{-(b_1-b_2)+2\alpha(b_1-b_2)}$ (see the proof in the Appendix).

In the ideal world with no sunk cost of blocking the access of free-riders to the service, the society would certainly be better off. Indeed, it is in the power of the regulator to leave the tariff unchanged, and with the fixed tariff the only change to the social welfare would be an increase in revenue of the service provider when fare-dodgers start paying. The decision of the regulator to change the tariff could only be motivated by further improvement in social welfare. Indeed, the regulator may decide not to block free-riders if the social cost of public funds required for this investment is higher than the an increase in the social welfare: $0 < \Delta CS + \alpha\Delta PS < (1+\lambda)F$.

4.2.2. Trusting partnership

It may turn out to be optimal for the society as a whole if investment in enforcing technology is made by the firm rather than the public authority. If the shadow cost of public funds is large, the following condition holds: $\alpha F < (1+\lambda)F$. Yet, the socially optimal tariff charged would be the same since FOC is unaffected. We claim that the establishment of a partnership provides a necessary incentive for the firm to incur such a fixed cost if it is compensated though higher tariff.

Proposition 3. Under symmetric information social welfare decreases with the share of service provider in the trusting partnership.

A higher proposed share of the service provider in the partnership will lead to a greater negative effect of its establishment on social welfare, if decision-making is delegated to an agent whose objectives differ from the social welfare maximization criteria. Hence, there exists a non-empty set of possible values of $\omega \in [\underline{\omega}, 1]$, under which the establishment of trusting partnership is perceived by the regulator as improving social welfare.

Notably, it may be beneficial for the firm to incur some fixed cost of blocking the access of free-riders even in the absence of a trusting partnership. Indeed when the social welfare function implies lower weight of producer surplus the change in social welfare is smaller than an increase in the firm's profit after deducting the fixed cost: $\Delta SW = \Delta CS + \alpha\Delta PS - (1+\lambda)F < \Delta PS - F = \Delta\pi$. In fact, as soon as the regulator finds it socially optimal to block free-riders from the service, it is also beneficial for the firm to incur such fixed cost even in the absence of trusting partnership. Consequently, the firm would seize every opportunity to propose a trusting partnership to increase its profit even further. Naturally, in absence of information asymmetry every offer made by the firm will be accepted by the regulator.

5. Discussion and conclusions

The concept of public service obligation is widely used in delivering passenger railway transportation services, and is applicable to both profitable and unprofitable railways. In the case of defaulting local governments unfunded service obligations would undermine the services. When a socially desirable tariff is set at a level below an economically optimal one and subsidies from the local budgets are insufficient to cover all the losses, any revenue maximising firm would avoid participating in public service provision. So, an economically optimal PSO contract becomes politically unfeasible. However, as the Russian railway reform shows, the very status of RZD being a profitable multiproduct monopoly prompts thelocal authorities to favour the company in meeting the pricing and demand obligations through internal cross subsidy. From an economic point of view this argument is not convincing since implicit redistribution from one customer (freight shippers) to another (passengers) may cause net loss in efficiency. Neither is it satisfactory from the RZD's commercial perspective. This political-economy landscape is a starting point for our game-theoretic framework which develops a formal model of how local cash-strapped governments may wish to choose trusting partnership as a delivery model which is initially proposed by the regulated service provider.

The establishment of Suburban Passenger Companies (SPCs) in the form of trusting partnerships between local authorities and regional divisions of Russian Railways has become an alternative to vaguely determined and weakly enforced Public Service Obligation compensation contracts for suburban operations. These delivery models vary across Russian regions in terms of the share of operator losses that Federal and local governments *de facto* compensate for as well as the ownership structure of SPCs which has been gradually changing for the last 15 years in Russia.

Our paper develops a conceptual framework for the analysis of the establishment of trusting partnerships in the form of PPP in Russia's suburban railway passenger sector and constructs a model of a 'regulatory bargaining game with delegation' as a new analytical tool for the analysis of the trusting partnership creation process. We contribute to the existing literature on public-private partnerships by making an organisational choice endogenous in the sense that local authorities are free to accept or reject the offer to partner with the regulated service provider.

