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Strategic partnerships in local public transport

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ABSTRACT

We present a rationale for the delegation of regulatory functions in public transport to a partnership that rebalances social and commercial interests according to an agreed and predetermined objective function. This allows for the improvement of economic efficiency providing a constructive commitment to tariff and subsidy policies. Using a simple model, we determine the optimal corporate structure for such a partnership between the local government and any regulated monopoly. The government's strategic option of using its stake in the partnership to generate budget revenue from sale proceeds and/or dividends encourages the relevant authorities to increase the commercial attractiveness of the joint enterprise by setting appropriate tariffs. We show that such a strategic partnership can lead to improvements in welfare if the local cost of public funds is relatively high. These theoretical findings are then examined through the prism of suburban railway transport reform in Russia.

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1. Introduction

Local authorities are traditionally viewed as having limited capacity to raise fiscal revenues but while also being subject to strong political pressure from local users, taxpayers, private firms and trade unions (Boardman & Vining, 2012). As Dementiev and Loboyko (2014) point out, in the case of suburban rail regulators are often more concerned with serving the interests of their local passengers than those of the service providers. When political factors shift the balance of bargaining power from service providers to consumers (voters), local authorities experience additional pressure on their budgets. The obvious solution – to increase tariffs from 'socially desirable' to economically optimal levels – may not be politically acceptable, and thus local authorities would prefer to extricate their tariff decisions from any political pressure. Not surprisingly, local public agents with limited financial resources seek various governance models in regulated markets, including but not limited to fully state-owned enterprises, mixed enterprises, public–private partnerships (PPPs) and regulated private firms.

Unlike many other public utilities, suburban rail services face competition from alternative modes of transportation, including public buses and private cars. This external competitive pressure also shapes the regulatory policy, affecting the choice of organisational capacity in the sector and providing local authorities with the option of abandoning services. The noticeable variety of alternative delivery models in local public transport worldwide and the flexibility that local authorities are perceived to have in designing institutional environments in their service areas mean that analysis of organisational transformation in local public transport demands intense research.

The growing number of local mixed enterprises (or institutionalised PPPs with a certain combination of public-sector and private sector joint share ownership) as well as contractual PPP arrangements (with sequential share ownership) has boosted research on the optimal choice of organisational capacity (Cruz, Marques, Marra, & Pozzi, 2014). Admittedly, this stream of literature remains mainly descriptive (Vining, Boardman, & Moore, 2014). The obvious conflict of objectives between owners makes institutional design of partnership structures fairly complicated from both a theoretical perspective and in respect of practical implementation. For instance, Moszoro (2014) considers the view that PPPs are special purpose vehicles, with the shares in equity contributed by the parties, which reflects the shareholders' voting power in managerial decisions.

In the case of regulated markets, the role of local authorities is at the least twofold: they should maximise social welfare measures as

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the regulator and provide for the returns left for stakeholders as the residual claimant in the partnership. Eventually, they delegate de facto tariff-setting responsibilities to an entity that rebalances the interests of the participants according to its share structure. Regulatory function in PPPs for the provision of transport infrastructure has been discussed by Carmona (2010). Indeed, the author points out that at the strategic level of regulatory action, there is a need to balance a multiplicity of objectives, which vary according to specific economic conditions.

Our paper lays out a positive theory of partnership design in the regulated public sector that is motivated by political considerations, yet benchmarked by social welfare maximisation criteria. In an attempt to improve social welfare and take into account society's preferences for redistribution, local authorities can delegate their regulatory functions to a more commercially oriented joint venture – an *ordinary partnership* – that values commercial profit more highly than general society does. The objective function of this intermediary will reflect the corporate structure of the partnership: $(\omega,1-\omega)$, where ω stands for the public agent's share, and $(1-\omega)$ represents the private agent's stake. The idea here is to use the establishment of an entity with a transparent decision making structure as a commitment to future regulatory policy that balances public and commercial interests in a predictable way (Kamijo & Tomaru, 2014). In particular, by allowing the private stakeholder to generate greater revenue, local authorities will tend to reduce the use of public funds for the sake of meeting fiscal constraints.

Similar analysis of Bennett and Iossa (2006) suggests that, in the context of contracting out public service provision, the decision rights can be strategically delegated to a PPP with a distinct objective function that has a greater profit orientation and a smaller concern for social benefit than the public sector agency. The relative weight placed by the PPP on social benefits is assumed to be exogenous in their paper. Its interrelation with the shadow cost of public funds proves to be crucial for the delegation scheme to be optimal for cost-reducing and quality-enhancing innovations. The authors admit, nevertheless, that if the value of this weight can be determined precisely to fit the government's goals, the delegation would result in a first-best solution. Our model develops this idea and shows how the optimal weight in the partnership's objective function depends on its (properly chosen) share structure $(\omega,1-\omega)$, the local cost of public funds (λ) and the regulator's concern for profits (α).

The problems with endogenous choice of regulatory arrangements in the context of local public transport in France have been thoroughly investigated in a recent paper by Gagnepain and Ivaldi (2016). They also adopt a positive approach and built a private interest theory of political regulation by assuming explicitly that local authorities, inter alia, care for the profit of the regulated firm more than a benevolent social welfare maximiser. The authors estimate a structural endogenous switching model to recover the parameters λ and α assuming that the type of regulatory contract (fixed-price or cost-plus) impacts costs but not prices and demand. On the contrary, our analysis rests on the assumption that the cost structure is unaffected by the regulatory arrangements while pricing decisions and corresponding local budget subsidies (T) crucially depend on λ and α as well as strategic considerations of the local authorities.

These strategic considerations reflect the dual role of local authorities being a price setting regulator on the one hand and residual claimant for the retained profit on the other hand. The temptation to use the partnership as a revenue 'cash cow' to finance budget needs changes its ex ante optimal share structure. From a contractual point of view such a regulatory arrangement – a *strategic partnership* – should explicitly state the dividend and/or privatisation policy principles. When designing the partnership's corporate structure, local authorities face a trade-off between their stake in the partnership (ω) and its profitability (π). Setting higher tariffs allows them to generate revenue from dividends and/or potential sale proceeds which can be used to at least partially relax their budget constraints and favour taxpayers at the expense of users. At the same time, such an increase in the commercial attractiveness of the joint enterprise implies that the government's involvement is relatively low (social concerns are moderate) and the partnership is dominated by the private agent.

Our model shows that the above-mentioned considerations increase the optimal government stake in the strategic partnership as compared to the ordinary partnership for any parameter values of λ and α. However, the first-best social outcome can only be achieved by means of strategic partnership arrangements if the local cost of public funds is high. Furthermore, the optimal corporate structure of such a partnership may not be unique. Hence, local authorities may choose between the alternatives in an attempt to minimise the net transfer from the budget $(T-\omega\pi)$ other things being equal. Remarkably, changing the government's involvement in a strategic partnership may not necessarily lead to a different regulatory policy (tariffs may remain the same), while in the case of an ordinary partnership a lower stake of the public agent always implies higher tariffs.

