The Engineering Project Organization Journal (June 2011) **1**, 143–156

Structuring PPP toll-road contracts to achieve public pricing objectives

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Received 21 January 2011; accepted 12 March 2011

Although the success of public–private partnership (PPP) contracts is often evaluated on financial terms, an even more fundamental question is whether these contracts achieve the public objectives for which they were designed. The state's responsibility as contracting agency for public infrastructure gives it a crucial role in defining these goals, which fall into multiple categories and can vary for each procurement. For toll-road PPPs, the category of pricing objectives is a significant component of these broader public goals. Such pricing objectives often include (1) achieving an affordable toll rate, (2) managing congestion and (3) minimizing state subsidy/maximizing up-front payment from concessionaires. To identify the specific PPP contract elements which support these pricing-related objectives, the method of qualitative comparative analysis was applied.

Through this recently developed approach for evaluating qualitative data quantitatively, patterns of PPP contract strategies which correspond to the three common pricing objectives above were identified through evaluation of 18 projects throughout the world. The analysis indicated, for instance, that PPPs targeting the objective of affordable tolls typically exhibited contracts with downside risk-sharing provisions or longer contract durations, while toll roads which prioritized congestion management used variable tolling but frequently avoided such downside risk-sharing clauses. These results provide a tool to aid public-sector decision-makers in selecting contract strategies which facilitate the achievement of desired pricing objectives for future PPPs.

Keywords: Infrastructure, procurement, public policy, qualitative comparative analysis, toll roads.

Introduction

Structuring contracts which effectively achieve their intended objectives has long been a salient challenge for project managers. In recent years, this challenge has become increasingly complex due to an expanding array of project-delivery methods. In the traditional design-bid-build context, for instance, construction-contract development has often focused on supporting project-specific goals such as the achievement of discrete performance targets and the optimization of limited resources under various constraints. While these goals are proper and necessary, the recent expansion of delivery methods which encompass a wider span of the project lifecycle brings additional challenges in ensuring contracts achieve their intended objectives.

The class of delivery methods termed public–private partnerships (PPPs) covers a variety of contract types. Although national agencies define PPPs differently (Kwak *et al.*, 2009), these procurements may range from design-build projects with short-term contractor financing to toll-financed concessions for which a developer provides long-term operations and maintenance in addition to design-build services. Just as it is crucial for the individual contracts (e.g. design, construction and finance) in these complex transactions to achieve their near-term objectives, it is likewise vital that each project as a whole, in order to be considered effective, also satisfies the longer-term public objectives for which it was conceived. While the private sector has its own goals for each project, sensitivity to the public sector's desired outcomes is essential, so that all parties can work together towards a contract structure which supports these objectives.

The subset of PPPs which involves toll roads brings additional complexity to the consideration of public

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The Engineering Project Organization Journal
ISSN 2157-3727 print/ISSN 2157-3735 online © 2011 Taylor & Francis
http://www.informaworld.com
DOI: 10.1080/21573727.2011.572256

objectives. Not only the broader goals for civil infrastructure must be addressed, such as safety improvements or capacity upgrades, but a more specific class of outcomes must also be identified to address the impact of road pricing on users. The research found that the following pricing-related goals represent the significant public objectives for toll-road PPPs:

(1) Toll affordability—setting user fees at a specific rate, independent of a project's capital and/or operational costs
(2) Congestion management—using toll rates to help redistribute traffic flow
(3) Subsidy minimization/income maximization—enacting toll schemes to generate the highest possible revenue, either to decrease the amount of public-sector monies necessary to realize a project or to fund a surplus payment to the state

The achievement of these goals is closely linked to the structure of a PPP contract's toll rate, duration and toll-revenue management clauses, as well as the project's external risk environment. Even so, the limited effectiveness of many recent toll-road procurements in achieving their intended pricing objectives indicates that this link is not well understood.

To investigate and characterize the relationship of pricing-related PPP objectives to specific contract provisions, the relatively new method of qualitative comparative analysis (QCA) was applied. This approach, first developed in 1987 for social-science research, combines qualitative and quantitative aspects to enable analysis of qualitative case-study data with quantitative rigour. For this study, 18 PPP toll-road procurements throughout the world were characterized according to the presence or the absence of key contract elements, and the resulting patterns were compared with the presence or the absence of each of the three pricing-related outcomes—toll affordability, congestion management and subsidy minimization/income maximization. From these numerical patterns, a general tool was developed to offer guidance to public-sector decision-makers in structuring future PPP toll-road contracts once the desired pricing objectives are chosen.