This modelling approach differs from the story of regulatory capture, because tariff setting is delegated to a third agent (a partnership) that has both public and private interest. In essence, trusting partnership is viewed as a specific institutional arrangement that aims at maximizing the composite objective function to determine tariff and reveals the firm's hidden characteristics due to trusting relationships within a partnership. The standard regulatory problem of optimal tariff setting under hidden information about the firm's cost becomes a subgame of the 'regulatory bargaining game with delegation'.

In particular, under certain conditions benevolent local authorities may find that a switch from Public Service Obligation delivery model to trusting partnership will improve the expected social welfare. Thus the organisational choice is made first, then information structure is determined, and finally socially optimal tariffs are set.

The offer made by the service provider at the first stage of the game aims to engage the regulating authority in a trusting partnership and seek 'fair' pricing at the expense of information rent. In particular, closer cooperation, participation in board of director meetings, more transparent contractual arrangements and mutual obligations between the partners all contribute to the elimination of information asymmetry. At the second stage, local authorities may accept or reject the offer to establish trusting partnership with a proposed corporate structure if they anticipate the offer to be ex ante welfare improving. With this sequencing of the game, trusting partnership emerges endogenously as an alternative delivery model. However, as our model shows, establishment of trusting partnership will not necessarily improve social welfare ex post.

In the extension with concessionary passengers, we assume that regulator is ex ante uncertain about demand and consider an isolated effect of this assumption by making the firm's cost known to regulator. To illustrate this point, concessionary passengers are deemed to be compensated directly from the budget ex post. The corresponding budget constraint may or may not be binding. In the latter case, the firm is unaware of the sufficiency of public funds that becomes a hidden characteristic of the regulator. Thus, we have two-sided asymmetry of information features here, in which either regulator or the firm may wish to preserve status quo and refrain from bargaining.

In the extension with fare dodgers, we return to the initial assumptions with no information asymmetry but introduce a specific group of consumers that illegally avoids paying for the service and therefore not eligible for any compensation from the budget. Obviously, it is socially optimal to enforce obedient behaviour of such passengers and block fare-dodgers from using transportation services. Technologies of access control (primarily via tourniquets) are cheaper for the firm than for the regulator due to the social cost of public funds. However, the legislative status of passenger transportation as a public service that ought to be provided on a non-excludable basis prevents the firm from blocking the access without partnering with local authorities. For instance, in Russia a commercial firm has no legal right to collect fines for the ticketless travel, which is an administrative offence. So, the partnership may be a viable option in such an institutional framework even in case of complete information.

The welfare comparison of alternative delivery models produces ambiguous results. Service provider will be better off by establishing trusting partnerships with desired (and proposed) ownership structure in all three cases while consumers will suffer in most cases (with one exception when the service provider turns out be very cost-efficient). Correspondingly, tariffs will increase in most cases (and decrease if the firm is very cost-efficient). In the extension with fare-dodgers when there is no information asymmetry, social welfare will definitely increase after a switch from PSO to a trusting partnership.

The proposed theoretical model and its extensions shed some light on the process of forming a trusting partnership. It rationalizes two important reasons for the delay in implementating reforms of Russia's suburban passenger transportation at the regional level. We claim that in the regions where the status quo is retained, the offer to establish trusting partnership was either not made by the service provider or rejected by the local authorities. The model also explains how different ownership structures in the already established SPCs may be formed. The descriptive power of the model goes beyond the case of suburban railway in Russia. Taking in to account the diversity of different organizational choices in this sector, the model has broader applications and implications. In particular, the proposed analytical framework allows us to account for the diversity of organizational choices in the public sector that seem to be socially optimal ex ante and prove to be ambiguous in terms of welfare ex post.

Appendix

Derivation of optimal tariff under complete information

$$W = V(P) - [1+\lambda]T_{RS} + \alpha[Q(P)\times[P-\theta] + T_{RS}] \xrightarrow{P\geq 0} \max$$
$$s.t.\ T_{RS} \leq T$$

$$\frac{(a-bP)^2}{2b} - (1+\lambda)T + \alpha((a-bP)(P-\theta)+T) \xrightarrow{P\geq 0} \max$$

$$\begin{aligned}\text{FOC}: & -(a-bP) + \alpha(-b(P-\theta) + (a-bP)) \\ & = (-a + \alpha b\theta + \alpha a) + (b - 2\alpha b)P = 0\end{aligned}$$

$$P = \frac{a - \alpha b\theta - \alpha a}{b(1-2\alpha)}$$

$$\text{SOC}: b - 2\alpha b = b(1-2\alpha)$$

For the tariff found to represent solution to the optimization problem in question it must be that second order derivative is negative, that is, the condition $1-2\alpha<0$ must hold, that implies $\alpha>1/2$.