These theoretical findings are then examined through the prism of the suburban railway transport reform in Russia. The reform resulted in the establishment of 26 profit-oriented train operating companies in 73 service areas organised as joint ventures (Suburban Passenger Companies or PPKs) between the local authorities and regulated service providers. The corporate structures of the established partnerships, as well as tariff policies, were designed at a regional level, while subsidies were also provided by the federal centre and in many cases were out of the control of local authorities.[1] Approximately half of all PPKs were organised on a parity principle between RZD (Russian Railways JSC) and local authorities, while some regions preferred lower stakes in PPKs. Their performance also turned out to be very different. Furthermore, the process of organisational transformation has diverged dramatically across different Russian regions and has culminated in the privatisation of the public stake in the Central PPK servicing the Moscow region on the one hand, and the abandonment of commuter services in economically depressed regions on the other hand. The observable variety of PPKs' corporate structures makes our theoretical findings applicable and relevant for policy making.

The rest of the paper is structured as follows. Section 2 develops a theory of organisational choice when delegation of regulatory functions to a partnership with an optimally chosen corporate structure improves social welfare. Section 3 presents the main theoretical results that depend on whether the partnership is 'ordinary' or 'strategic'. The model's implications are further discussed and interpreted in Section 4. The experience of the organisational transformation of suburban railway transport in Russia is placed in the context of theoretical discussion in Section 5. Section 6 concludes the paper.

2. The model

Consider a simple model of a regulated monopoly (the firm) that delivers a homogenous (transportation) service at a regulated unit price $P \geq 0$ and receives a transfer payment T from the government. For the sake of model tractability, we consider linear demand function $Q = 1 - P$ with the maximum willingness to pay

[1] In some regions and service areas (like Moscow Region, Saratov Region, Krasnodar Region and some other) more than one PPK operate the routes, but this is an exception.

normalised to 1. The firm incurs constant marginal cost c as well as non-negative fixed cost F (eg. infrastructure charges) which turns out to be changeable in the case to which we are applying our analysis. Naturally, this will affect the firm's participation constraint and be related to the lump-sum budget transfer T in equilibrium.

The general regulatory framework is based on Vickers and Yarrow (1988) and Armstrong and Sappington (2006). A benevolent regulator seeks to maximise the weighted sum of net consumer surplus (CS reduced by transfer payment T) and the firm's profit π. In a case of linear demand function (gross) consumer surplus $CS(P) = (1 - P)^2/2$ decreases in price for $P < 1$. Society's immanent preferences for wealth redistribution from the firm's shareholders to consumers is reflected by parameter $\alpha \in [0,1]$ in the following social welfare function: $W = CS - (1 + \lambda)T + \alpha\pi$, where $\lambda \geq 0$ is the local cost of public funds, and $\pi = (P - c)Q - F + T$ is the firm's profit, which includes transfer T. A reduction of $(1 + \lambda)T$ in the surplus enjoyed by consumers accounts for an additional loss of social welfare λT due to distortionary taxes levied on consumers to finance transfer T to the firm. The empirical estimates of the scope of tax distortions, measured by λ, and other applications of the model will be discussed in detail in Section 4.

As was shown in Dementiev and Loboyko (2014), for $\alpha < 1$ and $\lambda > 0$ social welfare declines when the firm's rent increases. There is no information asymmetry in the model, so the general setup for our analysis of alternative regulatory frameworks in the sector is:

$$\max_{P,T} W = \max_{P,T} \frac{(1-P)^2}{2} - (1+\lambda)T + \alpha\pi \; s.t. \; \pi = (P-c)(1-P) - F + T \geq 0, \; P \geq 0 \tag{1}$$

Formally speaking, this problem of constrained maximisation is solved by applying the Kuhn-Tucker theorem and using corresponding complementary-slackness conditions (see the proof of this and other results in the Appendix). The crucial factor that drives our main result is whether the firm's participation constraint ($\pi \geq 0$) and/or the regulator's budget constraint $T \leq \overline{T}$ are binding. In what follows, we consider different parameter restrictions that are distinct for specific economic contexts and regulatory environments; we also provide an economic interpretation of the results for equilibrium price and transfer while making a welfare comparison using the above-mentioned social welfare function.

Should the local cost of public funds be zero ($\lambda = 0$), optimal price will be equal to marginal cost $P_c = c$ and optimal transfer will just cover fixed cost ($T_c = F$). When λ is very high ($\lambda \gg 0$) it becomes socially optimal to finance consumers from the firm's profit. Thus, at the extreme, the regulator would set price $P_m = (1 + c)/2$ as if it is chosen by an unregulated profit-maximising monopolist. Obviously, the corresponding budget transfer $T_m = F - (1 - c)^2/4$ would be minimal among all possible regulatory alternatives (see the Appendix for the proof). Intuitively, this combination of price and transfer does not seem to secure maximum social welfare, and thus society values firms' profits less than consumer welfare and sets $\alpha < 1$. However, as we show in the next subsection, the mere (to a large extent arbitrary) discouragement of the firm's profit, does not lead to social optimality.

An apparent trade-off between the local cost of funding the project ($1 + \lambda > 1$) and the social value of the firm's profit ($\alpha < 1$) justifies an intention on the part of public authorities to save taxpayers' money and minimise transfer from the budget. However, when the firm's participation constraint is binding ($\pi = 0$), redistribution parameter α becomes irrelevant for the welfare maximisation problem, since the firm always receives zero economic profit. This is what happens in the case of *optimal regulation* with full information when the regulator manages to extract all the rent from the firm.

On the contrary, when the firm is allowed to have some non-negative profit $\pi \geq 0$ the optimality condition becomes dependent on α and departs from the social optimum, unless the marginal increase in the firm's rent is completely offset by a corresponding decrease in net consumer surplus. This will never take place under standard regulation since $\alpha < 1 + \lambda$ with our model parameter restrictions. This case is described as the Public Service Obligation (PSO) in Dementiev and Loboyko (2014) for the binding budget cap $T = \overline{T}$. As such, here we employ the same notation, namely *public service obligation*, but consider a more general case which will lead to optimal price and transfer if the regulatory framework is shaped by the partnership agreement.

The role of the local authorities (LA) in our model is viewed as an institutional designer that opts to improve relationships between the regulator and the firm by choosing welfare maximising organisational capacity. In particular, given the parameters α and λ, LA may initiate organisational transformation in the sector, establish a joint venture with the firm, and optimally choose its corporate share ω in the partnership (being either ordinary or strategic). All the regulatory functions are delegated to the partnership, which truthfully maximises its objective function. Ultimately, the welfare comparison of the organisational alternatives benchmarked by the optimal regulation framework should indicate the direction of the structural reform in the sector.

2.1. Optimal regulation

When a fully-informed benevolent regulator solves (1) subject to $\pi = 0$, the resulting optimal price $P_0 = (1 - (1 + \lambda)(1 + c))/(1 - 2(1 + \lambda))$ is always positive and increasing in both λ and c for $c < 1$. It is useful to introduce the variable $\beta \equiv \frac{1}{1+\lambda} \in (0; 1]$ which can be interpreted as the availability of non-distortionary public funding, or 'ease' of raising local public funds through local taxation. Given this notation, optimal price can be re-written as $P_0 = (1 + c - \beta)/(2 - \beta)$. For the zero cost of public funds, $\lambda = 0 \Leftrightarrow \beta = 1$, we have marginal cost pricing $P_0 = P_c = c$. At the other extreme ($\beta = 0$) we have monopoly price $P_0 = P_m = (1 + c)/2$ (see Eq. (A.7)). With some positive local cost of public funds $\lambda > 0$ optimal price lies between the perfectly competitive and the monopoly one: $P_c < P_0 < P_m$.