Background

To lay the groundwork for this investigation, several key concepts are defined and explored. First, an important distinction is made between public objectives and public interests. Subsequently, specific contractual elements are discussed; despite the wide variation in PPP procurement approaches, extensive study of international PPP toll-road documents and literature revealed several recurring and linked contractual themes: (1) toll-setting strategies, (2) concession duration and (3) treatment of toll revenues above or below forecasted amounts. These general categories, and their relationship to pricing-related outcomes, are examined more closely.

Public objectives

The public sector's objectives for infrastructure projects must first be differentiated from the public interest. Although the notion of *public interest* has been at the forefront of recent PPP debates in the United States in particular, many authors treat the term as a concept which needs little definition, regarding it broadly as that which promotes the general welfare (Hodge, 2006), or considering it essentially synonymous with concepts such as transparency, fairness and social equity (Ortiz and Buxbaum, 2008). Still, there is benefit in recognizing two distinct components of the term *public interest*: one which represents its policy-related project objectives and another which corresponds to best practices for public procurement (Figure 1).

The public-policy objectives for PPP projects often vary depending on an administration's priorities, while best practices for procurement and capital programming remain relatively constant. This latter component includes principles of proper value, transparency, appropriate competition and selection criteria, risk allocation, use of proceeds and so on (Miller *et al.*, 2000). With these static elements being crucial to any successful contract, some PPPs have failed (either financially or from a public-perception standpoint) because they did not comply with these principles. An example is the 2008 operating lease of Chicago's parking meters, a publicly reviled procurement that the city's inspector general censured for inadequate transparency and asset valuation.[1]

In addition to satisfaction of these *common procurement principles*, the public sector also seeks for transportation PPPs to achieve *specific project objectives*. These are the concrete aims that an owner intends to achieve in any given procurement; as such, they do not represent

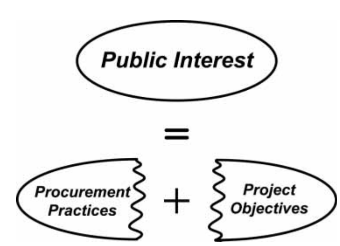

Figure 1 Public interest and project objectives

a static goal or single ideal which one optimal contract structure can satisfy. Some of these objectives are related to a contract's immediate circumstances: for one highway project, maintaining smooth traffic flow during construction may be paramount, for instance, while rapid project delivery may be prioritized for another. Still other objectives are related to high-level government policy, with a frequent goal (and often justification) for PPPs being the transfer of risk from the public to the private sector (Grout, 1997; Froud, 2003).

Toll-road projects introduce the additional complexity of pricing-related public objectives, which are numerous and often contradictory. For instance, the state may have a genuine interest in both maximum revenue and maximum vehicular throughput on a new tolled roadway, though for practical purposes, these goals are inherently in conflict and are difficult to satisfy simultaneously. Other public-sector objectives may include minimizing exposure to traffic risk or limiting the prospect of private-sector 'super-profits'. An owner may target one or more of these policy outcomes in a specific procurement.

This distinction between static procurement standards and dynamic project objectives is central to this study, which posits that differing policy objectives require differing PPP contract structures to ensure public pricing goals are satisfied.

Given the significance of public-policy outcomes in shaping procurements, and the variety of possible project objectives, a valid question is how these goals are chosen. According to Benouaich (2007), this selection, as well as the necessary arbitration among conflicting objectives, must be government decisions. Although one might profitably study which public-policy outcomes the state *should* favour under various conditions, such a focus is beyond the scope of this enquiry. This investigation seeks instead to probe which PPP contract structures support specific pricing objectives, providing public-sector decision-makers a tool to identify those means which most efficiently accomplish the desired ends.

In the pursuit of structuring PPP contracts to achieve public pricing objectives, the question also arises how private-sector interests are accommodated in the frequently sought 'balance of public and private interests'. In contrast to the public sector's diverse objectives, the private sector can be considered to have a single primary goal: to earn profits (Mayer, 2007; Vining and Boardman, 2008). This profit motive is not improper, but rather is a necessary incentive for promoting business and innovation. Without an opportunity to achieve returns greater than costs, the private sector will choose not to participate in contracts, whether PPPs or otherwise. Thus, a concessionaire's voluntary decision to pursue a project can be taken as implicit confirmation that it sees profit potential, and thus the achievement of its goal, in the contract.

Given this relative homogeneity in private industry, this investigation focuses on the more complex contract-structuring decisions necessary in the public sector to enable the desired pricing goals. This emphasis is further supported by an owner's dominant role in contract formation and its responsibility to tailor the content of procurement documents to accomplish specific public aims.

Toll-setting strategies

Three economic strategies commonly used for setting toll rates include average-cost pricing, marginal social-cost pricing and revenue-maximizing pricing. Each of these approaches has characteristics which affect its suitability for meeting specific policy objectives.