Proof of Lemma 1

$$\begin{aligned}\frac{\partial P}{\partial \alpha} &= \frac{-(b\theta+a)(b-2\alpha b) - (a-\alpha b\theta - \alpha a)(-2b)}{(b-2\alpha b)^2} \\ &= \frac{-b^2\theta + 2\alpha b^2\theta - ab + 2\alpha ab + 2ab - 2\alpha b^2\theta - 2\alpha ab}{b^2(1-2\alpha)^2} \\ &= \frac{-b^2\theta + ab}{b^2(1-2\alpha)^2} = \frac{a-b\theta}{b(1-2\alpha)^2} > 0\end{aligned}$$

if $a-b\theta>0$ (there exists break-even point for the firm that charges price at the marginal cost).

Proof of Lemma 2

Now, let's consider the condition in which charging the tariff imposed by the regulator results in negative operating profits:

$$P = \frac{a-\alpha(b\theta+a)}{b-2\alpha b} \vee \theta$$

$$\begin{aligned}\frac{a-\alpha(b\theta+a)}{b-2\alpha b} - \theta &= \frac{(a-\alpha b\theta - \alpha a) - (b\theta - 2\alpha b\theta)}{b-2\alpha b} \\ &= \frac{a + \alpha b\theta - \alpha a - b\theta}{b-2\alpha b} = \frac{(1-\alpha)a - b\theta(1-\alpha)}{b-2\alpha b} \\ &= \frac{(1-\alpha)(a-b\theta)}{b(1-2\alpha)} < 0\end{aligned}$$

Using the previously justified condition $a-b\theta>0$ as well as derived restriction $\alpha>1/2$, we could determine that $1-\alpha>0$, that is, $\alpha<1$ is additional restriction that is needed to be placed on the parameter.

Inequality $\alpha>1/2$ represents the condition required for internal solution to be obtained, as otherwise socially optimal tariff would be equal to zero. Yet, zero tariff is definitely less than unit product cost. As $\alpha<1$ is the restriction naturally incorporated in our model, a general conclusion could be made that within the framework we have constructed socially optimal tariff, that is, one that maximizes social welfare, turns out to be lower than economically optimal tariff, that is, tariff set at the level of marginal cost.

Proof of the possibility for negative profit

It remains to determine what the restriction on regulator's budget and consequently transfer to the monopoly makes the service provider end up with its losses not being fully covered:

$$\pi=(a-bP)(P-\theta)+T=\left(a-b\frac{a-\alpha b\theta-\alpha a}{b-2\alpha b}\right)\left(\frac{a-\alpha b\theta-\alpha a}{b-2\alpha b}-\theta\right)+T$$
$$=\left(\frac{a(1-2\alpha)-(a-\alpha b\theta-\alpha a)}{1-2\alpha}\right)\left(\frac{(a-\alpha b\theta-\alpha a)-\theta(b-2\alpha b)}{b-2\alpha b}\right)+T$$
$$=\left(\frac{a-2\alpha a-a+\alpha b\theta+\alpha a}{1-2\alpha}\right)\left(\frac{a-\alpha b\theta-\alpha a-\theta b+2\alpha b\theta}{b-2\alpha b}\right)+T$$
$$=\frac{(\alpha b\theta-\alpha a)(a+\alpha b\theta-\alpha a-\theta b)}{b(1-2\alpha)^2}+T$$
$$=\frac{\alpha(b\theta-a)(a(1-\alpha)-b\theta(1-\alpha))}{b(1-2\alpha)^2}+T=\frac{-\alpha(a-b\theta)^2(1-\alpha)}{b(1-2\alpha)^2}+T<0$$

$$T<\frac{\alpha(a-b\theta)^2(1-\alpha)}{b(1-2\alpha)^2} \quad (A.1)$$

Note that upper bound is positive under the restrictions imposed before, that is, there is non-empty set of values of region's budget that makes transfer to regulated monopoly insufficient to cover its operational losses.

