Research in Transportation Economics 36 (2012) 9–18

Contents lists available at SciVerse ScienceDirect

Research in Transportation Economics

journal homepage: www.elsevier.com/locate/retrec

A strategic model of public–private partnerships in transportation: Effect of taxes and cost structure on investment viability

Zitao (Arthur) Zhang, Pablo L. Durango-Cohen*

Department of Civil and Environmental Engineering & Transportation Center, Northwestern University, 2145 Sheridan Road, A316, Evanston, IL 60208-3109, United States

ARTICLE INFO

Article history:
Available online 3 May 2012

Keywords:
Public–private partnerships (PPPs) in transportation
Concession agreements
Taxes
Cost structure
Mechanism design

ABSTRACT

We formulate a game-theoretic model of a concession agreement between a government and a private party, a concessionaire, who has to engage a set of service providers as part of the operating responsibilities. We use the model to examine the importance of a government's tax policy to induce private investments in transportation infrastructure. Our analysis brings to fore insights that are useful in the design of partnership agreements, such as the importance of early and binding government commitments to ensure stable partnerships, and thus, successful projects. Our analysis shows that these strong commitments are even more critical in situations where the success of the partnership requires participation of additional, self-interested parties, such as specialized service providers. Finally, we consider variations of the model where government preferences are explicitly captured, and where the returns from the fixed cost portion of the concessionaire's investment are exempt from taxes. We show that both variations can lead to outcomes where the concessionaire's tax burden is shifted to the service providers. This flexibility can be critical in the design of partnership agreements for (high-risk or highly specialized transportation) projects where additional incentives may be needed to induce private party participation.

1. Introduction

As described by Macario (2010) and the references therein, there is an increasing, global trend in the adoption of public–private partnerships (PPPs) for the provision of transportation infrastructure and services. For example, Kappeler and Nemoz (2010) indicate that there have been more than 1400 PPPs signed in the European Union in the past two decades, valued at more than €260 billion. In the last 5 years, transportation projects accounted for approximately 40% of the total number, and 75% of the total value. In the United States there are over 40 active, large-scale PPPs in transportation (Rall, Reed, & Farber, 2010). In PPPs, private parties willingly agree to share responsibility for (a subset of the following activities) investment, finance, design, construction, renovation, maintenance, management, or operation of transportation facilities, e.g., roads, bridges, airports, parking facilities. From a government's perspective, these arrangements can provide direct benefits such as (additional) funding for projects, efficiencies in management and operations, as well as significant, though sometimes ignored, indirect benefits such as employment, which among other things, increases the tax base. As evidence of the potential benefits that can realize from private administration of transportation services, we note that a recent report prepared by the US Department of Transportation for Congress estimates that PPPs can result in savings of 6–40% (U.S.DOT, 2004).

The responsibilities of the different parties vary depending on the specific type of partnership agreement; however, as described by Garba (2009), it is common for the public sector to provide capital subsidies in the form of one-time grants to defray the initial investment, as well as tax credits to increase the returns on investment. This, in turn, serves as motivation for the work presented here in, where we model a concession agreement between a government (with limited resources) and a private party. The concessionaire decides to participate in the partnership by making an initial investment, and by engaging a set of service providers, e.g., a labor force, that will contribute to the operating phase of the project. The inclusion of service providers in the model constitutes a novel feature in this type of analysis, and is intended to capture the broad impact of transportation projects. From the government's perspective, the viability of the project is tied to its ability to raise revenue from taxes levied both on the concessionaire's investment return, and on the service providers' income. Our analysis of the proposed model provides a number of insights about the stability of

* Corresponding author.
E-mail addresses: zitao-zhang@northwestern.edu (Z.(Arthur) Zhang), pdc@northwestern.edu (P.L. Durango-Cohen).

0739-8859/$ – see front matter © 2012 Elsevier Ltd. All rights reserved.
doi:10.1016/j.retrec.2012.03.003

PPPs, and consequently, the success of projects. Specifically, our analysis highlights the importance of timing and strength of the government's commitments to avoid time inconsistent behavior leading to unstable partnerships (Chari, 1988; Chari, Kehoe, & Prescott, 1989). These characteristics are even more critical in agreements that require commitments from additional parties, such as the service providers. Our analysis also shows that government preferences and tax policies that rely on a project's cost structure, can lead to partnerships where the concessionaire and the service providers bear different proportions of the tax burden. The latter can be especially useful in the design of mechanisms to support PPPs because additional (or fewer) incentives may be necessary to motivate private party participation in certain agreements.