Average-cost pricing sets user fees at a level just adequate to cover a facility's long-term average costs, including ongoing operations and maintenance expenses, any capital expenditures and a normal profit for the operator. Economically, this approximates the regulation of utilities under a natural monopoly, as outlined by Brown and Heal (1983). Under this scenario, a facility's tolls and the operator's permissible rate of return are structured such that long-term average costs are just covered, giving the private sector an incentive to operate the road as efficiently as possible. For uncongested facilities, Sharp *et al.* (1986) objected to including construction expenses in these average costs, noting the resulting higher rates would create economic distortions and artificially decrease demand for roads. But either approach is subject to the significant challenge of incorporating uncertainty into the pricing structure, particularly when longer time spans are involved (Demsetz, 1968). Although a PPP need not be explicitly regulated to make use of the average-cost pricing model, an example of this toll-setting approach is the Dulles Greenway in northern Virginia: this PPP highway operates as a regulated utility and its tolls are periodically approved by the same state commission which sets rates for other investor-owned utilities such as water, gas and power.

But for roads with high demand, the Nobel-laureate economist William Vickrey (1963) eloquently objected to the use of average-cost pricing: 'The delusion still persists that the primary role of pricing should always be that of financing the service rather than that of promoting economy in its use. …[N]o device can function quite as effectively and smoothly as a properly designed price structure in controlling use and providing a guide to the efficient deployment of capital'. For toll rates on congested roads, he instead advocated marginal social cost pricing, sometimes termed throughput-maximizing pricing, which is linked to drivers' elasticity of demand. This approach sets tolls to offset social impacts, particularly traffic congestion, caused by each additional vehicle on the road. Although precise measurement of these costs was prohibitively difficult in Vickrey's day, economists developed numerous 'second-best solutions' to optimize social benefits for road pricing under various constraints (de Palma *et al.*, 2005). Other authors (Newbery, 1989; Chu and Tsai, 2004) investigated the feasibility of combining the average-cost and marginal-cost pricing approaches, proposing an optimal toll level by adding an average-cost operations component to the marginal social cost. Recent advances in tolling technology now enable approximating marginal-cost solutions through continuous monitoring of congestion levels and real-time variation of toll rates to influence drivers' demand and promote free flow of traffic. Examples of PPPs whose toll rates are based on marginal social cost pricing include Virginia's Route 495 HOT Lanes and Florida's I-595 Corridor Improvements.

A third tolling strategy, revenue-maximizing pricing, is also based on users' elasticity of demand but decouples the link between tolls and congestion levels. Rather, it estimates the levels of traffic demand for a specific transportation network segment under various toll rates, then sets pricing for that roadway at the level resulting in the highest overall toll revenues, as discussed by Buchanan (1956). Except in the rare case of perfectly elastic demand, Ubbels and Verhoef (2008) noted the revenue-maximizing toll rate is necessarily greater than the marginal-social-cost charge. The result, economically speaking, is an underutilized road with excess capacity. Still, PPPs may nevertheless be structured with revenue-maximizing tolls in some situations, by either the public or the private sector's choice. An example is the 2005 operating lease of the Chicago Skyway, for which the city approved an aggressive toll-escalation schedule intended to maximize the revenue produced by the contract.

Contract-length and revenue-management approaches

In addition to toll-setting strategies, the PPP procurement variables of concession length and toll-revenue management also influence the achievement of pricing objectives. These factors act in conjunction with each other: a private-sector developer may agree to accept a lower toll in exchange for a longer PPP concession, or for more favourable treatment if traffic demand (and thus toll revenue) is lower than forecast.

The question of ideal PPP duration has no simple answer. Relative to the 25- to 30-year PPP terms common internationally, US contract durations are often very long: with some recent exceptions, many US concessions start at 50 years in order to gain eligibility for federal tax benefits and can range up to 75 or even 99 years. For contracts in which the private sector holds toll-revenue risk, developers tend to favour longer concessions because the additional time also provides a buffer to smooth out historically common variations in traffic demand. Even so, Vassallo (2004) noted several disadvantages of long PPP durations: not only are traffic levels and technological improvements difficult to forecast far in the future, but long contracts also increase the risk that a concessionaire will assume monopoly control of a facility. Various approaches have been proposed, including fuzzy simulation models (Ng *et al.*, 2007) and Monte Carlo simulation (Zhang and AbouRizk, 2006), to manage these risks and develop optimal concession lengths.