Proof of the Eq. (1)

$$W^{PSO}=V(P)-[1+\lambda]T+\alpha\pi=\frac{\left(a-b\frac{a-\alpha(b\theta+a)}{b-2\alpha b}\right)^2}{2b}-(1+\lambda)T$$
$$+\alpha\left(\frac{-\alpha(a-b\theta)^2(1-\alpha)}{b(1-2\alpha)^2}+T\right)=\frac{((a-2\alpha a)-(a-\alpha b\theta-\alpha a))^2}{2b(1-2\alpha)^2}$$
$$-(1+\lambda)T+\alpha\left(\frac{-\alpha(a-b\theta)^2(1-\alpha)}{b(1-2\alpha)^2}+T\right)$$
$$=\frac{(\alpha b\theta-\alpha a)^2}{2b(1-2\alpha)^2}-(1+\lambda)T+\alpha\left(\frac{-\alpha(a-b\theta)^2(1-\alpha)}{b(1-2\alpha)^2}+T\right)$$
$$=\frac{\alpha^2(a-b\theta)^2}{2b(1-2\alpha)^2}-(1+\lambda)T-\alpha\frac{\alpha(a-b\theta)^2(1-\alpha)}{b(1-2\alpha)^2}+\alpha T$$
$$=\frac{\alpha^2(a-b\theta)^2-2\alpha^2(a-b\theta)^2(1-\alpha)}{2b(1-2\alpha)^2}-(1+\lambda-\alpha)T$$
$$=\frac{\alpha^2(1-2(1-\alpha))(a-b\theta)^2}{2b(1-2\alpha)^2}-(1+\lambda-\alpha)T$$
$$=\frac{-\alpha^2(1-2\alpha)(a-b\theta)^2}{2b(1-2\alpha)^2}-(1+\lambda-\alpha)T$$
$$=\frac{-\alpha^2(a-b\theta)^2}{2b(1-2\alpha)}-(1+\lambda-\alpha)T$$

Derivation of the upper bound on α that guarantees operating profit to be negative

$$P=\frac{a-\alpha bE\theta-\alpha a}{b-2\alpha b}\vee\theta$$

$$\frac{a-\alpha bE\theta-\alpha a}{b-2\alpha b}-\theta=\frac{(a-\alpha bE\theta-\alpha a)-\theta(b-2\alpha b)}{b-2\alpha b}=\frac{a(1-\alpha)-b\theta(1-\alpha)+\alpha b(\theta-E\theta)}{b-2\alpha b}\vee 0$$
$$\frac{(a-b\theta)(1-\alpha)+\alpha b(\theta-E\theta)}{b(1-2\alpha)}<0$$
$$(a-b\theta)(1-\alpha)+\alpha b(\theta-E\theta)>0 \quad (A.2)$$
$$(a-b\theta)(a-b\theta)+b(E\theta-\theta))>0$$
$$\alpha<\frac{a-b\theta}{a-b\theta+b(E\theta-\theta)}=1-\frac{b(E\theta-\theta)}{a-b\theta+b(E\theta-\theta)}$$

Derivation of the upper bound on θ under which it is optimal for the service provider to opt for tariff reduction

$$\frac{a-\alpha bE\theta-\alpha a}{b-2\alpha b}\vee\frac{a+b\theta}{2b}$$
$$(a+b\theta)(1-2\alpha)\vee 2(a-\alpha bE\theta-\alpha a)$$
$$a+b\theta-2\alpha a-2\alpha b\theta\vee 2a-2\alpha bE\theta-2\alpha a$$
$$2\alpha b(E\theta-\theta)\vee a-b\theta$$

Note that inefficient firm ($\theta>E\theta$) would never opt for tariff reduction, as expected. Yet, tariff reduction could be optimal for efficient firm if:

$$(b-2\alpha b)\theta>a-2\alpha bE\theta$$
$$\theta<\frac{a-2\alpha bE\theta}{b(1-2\alpha)} \quad (A.3)$$