The optimal compensatory transfer T that ensures the firm's participation constraint has a U-shaped form with respect to price P:

$$T = (F + c) - P(1 + c) + (P)^2 \tag{2}$$

The case under consideration is defined by Eq. (A.5) and shown in Fig. 1 at point 0 where $T_0 \equiv T(P_0)$. Minimum level of transfer $T_m = F - (1 - c)^2/4$ (see Eq. (A.8)) is associated with monopoly price P_m that exceeds the optimal price level P_0 (see Fig. 1). Social welfare function with zero profit constraint has an inverted U-shaped form with respect to price P:

$$W = \frac{(1-P)^2}{2} - (1+\lambda)\left((F + c) - P(1 + c) + P^2\right) \tag{3}$$

In the case of optimal regulation, social welfare reaches its maximum at $W_0 \equiv W(P_0)$, as shown in Eq. (A.6) and Fig. 1.

2.2. Public service obligation

Regulator's optimal choice of the price level P_α for the case of PSO is derived from the maximisation problem (1) subject to non-binding participation constraint $\pi \geq 0$ and is equal to $P_\alpha = (1 - \alpha(1 + c))/(1 - 2\alpha)$ provided that second-order condition holds (see Eq. (A.9) for evidence that $\alpha > 1/2$). Given certain

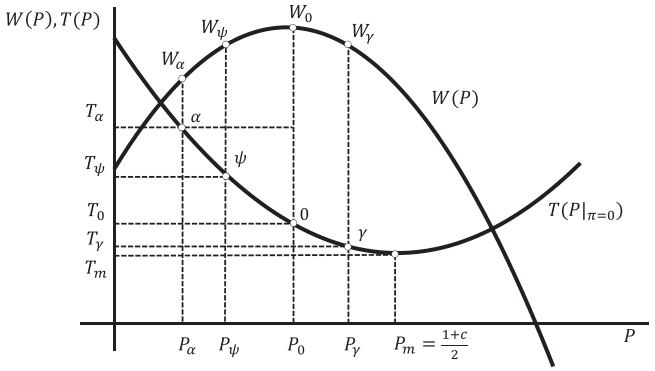

Fig. 1. Social welfare W and budget transfer T for the alternative organizational forms.

parameter restrictions $\alpha > 1/(1+c)$, for the price P_α to be positive we obtain an important property of the optimal price. Specifically, it monotonically increases with relative weight put on profit in the regulator's objective function: $\frac{\partial P_\alpha}{\partial \alpha} = \frac{1-c}{(1-2\alpha)^2} > 0$, for all $c < 1$ and $\alpha > \max\left\{\frac{1}{2}, \frac{1}{1+c}\right\}$.

This so called *monotonicity result* can be generalised to other regulatory frameworks: when the regulator, that is willing to leave the firm with higher rents, allocates additional weight to its profit in the extended welfare function, the regulated price goes up. As implied by (2), any price below the monopoly one is associated with lower budget transfer. Moreover, expression (3) helps us make a direct welfare comparison between alternative contractual arrangements that imply different preferences for redistribution.

In the case of PSO budget transfer, $T_\alpha \equiv T(P_\alpha)$ and social welfare W_α are defined by Eq. (A.10) and Eq. (A.11) correspondingly. Regulated price P_α appears to be suboptimal since condition $\alpha = 1 + \lambda$, that follows from Eq. (A.2), never holds given restrictions on parameters $\alpha < 1$ and $\lambda > 0$. Since in practice $\alpha < 1 + \lambda$, the price $P_\alpha < P_0$, which implies that $W_\alpha \equiv W(P_\alpha) < W_0 \equiv W(P_0)$.

Note that if the regulatory framework is shaped by the PSO type of contract, it leads to lower price and lower social welfare compared with the case of optimal regulation. Having realised this institutional limit, local authorities may seek alternative delivery models to ensure that regulatory agencies value the firm's profit relatively higher than society. Establishing a partnership with a purely commercially oriented enterprise may serve such a goal.

2.3. Ordinary partnership

Consider an ordinary partnership (OP) between the LA that maximises social welfare (1) and a profit maximising firm in the form of a joint venture with the corporate structure $(\omega, 1-\omega)$, where $0 < \omega < 1$. The LA performs like a benevolent social welfare maximiser and delegates price setting regulatory responsibilities to the partnership with the following objective function:

$$\max_P U^{OP} = \max_{T,P}\{\omega W + (1-\omega)\pi\} \; s.t. \; \pi \geq 0, \;\; P \geq 0 \tag{4}$$

By tilting the playing field in the favour of a commercially oriented agent, the LA effectively increase the relative weight of profit in the regulator's objective function. The maximand then becomes $\max_{T,P} \omega(CS - (1+\lambda)T + \psi\pi)$, where $\psi = \alpha + 1/\omega - 1$ is the effective relative weight of profit in the OP's objective function. For any $\omega < 1$, effective weight $\psi > \alpha$ and ψ is decreasing in ω. Due to the previously obtained monotonicity result, the expression for optimal price in this case can be easily written as $P_\psi = (1 - \psi(1+c))/(1-2\psi)$, where α in Eq. (A.9) is replaced by the new weight ψ. This optimal price P_ψ being plugged into Eq. (A.10) and Eq. (A.11) will give us the expressions for $T_\psi \equiv T(P_\psi)$ and $W_\psi \equiv W(P_\psi)$.

Obviously, as $\psi > \alpha$, $P_\psi > P_\alpha$ for all $\omega < 1$. By allowing for the greater participation of the private sector in the regulatory decision making (i.e. decreasing ω), the LA may cause an increase in the regulated price to socially optimal level P_0 when $\psi = 1 + \lambda$. The unique LA's share in the OP's structure that supports this optimality condition is thus: $\omega_\psi^0 = 1/(2 + \lambda - \alpha)$.

2.4. Strategic partnership

Many public authorities, as pointed out by Wen and Yuan (2010), tend to maximise the sum of gross consumer surplus and net government revenues weighted at the (gross) social cost of public funds: $CS + (1+\lambda)(\omega\pi - T)$, where $\omega\pi$ proxies an additional source for the budget revenues. This formalisation of the local governments' problem can be justified as follows: in a partial equilibrium context yearly dividend payments distributed to the public stakeholder are fully used to finance yearly transfers to a regulated firm. Naturally, these additional revenues are proportional to the firm's profit and grow with the government's stake in the partnership. For simplicity's sake, we do not consider here the discounted value of the future stream of profits because the private and public discount factors may be substantially different (see Moszoro (2014) for discussion and a formal model). Another complexity arises from the credibility issues described in Newberry (2002). In a post-privatisation stage, when the company is still regulated as a public utility, the future stream of revenues is solely driven by the regulator's commitment to tariff and subsidy policy. We focus here on the fact that the strategic consideration for a budget-oriented redistribution of dividends or privatisation alters the weight assigned to the profit in the new objective function.