A relatively new approach is the variable-length concession, which concludes when certain pre-specified financial targets are met, such as debt coverage, rate of return or present value of revenues collected. These contracts have been championed for their flexibility to accommodate actual demand, thus reducing risk to both the public and the private sectors (Engel *et al.*, 2002; Albalate and Bel, 2009). Further, an attractive public-policy consideration is the relative ease with which the public sector can change toll rates if circumstances require, since the financial target amount is not affected: the concession length simply adjusts to the new toll levels (Nombela and de Rus, 2004; Engel *et al.*, 2006). Such variable-length concessions are in increasing use in Europe and South America.

While these flexible contracts offer one response to the perennial challenge of forecasting toll-road demand, revenue-management strategies for fixed-length concessions can also help mitigate traffic-demand uncertainty by addressing downside risk-sharing and upside revenue-allocation scenarios (Mayer, 2007). Various forms of downside risk protection exist if traffic levels are significantly lower than pre-established contractual limits or ranges. For instance, the UK's Skye Bridge PPP allowed the concessionaire to raise tolls above initially specified levels if revenues fell below a certain threshold, while Canada's Confederation Bridge contract provides the developer an annual revenue contribution that approximates a revenue guarantee. Upside revenue-sharing between the public and the private sectors is becoming a more significant issue in recent PPPs as illustrated in Virginia's Route 495 HOT Lanes contract, under which the owner receives a percentage of gross project revenues when the concessionaire's equity internal rate of return exceeds certain targets. The intent here is often to allow the public sector to share in the potential revenue upside once private investors have achieved their necessary (and agreed on) return on investment.

Research objective and method

Based on this policy environment and the contractual toll rate, duration and revenue-management tools available, the central research question is posed: given specific road-pricing goals, how should public owners structure PPP contracts which support these outcomes?

Why qualitative comparative analysis?

The relatively new method of QCA, first propounded by sociologist Charles Ragin (1987), was chosen for this investigation due to its facility in accommodating the qualitative and the quantitative issues which arise in PPP research (Figure 2). As with the case-study approach, QCA retains a contextual sensitivity to interactions among variables, unlike statistical methods which analyse variables in isolation. But QCA also incorporates the systematic analysis and fixed rules characteristic of quantitative methods, thus providing rigour and strengthening its replicability and transparency.

Although this approach has been applied extensively in the fields of sociology and political science (e.g. Rihoux and De Meur, 2009), project-organization researchers have made limited use of QCA to date (e.g. McAdam *et al.*, 2010). Through its ability to analyse smaller data sets rigourously, though, the method offers an attractive option for investigations of large-scale projects whose sheer cost and magnitude frequently limit the number of samples available for evaluation. Relative to pure case-study methods, QCA also allows identification of meaningful patterns even when highly detailed and comprehensive case information is not available, such as with PPPs whose project data can often be commercially sensitive and difficult to obtain.

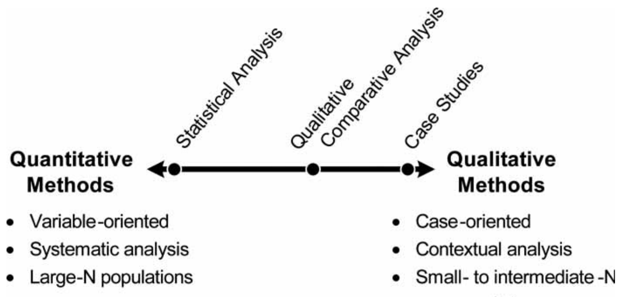

Figure 2 Spectrum of research methods

Overview of the method

In summary, QCA involves six main steps whose nomenclature is illustrated in Figure 3.

1. Identifying outcomes: the effect(s) to be studied are determined first to enable the targeted selection of cases for which each outcome is clearly present or absent, since the analysis will be more robust if the variables under consideration exhibit a relatively balanced combination of all possible values. A separate QCA evaluation is performed for each outcome.
2. Selecting cases: a preliminary set of cases is developed, with conscious inclusion of a wide variety of project characteristics. This guided selection is appropriate because QCA's logic is not probabilistic: that is, it does not consider whether few or many cases exhibit certain traits. Of interest rather is the existence at all of specific combinations of case conditions and outcomes.
3. Developing conditions: characteristics which are posited to contribute to each outcome are next established. Although QCA's conditions correspond superficially to the independent variables in a statistical analysis, this nomenclature is discouraged because these QCA variables are not truly independent; rather, the condition variables interact with each other to produce distinct patterns supporting each outcome (Rihoux and De Meur, 2009).
4. Constructing the data table: to develop values for the conditions and the outcome variables, the qualitative facts of each case are converted to quantitative data through application of rubrics or schemes, resulting in numerical patterns called configurations. Although the original formulation of QCA required strictly binary variables, subsequent expansions of the method now permit multi-valued and fuzzy-set variables (Ragin, 2000; Cronqvist, 2007).
5. Internal validity testing: the preliminary data table is checked for logic errors ('contradictory configurations') and evaluated to ensure sufficient diversity of conditions and outcomes. An interrater reliability test is also conducted to assess the robustness of the previous step's qualitative-to-quantitative data conversion. At this stage, cases may be added to or removed from the preliminary selection to develop a final case set.
6. Analysis and interpretation: the analysis step, typically automated with software, distils patterns from the data table which link certain recurring condition values, or groups of values, to each outcome. This process seeks to identify the