Proof of the Eq. (2)

$$\pi_0^{\mathrm{PSO}}=(a-bP)(P-\theta)+T=\left(a-b\frac{a-\alpha bE\theta-\alpha a}{b-2\alpha b}\right)\left(\frac{a-\alpha bE\theta-\alpha a}{b-2\alpha b}-\theta\right)+T=\left(\frac{a(1-2\alpha)-(a-\alpha bE\theta-\alpha a)}{1-2\alpha}\right)\left(\frac{(a-\alpha bE\theta-\alpha a)-\theta(b-2\alpha b)}{b-2\alpha b}\right)+T$$
$$=\left(\frac{a-2\alpha a-a+\alpha bE\theta+\alpha a}{1-2\alpha}\right)\left(\frac{a-\alpha bE\theta-\alpha a-b\theta+2\alpha b\theta}{b-2\alpha b}\right)+T=\left(\frac{\alpha bE\theta-\alpha a+\alpha b\theta-\alpha b\theta}{1-2\alpha}\right)\left(\frac{a(1-\alpha)-b\theta(1-\alpha)+\alpha b(\theta-E\theta)}{b-2\alpha b}\right)+T$$
$$=\left(\frac{-\alpha(a-b\theta)}{1-2\alpha}-\frac{\alpha b(\theta-E\theta)}{1-2\alpha}\right)\left(\frac{(a-b\theta)(1-\alpha)}{b-2\alpha b}+\frac{\alpha b(\theta-E\theta)}{b-2\alpha b}\right)+T=\left(\frac{-\alpha(a-b\theta)^2(1-\alpha)}{b(1-2\alpha)^2}+T\right)-\frac{\alpha b(\theta-E\theta)}{1-2\alpha}\frac{(a-b\theta)(1-\alpha)}{b-2\alpha b}$$
$$-\frac{\alpha b(\theta-E\theta)}{1-2\alpha}\frac{\alpha b(\theta-E\theta)}{b-2\alpha b}-\frac{\alpha(a-b\theta)}{1-2\alpha}\frac{\alpha b(\theta-E\theta)}{b-2\alpha b}=\pi^{PSO}-\frac{\alpha(1-\alpha)b(a-b\theta)(\theta-E\theta)+\alpha^2b^2(\theta-E\theta)^2+\alpha^2b(a-b\theta)(\theta-E\theta)}{b(1-2\alpha)^2}$$
$$=\pi^{\mathrm{PSO}}-\frac{\alpha(a-b\theta)(\theta-E\theta)+\alpha^2b(\theta-E\theta)^2}{(1-2\alpha)^2}$$

Proof of the Eq. (3)

$$W_0^{\mathrm{PSO}}=V(P)-[1+\lambda]T+\alpha\pi$$
$$=\left(V^{\mathrm{PSO}}(P)+\frac{\alpha^2(\theta-E\theta)(a-b\theta)}{(1-2\alpha)^2}+\frac{1}{2}\frac{\alpha^2b(\theta-E\theta)^2}{(1-2\alpha)^2}\right)-(1+\lambda)T$$
$$+\alpha\left(\pi^{PSO}-\frac{\alpha(a-b\theta)(\theta-E\theta)+\alpha^2b(\theta-E\theta)^2}{(1-2\alpha)^2}\right)$$
$$=W^{\mathrm{PSO}}+\frac{\alpha^2(\theta-E\theta)(a-b\theta)}{(1-2\alpha)^2}+\frac{1}{2}\frac{\alpha^2b(\theta-E\theta)^2}{(1-2\alpha)^2}$$
$$-\alpha\frac{\alpha(a-b\theta)(\theta-E\theta)+\alpha^2b(\theta-E\theta)^2}{(1-2\alpha)^2}$$
$$=W^{\mathrm{PSO}}+\frac{1}{2}\frac{(1-2\alpha)\alpha^2b(\theta-E\theta)^2}{(1-2\alpha)^2}$$
$$=W^{\mathrm{PSO}}+\frac{1}{2}\frac{\alpha^2b(\theta-E\theta)^2}{1-2\alpha}<W^{\mathrm{PSO}}$$