This strategic consideration makes sense, when $\pi \geq 0$. When regulatory responsibilities are delegated to a corresponding strategic partnership (SP), the LA faces a certain trade-off: the greater its involvement in the SP and relatively greater concern about consumer surplus, the lower the firm's profitability and net budget revenue:

$$\begin{aligned}\max_P U^{SP} = \max_{T,P}\{&\omega(CS - (1+\lambda)(T - \omega\pi) + \alpha\pi) \\ &+ (1-\omega)\pi\}, s.t. \; \pi \geq 0\end{aligned} \tag{5}$$

Intuitively, this regulatory framework appears to be even more 'pro-profit' since the de facto weight put on the firm's profit by the strategic partnership in its objective function increases further: $\gamma = \frac{1}{\omega} - (1-\alpha) + (1+\lambda)\omega$, which is greater than ψ for all α, λ and ω (see Fig. 2). The maximand for SP becomes: $\max_{T,P}\{\omega(CS - (1+\lambda)T + \gamma\pi)\}$. As in the previous case, optimal price that maximises (5) can be obtained by plugging γ instead of α into Eq. (A.9) to get $P_\gamma = (1 - \gamma(1+c))/(1-2\gamma)$. This optimal price P_γ being substituted into Eq. (A.10) and Eq. (A.11) gives us the expressions for $T_\gamma \equiv T(P_\gamma)$ and $W_\gamma \equiv W(P_\gamma)$.

Again, the monotonicity result implies that for $\gamma > \psi$, $P_\gamma > P_\psi$ for all $\omega < 1$. To replicate the socially optimal price P_0 by delegating the pricing decision to SP, one should equate the de facto weight of the firm's profit in SP's objective function to the local cost of public funds: $\gamma = 1 + \lambda$. Because the relationship $\gamma(\omega)$ is nonlinear, there may exist none, one, or two real roots of the corresponding quadratic equation:

$$\omega_\gamma^{1,2} = \left[(2 + \lambda - \alpha) \pm \sqrt{(2+\lambda-\alpha)^2 - 4(1+\lambda)}\right] \Big/ 2(1+\lambda)$$

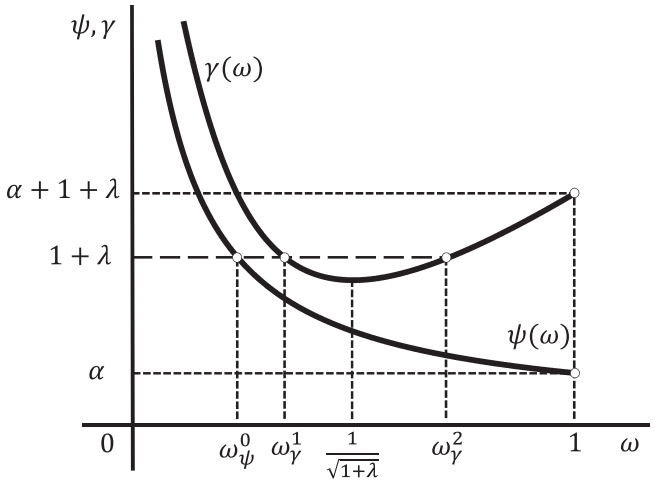

Fig. 2. Optimal corporate structures and relative weights of profits in the objective functions of ordinary partnership (ψ) and strategic partnership (γ).

Our main findings and their graphical illustrations are summarised in Figs. 1–3.

3. Results

In the PSO framework when local public funds are costly and the society values consumer surplus more than the firm's profit, the regulator sets the price P_α below optimal, while transfer payment T_α proves to be relatively high. Hence, social welfare does not reach its potential maximum, thus $W_\alpha < W_0$.

In the OP framework, the LA would de facto put higher weights on the firm's profit by delegating regulatory functions to an entity that integrates the confronting objectives of consumers, taxpayers and producers.

Proposition 1: The government may always replicate the socially optimal price P_0 that guarantees social welfare maximum W_0 by delegating regulatory decisions to an ordinary partnership with the share $\omega_\psi^0 = 1/(2+\lambda-\alpha)$ belonging to the benevolent public agent and $(1-\omega_\psi^0)$ to a regulated service provider.

This result is valid for all $\alpha > 1/2$, and $c < 1$ as illustrated in Fig. 2 by the point of intersection $\psi(\omega)$ function with the horizontal dashed line $1+\lambda$.

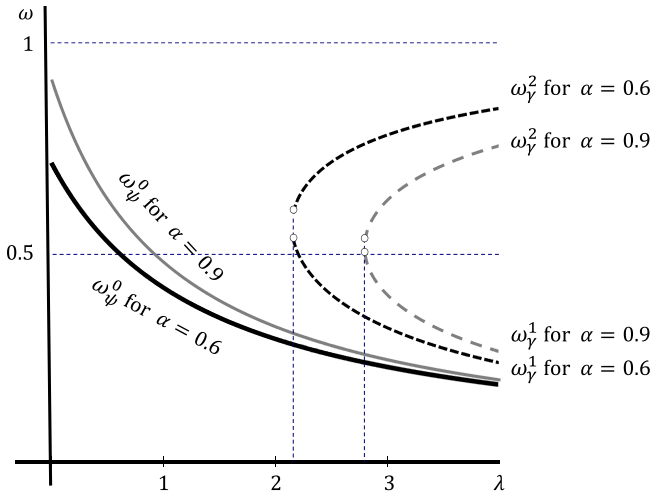

Fig. 3. Optimal government's shares ω_ψ^0 for ordinary partnership (solid lines) and ω_γ^1 and ω_γ^2 for strategic partnership (dashed lines).

In the SP framework, regulatory functions are delegated by LA to an entity with an explicit strategy to use the firm's profit as a budget revenue source. Such an organisational structure of the partnership may not necessarily allow the government to reach social optimum.

Proposition 2: The government may replicate the optimal price P_0 that guarantees social welfare maximum W_0 by delegating regulatory decisions to a strategic partnership only when the local cost of public funds is high enough, so $\lambda \geq 5-\alpha^2+1$. For the strict inequality, the two alternative corporate structures with $\omega_\gamma^{1,2}$ belonging to the benevolent public agent equally serve this goal, when $\omega_\gamma^{1,2} = [(2+\lambda-\alpha) \pm \sqrt{(2+\lambda-\alpha)^2 - 4(1+\lambda)}\,]/2(1+\lambda)$.

Fig. 2 shows the multiplicity of optimal corporate structures in the case of SP when λ is relatively high. The horizontal dashed line $1+\lambda$ crosses the U-shaped function $\gamma(\omega)$ twice at points ω_γ^1 and ω_γ^2. For relatively low λ there is no such strategic partnership that serves as a vehicle to achieve social welfare maximum W_0.

When the local cost of public funds is high, LA may choose between the two alternative share structures in SP to mimic this bliss point. In order to select either low ω_γ^1 or high ω_γ^2, the public agent should adhere to some additional criteria, such as net budget revenue maximisation, political motives, or institutional restrictions.

This result can be clearly seen in Fig. 3, where the optimal government's shares in OP and SP are demonstrated as a function of the local cost of public funds. For expository purposes, we have chosen two distinct values of α=0.6 (plotted in black) and α=0.9 (plotted in grey) for relatively high and low redistribution concerns respectively. As it in Proposition 1, an increase in λ gradually decreases the optimal government stake in OP, which serves as a special vehicle to mitigate the problem of welfare loss caused by politically motivated redistribution. When the availability of public funds is not a big problem (λ is low), the difference in the optimal ω for α=0.6 and α=0.9 is significant. However, this difference disappears when the problem of financing the public sector from the budget becomes more pronounced.