	Variables					
	Conditions					Outcome
Cases	Pricing Approach	Concession Length	Upside Revenue Sharing	Downside Risk Sharing	Demand Risk	Manage Congestion
I-495 HOT Lanes (Virginia)	1	2	1	0	0	1
El Melon Tunnel (Chile)	2	1	1	0	1	0
I-595 Improvements (Florida)	1	1	0	0	0	1
Route 460 (Virginia)	2	0	1	1	0	0
etc.				Configuration		

Figure 3 Sample data with QCA nomenclature

patterns of conditions which are both *necessary* and *sufficient* to produce each outcome, interpreting the questions: Which conditions are always present when a certain outcome is achieved? Does that outcome occur when a certain condition is present by itself, or only when that condition is simultaneously present with others?

Initial QCA steps

Identifying outcomes

Illustrating the above QCA steps for the current study, the investigation began by identifying the main pricing-related public objectives for PPPs, through a review of academic literature, institutional documents and individual projects. The variable names for these outcomes were assigned as follows:

1. TOLLRATE: achieving an affordable/specific toll rate[2]
2. FREEFLOW: managing congestion or maximizing throughput[3]
3. MINMAX: minimizing subsidy or maximizing revenue[4]

To obtain additional perspectives and triangulate towards assessing the validity of this selection, these outcomes were reviewed with senior public-sector officials with extensive experience in structuring PPP procurements. They concurred that these three objectives accurately characterized the public sector's major pricing goals.

Selecting cases

This study next identified 18 projects for analysis, drawing from PPP toll roads in North and South America, Europe and Australia which were contracted from 1990 to 2009 (Table 1). Although these projects included a wide range of contract structures, toll-setting strategies and objectives, QCA does not require that every possible combination of these variables be represented: valid analysis is possible with data sets as small as 10 cases or fewer. The methodological considerations for establishing appropriate QCA data set sizes, particularly in relation to the number of conditions, are discussed at length by Berg-Schlosser and De Meur (2009).

Developing conditions

As indicated in Figure 3, conditions are the QCA variables which influence the outcomes and distinguish one case from another. Based on literature review and case analyses, the characteristics posited to influence the achievement of public-sector pricing objectives were identified as the following set of QCA conditions, the first four of which were discussed previously.

1. PRICING: toll-setting approach
2. LENGTH: concession length
3. UPSIDE: upside revenue-sharing
4. DOWNSIDE: downside risk-sharing
5. RISK: traffic-demand risk

Because the demand for PPP toll roads surely interacts with contractual conditions to influence a project's ability to achieve pricing objectives, the fifth condition assessed this demand risk by evaluating external factors such as the presence of competing routes, drivers' income and time-sensitivity and local congestion levels. This approach was based on the elements of the Standard & Poor's traffic-risk index presented in Bain (2009) and modified by Gross (2010).

As with the QCA outcomes, this list of conditions was reviewed with public-sector procurement officials, who concurred these variables are appropriate and highly significant factors influencing the achievement of PPP pricing objectives.