Supplementary derivation for the proof of Eq. (3)

$$V_0^{\mathrm{PSO}}(P)=\frac{\left(a-b\frac{a-\alpha bE\theta-\alpha a}{b-2\alpha b}\right)^2}{2b}=\frac{1}{2}\frac{((a-2\alpha a)-(a-\alpha bE\theta-\alpha a))^2}{b(1-2\alpha)^2}$$
$$=\frac{1}{2}\frac{(\alpha bE\theta-\alpha a)^2}{b(1-2\alpha)^2}=\frac{1}{2}\frac{\alpha^2(a-b\theta+b\theta-bE\theta)^2}{b(1-2\alpha)^2}$$
$$=\frac{1}{2}\frac{\alpha^2\left((a-b\theta)^2+2(b\theta-bE\theta)(a-b\theta)+(b\theta-bE\theta)^2\right)}{b(1-2\alpha)^2}$$
$$=\frac{1}{2}\left(\frac{\alpha^2(a-b\theta)^2}{b(1-2\alpha)^2}+\frac{2\alpha^2b(\theta-E\theta)(a-b\theta)}{b(1-2\alpha)^2}+\frac{\alpha^2b^2(\theta-E\theta)^2}{b(1-2\alpha)^2}\right)$$
$$=V^{\mathrm{PSO}}(P)+\frac{\alpha^2(\theta-E\theta)(a-b\theta)}{(1-2\alpha)^2}+\frac{1}{2}\frac{\alpha^2b(\theta-E\theta)^2}{(1-2\alpha)^2}$$

Proof of deviation of PPP's objective function from society's objective function increasing with the share in PPP devoted to the service provider

$$U_{\mathrm{PPP}}=\omega W(P)+[1-\omega]\pi=\omega[V(P)-[1+\lambda]T+\alpha\pi]+[1-\omega]\pi$$
$$=\omega V(P)-\omega[1+\lambda]T+[1-\omega[1-\alpha]]\pi$$
$$=\omega\left[V(P)-[1+\lambda]T+\frac{[1-\omega[1-\alpha]]}{\omega}\pi\right]$$
$$U_{\mathrm{PPP}}=\omega[V(P)-[1+\lambda]T+\psi\pi]$$

where ψ is a new variable introduced that represents a relative weight placed on producer surplus in PPP's objective function – analogue to α in regulator's objective function

$$\psi=\frac{(1-\omega(1-\alpha))}{\omega}=\frac{1}{\omega}-(1-\alpha)=\alpha+\left(\frac{1}{\omega}-1\right)$$
$$\psi=\alpha\ \text{ if }\ \omega=1$$
$$\frac{\partial\psi}{\partial\omega}=-\frac{1}{\omega^2}<0 \tag{A.4}$$

Proof of the service provider being the better off the greater is its share in PPP

$$\frac{\partial\pi}{\partial\omega}=\frac{\partial\pi}{\partial\psi}\frac{\partial\psi}{\partial\omega}$$
$$=\left(\frac{-(a-b\theta)^2(1-\psi)+\psi(a-b\theta)^2}{b(1-2\psi)^2}+2\frac{\psi(a-b\theta)^2(1-\psi)}{b(1-2\psi)^3}(-2)\right)$$
$$\times\left(-\frac{1}{\omega^2}\right)=\left(\frac{-(a-b\theta)^2(1-2\psi)}{b(1-2\psi)^2}-4\frac{\psi(a-b\theta)^2(1-\psi)}{b(1-2\psi)^3}\right)$$
$$\times\left(-\frac{1}{\omega^2}\right)=\frac{-(a-b\theta)^2\left((1-2\psi)^2+4\psi(1-\psi)\right)}{b(1-2\psi)^3}\left(-\frac{1}{\omega^2}\right)$$
$$=\frac{(a-b\theta)^2\left((1-4\psi+4\psi^2)+(4\psi-4\psi^2)\right)}{b(1-2\psi)^3}\frac{1}{\omega^2}=\frac{(a-b\theta)^2}{b(1-2\psi)^3}\frac{1}{\omega^2}<0 \tag{A.5}$$