The logic of optimal organisational choice changes when the local government finances its budget needs from the firm's profit (when the net budget transfer becomes $T-\omega\pi$). This may be either in the form of dividends or proceeds from privatisation. By establishing an appropriate institutional framework in the form of SP, which allows the LA to take greater risks and opt for higher rewards, they empower themselves with additional fiscal instruments. This separate task becomes significant when the external budgeting of localities is very limited (T is low). Naturally, any meaningful measure of the local cost of public funds λ will be fairly high in this case.[2]

According to Proposition 2, if λ is large enough to justify the organisational choice of SP, the LA should definitely opt for a higher stake in SP as compared to OP. This should occur while the partnership's optimal share structure is ambivalent. In particular, when the regulator equally weighs net government revenues and the firm's profit (i.e. $1+\lambda=\gamma$), social welfare optimum may be reached, either by redistributing a greater share of smaller profit, or a lower share of higher profit.

Our simple model allows for the direct welfare comparison of the alternative regulatory frameworks and organisational structures. Fig. 1 shows that moving right along the inverted-U-shaped curve $W(P)$ from point W_α to point W_0 improves social welfare and decreases required budget transfer ($T_0 < T_\alpha$). This result implies that the suboptimal solution for PSO contractual arrangement (point α) may be partially (point ψ) or fully (point 0) resolved by

[2] Relevant empirical literature on the local cost of public funds will be discussed in the following section.

delegating regulatory functions to OP. This should be done with 'wisely' mixed objectives and legislative restriction the prohibits the use of the firm's profit as a budget revenue source. Instrumentally, the government chooses to increase its stake in OP with α and decrease with λ. For instance, when the government has a stake of approximately 50% (as illustrated by the horizontal dashed line at ω=0.5 in Fig. 3) the corresponding OP structure perfectly serves this goal if $\alpha=\lambda<1$. At the same time, it is only optimal for the SP structure if the local cost of public funds is dramatically higher.

We have shown, that fiscally constrained governments aiming to raise additional budget revenues may strategically design corporate procedures of the SP. This allows for the firm's profit redistribution in favour of the government budget. Our model predicts that in this case, the two alternative corporate structures ω_γ^1 and ω_γ^2 (illustrated as the decreasing and the increasing dashed curves in Fig. 3) are equally optimal from a social point of view for a given λ.

4. Implications for local public transport

The theory developed in the previous section alludes to local governments that are facing certain financial or institutional constraints. These governments are realising the scope of distortions associated with budget transfers to support socially desirable public transport projects. Indeed, they may consider partnership agreements with a regulated monopoly as a possible solution in case of limited fiscal capacity at the local level.

4.1. Fiscal capacity of local authorities

Delegation of tariff decisions to a partnership with predetermined share structure may serve this purpose. In the absence of any uncertainty about cost parameter c, there might be a reason to strategically delegate the right to pursue regulatory policy to a partnership with the agreed objective function that departs from those of both partners. Indeed, social welfare can be improved if the regulated price P maximises this modified objective function. Moreover, lump-sum transfer T is set at a level that is sufficient to completely compensate for any losses associated with such a tariff regulation, as this ensures that the firm will break even (π=0).

If the local government delivers transportation services under a PSO agreement and has a budget $\overline{T}$ that is insufficient (i.e. $T_\alpha>\overline{T}$) to secure the lowest price P_α, it will seek alternative delivery models with an increased participation of the private sector, such as an ordinary or strategic partnerships. If the lowest possible transfer (which is the monopoly case) is still above the budget cap $T_m>\overline{T}$, then the project will be abandoned because the firms' participation condition will be violated for any price level.

It is commonly asserted that subnational governments in a federation may have different fiscal capacities. This can cause certain variations in the provision of local public services. Table 1 shows that, for the majority of Russian regions with suburban railway services, the full-scale cost recovery in the form of ex post compensatory transfer to the service provider was not guaranteed. This may indicate the scope of horizontal fiscal imbalances that Dahlby (2008) proposes to define in terms of local governments' marginal cost of public funds (or local cost of public funds $1+\lambda$ in our framework). The author argues that many expenditure policies adopted in a federation would not imply an optimal allocation of the tax burden that requires equal λ for all the localities. Eq. (A.5) implies that the optimal transfer T decreases in λ, meaning that ensuring adequate budget financing of suburban railway transport becomes problematic in the regions with relatively high λ.

Apparently, politically concerned local authorities with limited fiscal capacity would prefer to shift the burden of full cost recovery from the taxpayers to train-users by means of the 'right' organisational choice. This depends on the local cost of public funds and would eventually increase tariffs and decrease transfers.

Table 1
Availability of public funds for suburban rail cost recovery in 73 Russian regions.

Number of regions	2011	2012	2013	2014
Compensation is not required	6	5	6	4
100% compensation	15	16	9	14
>50% compensation	14	15	22	22
<50% compensation	32	33	34	28
Not provided	6	4	2	5

Source: RZD

4.2. Local cost of public funds

The existing methodological and empirical literature on the cost of public funds and similar concepts (including shadow, marginal, social, or opportunity costs) is far from conclusive (see Browning, Gronberg, and Liu (2000) and Massiani and Picco (2013) for the detailed discussion of this multifaceted notion). The estimates of the efficiency loss λ due to distortionary taxation at the national level ranges from the very moderate λ=0.1 according to Ballard and Fullerton (1992) to λ=1.65 as in Feldstein (1999). Gagnepain and Ivaldi (2016) argue that in countries with a developed tax collection system, $(1+\lambda)$ falls in the range of 1.15 to 1.50. Their own estimates of the local cost of public funds in the context of the French urban transport industry reach $(1+\lambda)$=1.47. This is far below the value of $(1+\lambda)$=2.41 estimated by the European Commission (2013) for labour taxes in France.

Admittedly, at the local level (which is more relevant to our story), the perceived marginal cost of funds may be lower for the regions that receive financial support from the central budget and vice versa. Recent estimates by Dahlby and Ferede (2012) for the Canadian provinces show that the marginal cost of public funds for personal income tax ranges from 1.44 in Alberta to 3.81 in Quebec. Naturally, one should expect even higher distortionary effects for the less mature taxation systems, as in many Russian regions.

For illustrative purposes, consider the following numerical example. When the local cost of public funds is very high $(1+\lambda=4)$ and local authorities have great concerns about the firm's profit (α=1), then (according to Proposition 1) the optimal stake of LA in the ordinary partnership should amount to $\omega_\psi^0=1/(1+4-1)=0.25$. If the corporate procedures of the partnership imply that profit can be distributed to private and public stakeholders proportional to their shares, then such a partnership is deemed to be a strategic one. Accordingly, as indicated by Proposition 2, the optimal stake of LA in the strategic partnership should be $\omega_\gamma^1=\omega_\gamma^2=0.5$ in this case. Turning to an ordinary partnership, it should be noted that similar corporate structure $\omega_\psi^0=0.5$ of the partnership, which lacks the possibility of profit sharing, would be optimal only for relatively low values of local cost of public funds, when $\alpha=\lambda<1$.