Table 1 Overview of project cases

Project	Location	Year of contract	ID	Description
Route 460 Corridor Improvements	USA (Virginia)	–	ROUTE460	Proposed new highway with parallel free route; procurement restructured in 2010
I-595 Express Lanes	USA (Florida)	2009	I-595	Tolled express lanes for congestion relief; first US PPP with availability payments
I-495 Capital Beltway HOT Lanes	USA (Virginia)	2007	I-495	Tolled express lanes in median of congested Washington beltway
Chicago Skyway	USA (Illinois)	2005	SKYWAY	Operating lease of elevated roadway; up-front payment and long concession term
SR-91 Express Lanes	USA (California)	1990	SR91	Freeway project; profitable due to strong demand and was bought back by state
SH-121 Managed Lanes	USA (Texas)	2007	SH121	Tolled express lanes planned to reduce congestion in Dallas-Fort Worth area
Warnow Tunnel—first procurement	Germany	1996	WARNOW1	Germany's first PPP; tunnel replaced ferry service across river
Warnow Tunnel—renegotiated contract	Germany	2006	WARNOW2	Concession for above tunnel was lengthened due to low traffic demand
Herren Tunnel	Germany	1999	HERREN	Germany's second PPP; tunnel replaced bridge crossing, but with low demand
Skye Bridge	UK	1991	SKYE	Bridge provided sole fixed link from UK mainland to lightly populated island
Second Tagus Crossing	Portugal	1994	LISBON	Additional bridge in downtown Lisbon provided congestion relief
Autopista M-12	Spain	2003	MADRID	Highway and tunnel enabled access to new airport terminal in Madrid
El Melón Tunnel	Chile	1993	ELMELON	Chile's first PPP; toll tunnel provided alternative to free mountain-pass route
Santiago-Valparaíso-Viña del Mar Tollroad	Chile	1998	SANTIAGO	Highway connecting major cities was first variable-length concession in Americas
407 ETR—first procurement	Canada	1994	407ETR1	Highway for congestion relief in Toronto was developed with public financing
407 ETR—second procurement	Canada	1999	407ETR2	Operating lease was granted for recently built highway, resulting in toll increases
Confederation Bridge	Canada	1992	CONFED	Bridge provided sole fixed link to Canadian province of Prince Edward Island
Cross City Tunnel	Australia	2002	CROSCITY	Tunnel under downtown Sydney was planned to reduce surface congestion

Constructing the data table

Table 2 summarizes the selection of variables, along with the assignment of condition and outcome values to be used for converting qualitative project data into quantitative elements.

For variables based on a continuous range, such as LENGTH and RISK, careful attention was necessary in specifying cutoff values to convert continuous data to discrete QCA values, since the choice of these thresholds could materially affect the analysis results. The 50-year limit for dividing short and long concession lengths represented one such cutoff value, chosen at a natural breakpoint in the data set due to the favoured tax treatment of US concessions longer than 50 years. For the RISK traffic-demand variable, the modified Standard & Poor's traffic-risk index yielded a continuous score from 1 to 5; to convert this to a QCA variable, a sensitivity analysis was performed to establish and validate the threshold between low-risk and high-risk projects.

Next, a case history was drafted for each PPP, highlighting the project facts corresponding to specific QCA characteristics. Formal rubrics for converting this information into numerical scores for conditions

Table 2 QCA variables (conditions and outcome) and values

	Variable name	Meaning	Value
Conditions			
Toll-rate approach	PRICING	Average cost pricing (ACP)	0
		Marginal social-cost pricing (MSC)	1
		Revenue-maximizing pricing (RMP)	2
Concession length	LENGTH	Variable length	0
		Short concession (<50 years)	1
		Long concession (≥50 years)	2
Upside revenue sharing	UPSIDE	Absent	0
		Present	1
Downside risk sharing	DOWNSIDE	Absent	0
		Present	1
Traffic-demand risk	RISK	Low risk (index = 1–2.2)	0
		High risk (index = 2.3–5.0)	1
Outcomes			
Achieve specific toll rate?	TOLLRATE	No	0
		Yes	1
Manage congestion?	FREEFLOW	No	0
		Yes	1
Minimize subsidy or maximize revenue?	MINMAX	No	0
		Yes	1

and outcomes were developed, based on the classifications in Table 2, to produce the data table.

Internal validity testing

Several intermediate tests of internal validity were then performed to ensure the robustness of the subsequent analysis. As further detailed in Gross (2010), these checks evaluated the data set and data-conversion process to ensure the following:

1. Resolution of any contradictory configurations, defined as pairs of cases with identical condition values but dissimilar outcomes;
2. Sufficient data diversity, indicated by adequate representation of each condition and outcome; and
3. Inter-rater reliability, assessing the clarity of the formal rubrics used for converting qualitative case histories to quantitative form.

The resulting data table, following corresponding adjustments, is shown in Table 3.

Analysis and interpretation

With a tested and conflict-free data table established, the next step was to reduce the data to identify patterns of condition values corresponding to each of the three outcomes. This process can follow two paths: as one option, it can use solely the existing cases to achieve a descriptive summary of the data set, yielding a more complex solution. Alternately, the analysis can 'connect the dots' of these observed cases and incorporate consistent but non-observed project configurations; this latter approach enables simplified, more concise explanations of data relationships, as explained in Rihoux and De Meur (2009). Both approaches were computed for each of the three outcomes: TOLLRATE (achieving a specific toll rate), FREEFLOW (managing congestion) and MINMAX (minimizing subsidy or maximizing revenue).

TOLLRATE results

The procedure for developing and interpreting a QCA solution is explained in detail for the TOLLRATE outcome. Since the process for the FREEFLOW and MINMAX outcomes is similar, those solutions are discussed in summary form, with full details provided in Gross (2010).