Derivation of social welfare function under PPP

$$\mathrm{EU_{PPP}} = E\left(\omega\left(\frac{-\psi^2(a-b\theta)^2}{2b(1-2\psi)} - (1+\lambda-\psi)T\right)\right)$$
$$= \omega\left(\frac{-\psi^2 E(a-b\theta)^2}{2b(1-2\psi)} - (1+\lambda-\psi)T\right)$$
$$= \omega\left(\frac{-\psi^2\left[b^2\sigma_\theta^2 + (a-bE\theta)^2\right]}{2b(1-2\psi)} - (1+\lambda-\psi)T\right)$$

Derivation of optimal tariff under Extension 1

$$W = \mathrm{CS}(P) + U_{\mathrm{CP}} - [1+\lambda]T + \alpha[\pi(P)+T] = \frac{(a-bP)^2}{2b} + U_{\mathrm{CP}} - (1+\lambda)\theta E\tilde{a} + \alpha(P(a-bP) - \theta(a-bP+\tilde{a}) + \theta E\tilde{a})$$
$$\frac{(a-bP)^2}{2b} + U_{\mathrm{CP}} - (1+\lambda)\theta E\tilde{a} + \alpha((P-\theta)(a-bP) + \theta(E\tilde{a}-\tilde{a}))$$

$$\mathrm{FOC}: \frac{\partial W}{\partial P} = -(a-bP) + \alpha(a-2bP+b\theta)$$
$$= (-a + \alpha(a+b\theta)) + (b-2\alpha b)P = 0$$

Proof the expected effect of asymmetry of information elimination on social welfare is zero under unlimited budget for compensation of concessionary passengers' transportation

Under such an assumption, once the actual number of concessionary passengers is revealed, the service provider will obtain the transfer $\theta\tilde{a}$. Expected transfer based on actual number of concessionary passengers is thus $\mathrm{ET} = E(\theta\tilde{a}) = \theta E\tilde{a}$ as there is no uncertainty regarding unit product cost of providing the service defined exogenously. However, this exactly equals to transfer based on expected number of concessionary passengers, that is, one paid under compensatory agreement. Consequently, the expected effect of asymmetry of information elimination on social welfare is zero. The reason behind is that the transfer represents the linear function of the number of concessionary passengers in this case (see Fig. 1a and b).

Analytical proof of the expectation of compensation for transporting concessionary passengers to be reduced:

$$f(E\tilde{a}) \vee Ef(\tilde{a})$$

$$Ef(\tilde{a}) = \sum_{i=1}^{N} p_i f(\tilde{a}_i) = \sum_{i=1}^{n} p_i\theta\tilde{a}_i + \sum_{i=n+1}^{N} p_i A$$

where $\theta\tilde{a}_n < A < \theta\tilde{a}_{n+1}$.

Yet, the transfer paid under compensatory agreement could either be lower than the transfer based on expected number of concessionary passengers or not, both these possibilities being further investigated.

If under compensatory agreement the service provider is fully compensated for expected number of concessionary passengers.

$$f(E\tilde{a}) = f\left(\sum_{i=1}^{N} p_i\tilde{a}_i\right) = \theta\sum_{i=1}^{N} p_i\tilde{a}_i = \sum_{i=1}^{N} p_i\theta\tilde{a}_i$$
$$= \sum_{i=1}^{n} p_i\theta\tilde{a}_i + \sum_{i=n+1}^{N} p_i\theta\tilde{a}_i$$

so that

$$f(E\tilde{a}) \vee Ef(\tilde{a})$$
$$\sum_{i=1}^{n} p_i\theta\tilde{a}_i + \sum_{i=n+1}^{N} p_i\theta\tilde{a}_i \vee \sum_{i=1}^{n} p_i\theta\tilde{a}_i + \sum_{i=n+1}^{N} p_i A$$
$$\sum_{i=n+1}^{N} p_i\theta\tilde{a}_i \vee \sum_{i=n+1}^{N} p_i A$$
$$\sum_{i=n+1}^{N} p_i(\theta\tilde{a}_i - A) \vee 0$$
$$\sum_{i=n+1}^{N} p_i(\theta\tilde{a}_i - A) > 0$$