Thus, an institutional designer that opts to improve social welfare by selecting optimal organisational capacity should establish explicit commitments regarding profit sharing policy. This is applicable to both dividend policy principles and privatisation strategy. Specifically, governments should choose between OP and SP as a way to credibly signal their intention to impose fiscal discipline on themselves and their commitment to a balanced tariff and subsidy policies.

4.3. Partnerships in local public transport

Our model has broader implications for various partnerships in public transport. When a government's commitment powers are limited and social concerns are high, partnership agreements

(institutionalised, contractual, trusting, etc.) may deserve consideration. Empirical research on the effectiveness of the alternative ownership structures and contractual arrangements in the public sector is not convincing. As shown in Stanley and Hensher (2008), there has been a great deal of success for bus services when it comes to employing tactical trusting partnerships between the authority and operator. These are extended to the operational level of planning in public transport. Relationship management principles and negotiated procedures provide for shared objectives between the parties rather than 'capturing authorities'.

Boitani, Nicolini, and Scarpa (2013) analyse 77 companies operating in large European cities over the period 1997 to 2006, They show that partially privatised operators in the local public transport sector demonstrate lower productivity compared with private firms. Moreover, competitive tendering as a selection procedure outperforms negotiated contracts. However, their approach is not immune to the problem of endogeneity of organisational choice (see Chong, Huet, Saussier, and Steiner (2006) for a discussion). The following section discusses the experience of organisational choice in the suburban railway transport system in Russia in the context of theoretical predictions of the model.

5. Application to suburban railway transport in Russia

5.1. The original reform plan

According to the reform plan, the delivery models of suburban services in 73 Russian regions with railway infrastructure were to be changed by 2011. Vaguely determined and weakly enforced PSO contracts between LA and RZD had to be substituted by a new delivery model. This model implied delegation of contracting and thus regulatory decisions to profit-oriented joint ventures between these parties. Moreover, regions were given a certain freedom to determine the share structure of the established Suburban Passenger Companies (PPKs).

Setting tariffs for regulated PPKs at the so called 'socially optimal' level and providing adequate compensation for all associated losses has remained the responsibility of LA. In fact, all transport planning decisions at the tactical level were delegated to PPKs, while the key assets required for the service delivery (rolling stock, railway stations, etc.) remained with RZD. Such a development in organisational capacity towards a partnership structure has been viewed as an improvement of institutional flexibility. This is because it enabled a platform for more trustworthy 'in-house' negotiations between LA and RZD.

By the end of 2011, 26 commuter rail enterprises had been established as joint ventures having very small authorised capital (approximately 100–150 thousand RUB). Another two purely private operators – Permskiy Express and InterRegion PK – both established in 2009, were competing with region-based PPKs and later ceased their operations (in December 2012 and September 2015 correspondingly).

The initially adopted reform plan prescribed a parity principle in establishing new PPKs at the local level. However, the actual process of organisational transformation in the suburban railway transport system in Russia revealed a tendency for diversification in the implemented delivery models across the regions. Among 26 subsidiaries of RZD, 5 PPKs were solely (or 99%) owned by RZD; 2 PPKs (North-West and North-Kavkaz) were dominated by RZD's share of 74%; 13 PPKs had RZD's share of slightly above 50%, and 6 PPKs had slightly below 50%. To ensure the operational profitability of suburban transportation services, in 2011, the Federal Government decided to provide a 99% discount of the infrastructure access charge (captured by the term F in our model) for all PPKs and compensated RZD directly for the associated costs.

5.2. Endogenous organisational choice

Russian regions differ substantially in their choice of organisational capacity in local public transport. During the first year of operation under this favourable regulatory regime the local government's share in Central PPK (serving the most lucrative suburban transportation market in Moscow City and Moscow Region) decreased from 50% to 25%. In fact, Moscow City authorities sold their 25% share in the company in 2011 for just 21 mln RUB. Less than a year after, RZD sold the same stake of 25% for 780 mln RUB in 2012.

The largest suburban operator, Central PPK, has an exceptional position in the Russian transportation market. It operates in 11 regions and serves an area comprising 28.5 mln inhabitants (approximately 20% of the total Russian population). In 2014, it had an 80% share of the Moscow rail commuter market, or around a 61% share nationwide. The company was formed on January 1 2006, with RZD holding 50% minus two shares, the city of Moscow 25% plus one share, and the Moscow region having 25% plus one share.

In 2010, Central PPK recorded a loss of 44 mln roubles. A year later, its profit jumped to 4.65 bln roubles. Table 2 explains the main reason for such a dramatic improvement in the company's financial results. On October 27 2011, the decision was taken at the federal level to give all Russian PPKs a 99% discount from the tariff for rail infrastructure access charged by RZD. Just a few weeks before that crucial decision, Moscow City authorities sold its 25% stake for the sum of just 21 mln roubles to a private investor. A year later, on December 21 2012, the equivalent stake of 25% minus three shares was auctioned by RZD to the same private investor, which paid 780 mln roubles and accumulated 50% minus two shares in Central PPK (see Table 2 for the financial details). It is worth noting that the Moscow Region refused to sell its stake of 25% in Central PPK in 2012 and continued to influence tariff decisions through its shareholder's rights in the company.

Our model predicts that, if the observed organisational structure was optimally designed as an ordinary partnership (as specified by Proposition 1), such a decrease in the government's stake could be a result of either a sharp increase in the local cost of public funds or a dramatic decrease in the regulator's concerns for profits. Both explanations are in marked contrast to the regulatory measures described above, which relived financial pressure on local budgets (decreasing λ) and made (potential) private stakeholders looking for larger returns and lobbying higher profits (increasing α). Thus we may reject the hypothesis that Central PPK was established as a pure contractual (or ordinary) partnership without any intention to redistribute profits from the private sector to tax-payers.

Alternatively, we may hypothesise that the original organisational structure of Central PPK reflected the local authorities' inclination to use the partnership as a revenue 'cash cow' to finance local public goods. In fact, the combined share of the two public agents (the Moscow City and the Moscow Region) in Central PPK was close to 50% at the beginning. Assuming that the corporate share structure for the strategic partnership was optimal, the associated regulated tariff for Central PPK services was also set at the socially optimal level. The indirect evidence for such an optimality could be an ongoing increase in patronage in the Moscow service area (see Table 2).

The specific objective function of the strategic partnership ensures that the marginal increase in the firm's profit (due to a higher lump-sum transfer payment from the budget) is fully offset by the marginal decrease in the net government revenue. However, when profit is affected by cost or productivity shocks, both consumer and producer surpluses increase. In our story, a permanent decrease in fixed cost F (namely, infrastructure charge, see Table 2) caused an

Table 2
Financial results of Central PPK.