Typical QCA output from the data-reduction process is as shown in Table 4, whose first row represents the simplified solution for the TOLLRATE outcome. These terms indicate the combinations of contract strategies which are necessary and sufficient to support a specific toll rate: 'Either average-cost pricing is used,

Table 3 Final QCA data table

	Conditions					Outcomes		
Case ID	PRICING	LENGTH	UPSIDE	DOWNSIDE	RISK	TOLLRATE	FREEFLOW	MINMAX
ROUTE460	2	0	1	0	1	0	0	1
I-595	1	1	0	0	0	0	1	0
I-495	1	2	1	0	0	0	1	0
SKYWAY	2	2	0	0	0	0	0	1
SR91	1	1	1	0	0	0	1	0
SH121	1	2	1	1	0	1	1	0
WARNOW1	0	1	0	0	1	1	0	0
WARNOW2	2	2	0	0	1	1	0	1
HERREN	2	1	0	0	1	0	0	1
SKYE	0	0	0	1	1	1	0	0
LISBON	0	0	0	0	0	1	0	0
MADRID	0	1	0	0	0	1	0	0
ELMELON	2	1	1	0	1	0	0	1
SANTIAGO	2	0	0	1	0	1	0	0
407ETR1	1	1	0	0	1	0	1	0
407ETR2	2	2	0	0	0	0	0	1
CONFED	0	1	0	1	1	1	0	0
CROSCITY	2	1	0	0	1	0	0	1

or downside-risk protection is present, or a concession 50 years or longer exists and high traffic-demand risk is present'. As is standard practice for QCA output, the results are given in Boolean notation, in which addition represents OR and multiplication represents AND. The cases in the data set which are represented by each term are also shown.

Although complex solutions are sometimes of use for detecting more subtle patterns in the data, the complex solution for the TOLLRATE outcome (shown for illustration in Equation 1) is not of significant benefit towards this end.

PRICING{0} * LENGTH{1} * UPSIDE{0} * RISK{1} + PRICING{0} * LENGTH{1} * UPSIDE{0} * DOWNSIDE{0} + PRICING{1} * LENGTH{2} * UPSIDE{1} * DOWNSIDE{1} * RISK{0} + PRICING{2} * LENGTH{2} * UPSIDE{0} * DOWNSIDE{0} * RISK{1} + PRICING{0} * LENGTH{0} * UPSIDE{0} * DOWNSIDE{1} * RISK{1} + PRICING{0} * LENGTH{0} * UPSIDE{0} * DOWNSIDE{0} * RISK{0} + PRICING{2} * LENGTH{0} * UPSIDE{0} * DOWNSIDE{1} * RISK{0} (1)

This unwieldy expression is essentially a descriptive summary of the condition values in the cases for which TOLLRATE = 1 (i.e. the project's policy objective was to achieve a specific toll level). Only the first two terms in this expression evidence even a limited amount of summarization of the five QCA conditions.

TOLLRATE interpretation

The next step was to evaluate the concrete meanings of the expressions developed in the analysis above and consider whether these patterns provide constructive guidance which can be applied to other cases outside the original data set. This step focused primarily on

Table 4 Simplified QCA solution for TOLLRATE outcome

Expression	PRICING{0} +	DOWNSIDE{1} +	LENGTH{2}RISK{1}
Interpretation	Average cost pricing OR	Downside risk protection OR	Concession 50+ years AND high traffic-demand risk
Cases explained	(WARNOW1 + SKYE + LISBON + MADRID + CONFED)	(SH121 + SKYE + SANTIAGO + CONFED)	(WARNOW2)

the simplified solutions, due to their greater generality and broader applicability. For the TOLLRATE outcome (Table 4), this expression signified, 'PPP contracts are conducive to supporting a targeted toll rate when average-cost pricing is used, downside risk-sharing is present, or the project has a concession term 50 years or longer and high traffic-demand risk'.

Each term of this solution was considered individually for plausibility. The first element, the suitability of average-cost pricing in achieving a specific toll level, was reasonable enough to be almost self-apparent, since this approach is the lowest-cost of the three pricing options and the only one which is based on infrastructure supply, not demand. This element's presence in the TOLLRATE = 1 expression, while not surprising, verifies that the method can accurately identify contract strategies which correspond to certain outcomes.

The next term in the solution, the presence of downside risk-sharing, was less obvious but also very plausible: when a fixed toll rate is specified in a PPP agreement, the concessionaire has less contractual flexibility to make up potential shortfalls, and thus the added incentive of downside risk sharing (perhaps in the form of a traffic or revenue guarantee) would be attractive in offsetting the contract's greater risks.