If under compensatory agreement the service provider is not fully compensated for expected number of concessionary passengers,

$$f(E\tilde{a}) = f\left(\sum_{i=1}^{N} p_i\tilde{a}_i\right) = A = A\sum_{i=1}^{N} p_i = \sum_{i=1}^{N} p_i A$$
$$= \sum_{i=1}^{n} p_i A + \sum_{i=n+1}^{N} p_i A$$

so that

$$f(E\tilde{a}) \vee Ef(\tilde{a})$$
$$\sum_{i=1}^{n} p_i A + \sum_{i=n+1}^{N} p_i A \vee \sum_{i=1}^{n} p_i\theta\tilde{a}_i + \sum_{i=n+1}^{N} p_i A$$
$$\sum_{i=1}^{n} p_i A \vee \sum_{i=1}^{n} p_i\theta\tilde{a}_i$$
$$\sum_{i=1}^{n} p_i(A - \theta\tilde{a}_i) \vee 0$$
$$\sum_{i=1}^{n} p_i(A - \theta\tilde{a}_i) > 0$$

Proof that the service provider could never loose under Extension 2

In case of the offer being rejected he is as well of. In case of the offer being accepted he is better off. Indeed, the service provider obtains higher tariff anyway. If actual number of concessionary passengers is lower than the expected figure he could either be compensated less yet fully, what he has accounted for when deciding on optimal share in PPP, or the same in case of available budget being even lower. If actual number of concessionary passengers is higher than the expected figure he would have to be compensated more but even if not being compensated fully he would be compensated not less than before.

Derivation of optimal tariff under Extension 2 (no access blocking)

$$W = \frac{((a_1+a_2) - (b_1-b_2)P)^2}{2(b_1-b_2)} + \alpha(P(a_1-b_1P) - \theta((a_1+a_2)$$
$$- (b_1-b_2)P))$$

$$\text{FOC}: \frac{\partial W}{\partial P} = -((a_1 + a_2) - (b_1 - b_2)P) + \alpha(a_1 - 2b_1P + \theta(b_1 - b_2)) = (-(a_1 + a_2) + \alpha(a_1 + \theta(b_1 - b_2))) + ((b_1 - b_2) - 2\alpha b_1)P = 0$$

$$\text{SOC}: (b_1 - b_2) - 2\alpha b_1 < 0$$

$$P = \frac{-(a_1 + a_2) + \alpha(a_1 + \theta(b_1 - b_2))}{-(b_1 - b_2) + 2\alpha b_1}$$

Derivation of optimal tariff under Extension 2 (complete access blocking)

$$W = \frac{((a_1 + a_2) - (b_1 - b_2)P)^2}{2(b_1 - b_2)} - (1 + \lambda)F + \alpha((P - \theta)((a_1 + a_2) - (b_1 - b_2)P))$$

$$\text{FOC}: \frac{\partial W}{\partial P} = -((a_1 + a_2) - (b_1 - b_2)P) + \alpha((a_1 + a_2) - 2(b_1 - b_2)P + \theta(b_1 - b_2)) = (-(a_1 + a_2) + \alpha((a_1 + a_2) + \theta(b_1 - b_2))) + ((b_1 - b_2) - 2\alpha(b_1 - b_2))P = 0$$

$$\text{SOC}: (b_1 - b_2) - 2\alpha(b_1 - b_2) < 0$$

$$P = \frac{-(a_1 + a_2) + \alpha((a_1 + a_2) + \theta(b_1 - b_2))}{-(b_1 - b_2) + 2\alpha(b_1 - b_2)}$$

Proof of the increase in tariff becoming optimal as a result of access to the service by free-riders being blocked

As nominator is increased by αa_1 while denominator is reduced by $2\alpha b_2$, both nominator and denominator remaining positive, tariff is increased as a result of access to the service by free-riders being blocked. This result is an intuitive one. Before the tariff representing the solution to social welfare maximization problem was set at such a level that marginal loss to consumer surplus from tariff increase was equal to marginal gain to producer surplus from tariff increase multiplied by α. With free-riders having turned into obedient passengers, marginal gain to producer surplus from higher tariff weighted by α increases exceeding the corresponding marginal cost to consumer surplus which is unaffected by the change. Consequently, higher tariff becomes socially optimal.

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