		2009	2010	2011	2012	2013	2014
Central PPK passengers	mln	539	449	506	568	586	596
All other suburban passengers[a]	mln	480	383	372	374	383	371
Tariff per 15 pass-km	RUB	24	26	26	26	26	28
Net profit	bln RUB	0.38	−0.04	4.65	3.74	3.30	2.18
Federal and regional subsidies	bln RUB	4.74	4.30	6.80	6.98	7.17	7.72
Infrastructure subsidy	bln RUB	0.00	0.72	0.21	0.45	0.30	0.23
Infrastructure charge	bln RUB	4.75	5.00	0.10	0.11	0.12	0.13
Privatisation proceeds from 25% stake	bln RUB			0.02	0.78		

[a] Suburban passengers in all other Russian regions has been decreasing since 2006.
Source: RZD, Central PPK

increase in the commercial attractiveness of the partnership, as well as profit and net government revenues.[3]

How can our theory reconcile the two stylised facts: stable tariffs (26 RUB per 15 pass-km from 2010 to 2013, see Table 2) and change in the ownership structure of the partnership? In terms of our model the answer is: $\psi(\omega_{\psi}^{0}) = \gamma(\omega_{\gamma}^{1}) = 1 + \lambda$ (see Fig. 2). It means that the sale of 25% stake in the partnership effectively transformed its nature from SP to OP leaving the tariff at its optimal level P_0 (as illustrated by point 0 in Fig. 1).

The remaining 25% governments' stake in Central PPK is likely to be considered by the Moscow region authorities as an instrument to keep the balance between local interest groups. Initially they planned to auction their share in Central PPK but changed their minds in 2012. The attractiveness of the opportunity to raise funds from privatisation had been gradually decreasing since 2012, as net profit had been shrinking. It seems that the Moscow Region authorities have no intention to sell their stake anymore, and are likely to be engaged in an ordinary partnership with a dominant share of the pro-profit partner. This is also the case of the North-West PPK that operated in the third most lucrative passenger transportation market in Saint Petersburg. The LA's share of 26% in the partnership is close to what our model predicts given the same parameters α and λ for Russia's 'second' capital city.

5.3. When do partnerships fail?

The year 2015 witnessed a dramatic failure of public–private relations in the sector of suburban railway transportation in several Russian regions. Indeed, it was announced that the infrastructure charge discount was to be decreased from 99% to 'just' 75%, and 37 local authorities abandoned 312 trains across the country. After mass protests by regional commuters, policy action at the federal level followed in the form of a return to a preferential rate of infrastructure charge of 1%. There was also a VAT tax holiday until the end of 2017 for all PPKs, together with an additional transfer of 8.8 bln RUB from the Federal Anti-Crisis Fund in 2016.

Nevertheless, several regions failed to recover all of the services in full. Our model suggests that, for local authorities with a relatively high local cost of public funds, the share of a public agent in an ordinary partnership should be low. Indeed, the LA's stakes in the regions that completely or partially abandoned suburban services in 2014 and 2015 were as small as 9%, as in Belgorod (having compensated only 5% of the cost, see Table 1), or even 0%, as in Smolensk, Ulyanovsk, Penza, Orel, Pskov and Vologda.

Regarding a proxy for the local cost of public funds in these regions, one may consider a regional debt to budget revenues ratio that exceeds 110% for Smolensk, for instance. According to the RIA Rating (2015), the above mentioned regions belong to the lowest quartile of the most indebted regions in Russia (excluding the republics of the North Caucasus). An alternative approach that tackles the cross-region diversity in tax distortions was proposed by Gagnepain and Ivaldi (2016), who found that, in France at least, the local cost of public funds is significantly higher in constituencies with left-wing governments. Most regions that were cancelling suburban services in 2014 and 2015 belonged to the so called Russian 'red belt' where a relatively high rural population inherently have communist sentiments (Ahrend, 2012). This caused higher λ and justified lower share of LA in the partnership. However, there are natural boundaries for our theoretical predictions.

Obviously, when the firm's participation constraint (Eq. (A.5)) is not guaranteed, the problem should be addressed directly through intergovernmental transfers, rather than indirectly through the proper choice of organisational capacity. Clearly, a 'one size fits all' approach to the problem of optimal organisational choice is inadequate. If this theoretical consideration is ignored, the so-called 'exit option' will be exercised by LA and the socially desirable service will be terminated.

6. Conclusions

This paper has presented a theoretical framework and welfare comparisons for alternative organisational structures in the sector of public transport. This has shown that local authorities may enhance social welfare by delegating tariff setting decisions to a partnership between a public and a private agent with a specifically determined corporate structure. Public service obligation arrangements do not lead to socially optimal prices and transfer due to the distortionary nature of taxation and society's ad hoc preferences for redistribution when the public values corporate profit relatively less than consumer surplus. Strategic considerations regarding the potential redistribution of the partnership's profits in favour of local budgets make local authorities more 'commercially oriented' in their regulatory decisions.

An organisational capacity for a more flexible and, more importantly, endogenously determined regulatory framework, is provided in the form of ordinary and strategic partnerships. Both partnerships' corporate structure shapes the corresponding objective function of an agent with mixed public–private objectives. By taking into account the local cost of public funds and immanent redistribution preferences of society, public authorities may initiate an optimal partnership structure that replicates the welfare maximising price and transfer. If the government lacks funds but the firm's participation constraint is binding, it would be optimal to decrease the government's share in the ordinary partnership and let the profit-maximising firm enjoy the rent.

[3] Ironically, this all happened after Moscow City had sold its 25% stake in the partnership.

If the government considers the option of selling its stake in the partnership, additional revenues would partially relax the budget constraint, at least in the short run. This may support the decision of short-sighted politicians to become engaged in the privatisation of public stakes due to fiscal reasons. The establishment of a strategic partnership with a service provider may serve as a commitment to a predictable regulatory policy. When the tariff decision is agreed to be delegated to an entity whose objective function puts greater weight on commercial profits, the public agent explicitly commits to procedural formalities (according to corporate law) that minimise discretion and increase the responsibilities of authorities in tariff setting and subsidy formation. The very involvement in a joint venture between local authorities and service provider alters the nature of their relationships. Dementiev and Loboyko (2014) suggest that the main reason to reach a mutual agreement between parties and form a trusting partnership is elimination of asymmetric information and corresponding rent in regulatory practices. Here we have a completely different motivation to form an optimal partnership structure.

When the government is concerned with budget constraints, there is a need to evaluate the trade-off between higher prices (thus lower consumer surplus) and lower transfer (thus higher net government revenues). In the case of a perfectly contestable market, the (temporary) monopoly service provider faces binding participation constraint, and so economic profit disappears. In the case of perfect information concerning a producer's costs, its surplus is also nullified via efficient regulation.

Alternatively, having faced tough budget constraints, local authorities may initiate the complete abandonment of the rail services and switch to an alternative and relatively cheaper (in the short-run) transportation mode (such as buses). This could turn out to be socially optimal if commuters' demand for transportation by rail is relatively small and highly elastic due, for instance, to higher tariffs. These strategic considerations of future privatisation and the potential termination of services may shed some light on the observed diversity of organisational forms, for instance, in the suburban transportation sector in Russia. The theoretical insights of this paper can be further generalised to cases with limited public sector institutional capacity.