Our model builds on a large body of work in Economics (too vast to be reviewed here in a meaningful way),[1] with the seminal work of Ramsey (1927), on taxation issues in the context of public finances, providing, perhaps, a reasonable starting point. He posed the question of raising revenue by imposing taxes on some or all uses of income, the taxes on different uses being possibly at different rates. In this context the decision being to select rates so as to minimize the utility reduction. In this static, representative consumer economy with many goods, he investigated the decision that the government should make in a competitive equilibrium when choosing tax rates to maximize the welfare of the representative consumer, given a set of determined taxes, prices and quantities. Other relevant work includes the Fischer (1980), who presented a capital taxation model where the circumstances under which the problem of dynamic inconsistency arises, and discussed its implications for control theory and optimal policy-making. He explained that the problem arises when the government does not have commitment instruments, and when expectations of future variables are relevant to current private sector decisions. Chari (1988) and Chari et al. (1989) extended the discussion of the time consistency problem and the ensuing optimal policy design in detail with the illustration of taxation model and government debt model, where they focused on sustainable equilibria based on certain sequential rationality conditions. Further, Atkeson, Chari, and Kehoe (1999) argue that taxing capital investments may deter private parties from making investments. This, in turn, serves as motivation for our analysis of how an investment's cost structure can be used as part of the tax regime to engineer a successful partnership. This, of course, makes the work related to the literature on Mechanism Design (see Myerson (1982, 1983) and the references therein). Finally, we mention the work of Baron and Myerson (1982), who discussed the case of regulating a monopolist with unknown costs, and showed the effects of treating consumers and firm differently by maximizing a weighted sum of utility functions. This work inspired our analysis of government preferences on the proportion of taxes that the other two parties pay.

Our model adds to the growing literature in transportation economics, where conceptual models such as ours, are being used to understand the interactions between self-interested parties, and specifically how the alignment, or lack thereof, of these interests influences project viability, and parameters such as capacity, service quality, etc. Small and Verhoef (2007) provide a seminal treatment of this literature. These papers are complements to recent quantitative and qualitative literature, see e.g., Abdul-Aziz (2006), Central-Guidelines (2003), Evenhuis and Vickerman (2010), Karlaftis (2007), Lopez-Lambas and Monzon (2010) documenting outcomes of PPPs, and lessons learned from their adoption.

The remainder of the paper is organized as follows: Section 2 provides a description of our model and the technical assumptions. Our analysis of the model is presented in Section 3, where in Section 3.1 we analyze the effect of the timing of the government's commitments to tax rates on the stability of the partnership. We show that weak (or non-binding) commitments, i.e., reactive governments, can lead to unstable partnerships. In this analysis we, initially assume that the concessionaire and the service providers are represented by a single entity. In Section 3.2 we relax this assumption, and argue based on the structure, i.e., the sequence of utility maximization problems, that securing commitments from additional parties also motivates the need for early and binding government commitments. We then turn our attention to the design of tax policies that can lead to different splits in the proportion of taxes paid by the concessionaire and the service providers. In Section 3.3, we analyze the effect of government preferences, and in Section 3.4, we consider tax incentives that the concessionaire receives based on the cost structure of the initial investment. We conclude in Section 4 by summarizing some of the main insights drawn from our analysis.

2. Model formulation

We consider a situation where a *government* wants to execute a project, with associated capital costs, $\$W$, for which it does not have sufficient funding or willingness to invest/borrow. This, in turn, motivates the government to seek a partnership with a private party, i.e., a *concessionaire*, that will cover a portion of the capital costs, and will be responsible for the project's operation. As part of the operating responsibilities, the concessionaire has to engage a set of *service providers*, e.g., a labor force. Building on Chari (1988), we formulate a two-stage, game-theoretic model to analyze the conditions that lead to stable partnerships between the aforementioned parties, and successful project executions. In the remainder of the section, we document the elements and technical assumptions in our model.

As stated, we formulate a three-player, two-stage game of complete and perfect information. The stages correspond to the project's *investment* and *operating* phases. In the investment phase, a concessionaire with a budget of $\$C$, and a government decide to participate in the project by investing amounts, i and f, respectively, and where $0 \leq i \leq C$ and $f = W - i$. In order to operate the project, the concessionaire engages a set of service providers, who in turn decide to participate in the project by committing effort level, l, where $l \geq 0$ and might be measured in hours per year. The service providers are compensated at a rate of $\$W$, e.g., per hour.[2] Successful execution of the project leads to operating returns, iR, where $R > 1$.[3] In our model, the government's willingness to commit to the project by investing $W - i$, depends on its ability to generate revenues of at least $\$G$ during the operating phase. The government generates revenue by levying taxes on the concessionaire's operating returns at a rate θ, and on the service providers' income at a rate τ. We assume $\theta \leq 1$ and $\tau \leq 1$.[4] Thus, the total tax revenue is given by $\theta iR + \tau wl$.

[1] Hall and Jorgenson (1967); Hassett (1999); Shoup (2006) provide excellent reviews of the relevant literature in Economics.

[2] For consistency, the specification of w may include a present value factor.

[3] This amounts to assuming that, pre-taxes, the present value of the investment, $iR - i = (R - 1)i$ is non-negative, i.e., the investment is viable. Importantly, we assume that the returns are proportional to the investment, i. This setup constitutes a small variation to the model presented in Fischer (1980).

[4] $\theta < 0$ or $\tau < 0$ corresponds to tax credits.