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Appendix

Social welfare maximisation problem $\max_{P,T} W = \max_{P,T} (1-P)^2/2 - (1+\lambda)T + \alpha\pi$ with inequality constraints $\pi = (P-c)(1-P) - F + T \geq 0$ and $P \geq 0$ is formally solved by writing the Lagrangian function as:

$$\mathscr{L} = (1-P)^2 \Big/ 2 - (1+\lambda)T + \alpha(\,(P-c)(1-P) - F + T) + \mu \cdot [\times (P-c)(1-P) - F + T]$$

Kuhn-Tucker conditions:

$$\frac{\partial \mathscr{L}}{\partial P} = -(1-P) + (\alpha+\mu)(1-2P+c) \leq 0, \quad \frac{\partial \mathscr{L}}{\partial P} \cdot P = 0 \tag{A.1}$$

$$\frac{\partial \mathscr{L}}{\partial T} = -(1+\lambda) + \alpha + \mu = 0 \tag{A.2}$$

$$\frac{\partial \mathscr{L}}{\partial \mu} \cdot \mu = 0, \quad \mu \geq 0 \tag{A.3}$$

Optimal regulation

Reasonable constraint $P > 0$ implies $\frac{\partial \mathscr{L}}{\partial P} = 0$. For $\mu > 0$ the firm's participation constraint becomes binding: $\pi = 0$. So we obtain optimal regulated price P_0 by combining Eq. (A.1) and Eq. (A.2):

$$P_0 = \frac{1-(1+\lambda)(1+c)}{1-2(1+\lambda)} = \frac{\frac{1}{1+\lambda} - (1+c)}{\frac{1}{1+\lambda} - 2} = \frac{1+c-\beta}{2-\beta} \tag{A.4}$$

By adding Eq. (A.3) we derive the optimal transfer T_0 with binding participation constraint:

$$\begin{aligned} T_0 &= (F+c) - P_0(1+c) + (P_0)^2 \\ &= (F+c) - \frac{1+c-\beta}{2-\beta}(1+c) + \left(\frac{1+c-\beta}{2-\beta}\right)^2 \end{aligned} \tag{A.5}$$

Social welfare with binding participation constraint becomes:

$$\begin{aligned} W_0 \equiv W(P_0) &= \frac{(1-P_0)^2}{2} - (1+\lambda)\left(F + c - P_0(1+c) + P_0^2\right) \\ &= -\left(\frac{1}{2} + \lambda\right)P_0^2 - P_0 - (1+\lambda)(F + c - P_0(1+c)) + \frac{1}{2} \end{aligned} \tag{A.6}$$

Second order condition $-\left(\frac{1}{2}+\lambda\right) < 0$ guarantees that P_0 is a global maximum of W_0.

Transfer minimisation

With binding participation, the constraint transfer minimisation problem effectively becomes equivalent to the profit maximisation problem of unregulated monopolist:

$$\begin{aligned} \min_P T &= \min_P \left\{(F+c) - P(1+c) + P^2\right\} \\ &= \min_P \left\{F - P + c + P^2 - Pc\right\} \end{aligned}$$

First order condition $dT/dP = 2P - (1+c) = 0$ is analogous to marginal revenue being equal to marginal cost $2P - 1 = c$, so the monopoly price:

$$P_m = (1+c)/2 \tag{A.7}$$

guarantees that the budget transfer (possibly negative) just allows the firm to break-even:

$$T_m = F - (1-c)^2 \Big/ 4 \tag{A.8}$$

Public service obligation

Again, positive price $P > 0$ implies $\frac{\partial \mathscr{L}}{\partial P} = 0$. However, condition $\mu = 0$ opens up room for non-negative profit: $\pi \geq 0$, that being incorporated into Eq. (A.1) yields:

$$P_\alpha = \frac{1-\alpha(1+c)}{1-2\alpha} \tag{A.9}$$

Notice that the sufficient second-order condition needed for this solution to be a welfare maximising one requires $\alpha > 1/2$. Accordingly, from Eq. (A.3) we get the expression for the transfer:

$$T_\alpha \geq F - \frac{(1-c)^2(\alpha-1)\alpha}{(1-2\alpha)^2} \tag{A.10}$$

Social welfare in the case of PSO W_α is related to transfer T which now becomes an independent regulatory instrument: $W_\alpha = \frac{\alpha^2(1-c)^2}{2(2\alpha-1)} - (1+\lambda-\alpha)T$. Due to $1+\lambda>\alpha$ it becomes socially optimal to minimise the transfer up to the level that secures the firm's break-even condition: $\pi_\alpha=0$. In this case, social welfare function takes the form:

$$\begin{aligned} W_\alpha \equiv W(P_\alpha) &= \frac{(1-P_\alpha)^2}{2} - (1+\lambda)\Big(F + c - P_\alpha(1+c) + P_\alpha^2\Big) \\ &= -\left(\frac{1}{2}+\lambda\right)P_\alpha^2 - P_\alpha - (1+\lambda)(F + c - P_\alpha(1+c)) \end{aligned} \tag{A.11}$$

Ordinary partnership

$$\begin{aligned} \max_P U^{OP} &= \max_P\{\omega W + (1-\omega)\pi\} \\ &= \max_{T,P}\{\omega(CS - (1+\lambda)T + \alpha\pi) + (1-\omega)\pi\} \\ &= \max_P \omega(CS - (1+\lambda)T + \psi\pi) \end{aligned}$$

$$s.t.\ \ \pi = (P-c)(1-P) - F + T \geq 0$$

Socially optimum price $P_0 = P_\psi$ is reached when: $\psi = \frac{1}{\omega} - (1-\alpha) = 1+\lambda$. The unique solution is thus $\omega_\psi^0 = 1/(2+\lambda-\alpha)$.

Strategic partnership

$$\begin{aligned} \max_P U^{SP} &= \max_P \omega(CS - (1+\lambda)(T - \omega\pi) + \alpha\pi) + (1-\omega)\pi \\ &= \max_P \omega(CS - (1+\lambda)T + \gamma\pi) \end{aligned}$$

$$s.t.\ \pi = (P-c)(1-P) - F + T \geq 0$$

Socially optimum price $P_0 = P_\gamma$ is reached when: $\gamma = \frac{1}{\omega} - (1-\alpha) + (1+\lambda)\omega = 1+\lambda$. There are two real roots of the corresponding quadratic equation: $(1+\lambda)\omega^2 - (2+\lambda-\alpha)\omega + 1 = 0$ when $D = (2+\lambda-\alpha)^2 - 4(1+\lambda) \geq 0$ and $\omega \in (0,1)$:

$$\omega_\gamma^{1,2} = \frac{(2+\lambda-\alpha) \pm \sqrt{(2+\lambda-\alpha)^2 - 4(1+\lambda)}}{2(1+\lambda)}$$

For $0.5 < \alpha < 1$, the two real roots exist when social cost of public funds is very high, that is $\lambda > 5 - \alpha^2 + 1$.

The relationship $\gamma(\omega)$ is non-linear with $\gamma(1) = 1+\lambda+\alpha$ and $\omega_\gamma^{min} = \operatorname{argmin}\,\gamma = \frac{1}{\sqrt{1+\lambda}} = \sqrt{\beta}$

$$\gamma_{min} = \sqrt{1+\lambda} - (1-\alpha) + \frac{1+\lambda}{\sqrt{1+\lambda}} = \frac{1}{\sqrt{\beta}} - (1-\alpha) + \frac{\sqrt{\beta}}{\beta}$$

For the tangent condition $\gamma_{min} = (1+\lambda)$, and for a single root of the quadratic equation there must be a unique combination of parameters: $\lambda = \alpha + 2\alpha$.

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