Finally, the combination element of greater concession length with higher traffic risk was similarly reasonable: when the private sector has not permitted the flexibility to make up revenue shortfalls through toll-rate adjustments, a longer concession term is entirely logical as a buffer to absorb short-term revenue fluctuations, particularly when a project already has higher traffic-demand risk.

In application, then, a public-sector agency which sets the achievement of a specific toll rate as a priority should consider these three contract strategies, particularly the establishment of downside risk sharing and a longer concession term, as sound options in structuring a PPP agreement.

FREEFLOW results and interpretation

Similar analyses were conducted for the FREEFLOW and the MINMAX outcomes. For FREEFLOW, the simplified solution was very concise and logical (Table 5): 'PPPs tend to be effective in controlling congestion when marginal social cost pricing is used'.

Because this explanation is such an obvious solution (though again a reassuring verification of the method's discrimination), it is worthwhile to probe the more complex solution to seek additional patterns in the data. Prior to 'connecting the dots' with simplifying assumptions, two of the three terms in the expression included LENGTH = 1, DOWNSIDE = 0 and RISK = 0.

Table 5 Simplified QCA solution for FREEFLOW outcome

Expression	PRICING{1}
Interpretation	Marginal social cost pricing
Cases explained	(I-595 + I-495 + SR91 + SH121 + 407ETR1)

Do these make sense as potential tools for supporting the objective of throughput maximization? These elements indicate, respectively, that shorter concession lengths (up to 50 years), absence of downside risk sharing and lower traffic-risk projects are aspects which correspond with this goal. As might be expected from the less-conclusive approach for distilling these factors, the practical justification is less strong for these strategies than for those supporting the previous outcome. Still, one could draw the rational conclusion that roadways on which congestion control is desirable are obviously experiencing proven demand and thus will have lower traffic-risk index scores. As a result of this strong demand, the private-sector partner can reasonably expect significant downside traffic-risk will be less likely, and it can thus recoup its costs during a shorter concession period than otherwise.

An application of these concepts might include strengthening the public sector's negotiating position for PPP contracts on facilities for which congestion-control pricing is targeted, in that the established demand reduces the need for long concessions or traffic-risk-sharing provisions.

MINMAX results and interpretation

As with the previous outcome, the MINMAX = 1 objective produced a succinct QCA solution (Table 6): 'The PPP goal of low subsidies or high income tends to be achieved when revenue-maximizing pricing is applied in the absence of downside risk sharing'.

Although the pricing aspect of the expression seems self-apparent, it is also understandable (though not immediately obvious) that the prospect of a more-likely upside benefit might be balanced with unlimited downside risk as well. In practice, though, owners

Table 6 Simplified QCA solution for MINMAX outcome

Expression	PRICING{2}DOWNSIDE{0}
Interpretation	Revenue-maximizing pricing with no downside-risk protection
Cases explained	(ROUTE460 + SKYWAY,407ETR2 + WARNOW2 + HERREN,CROSCITY + ELMELON)

have sometimes used the incentive of revenue-maximizing pricing in an attempt to make risky projects more marketable, as exemplified by a review of the data table for the El Melon Tunnel and Route 460. Even though these projects' downside scenario is more likely, both procurements optimistically included provisions for upside revenue sharing, without corresponding downside protections.

These less-than-crisp results from the simplified MINMAX solution suggest exploring this outcome's more complex QCA expression for additional guidance. In this instance, a fairly concise alternate result was identified: PRICING{2}LENGTH{1,2} + PRICING{2}RISK{1} is another valid solution and indicates the MINMAX = 1 outcome corresponds to both long and short concessions (but not variable-length ones) or projects which have a high risk index. This secondary solution is also intuitively reasonable and sheds additional light on the factors influencing the minimum-subsidy/maximum-revenue outcome.

One application of this alternate solution lies in the negative rather than the positive: while PPPs for which high revenue-generation is prioritized should certainly employ revenue-maximizing pricing, the outcome is not supported by using that toll-rate strategy in conjunction with variable-length concessions or for low traffic-risk projects. These findings are intuitive: by its structure, the variable-length concession is not conducive to excess revenue generation. Neither are PPPs with minimal demand risk likely to be coupled with a reward disproportionate to their low risk.

Practical application

Among the practical tools resulting from this investigation is contract-structuring guidance for PPP decision-makers, based on the previous analytical QCA findings. These combinations of contract strategies which support specific pricing outcomes can be applied to procurements in development, as illustrated by Virginia's Midtown Tunnel PPP, currently in procurement as of March 2011.

Project history

The Hampton Roads region of southeastern Virginia both benefits and suffers from the numerous waterways criss-crossing the area. Although the Chesapeake Bay and the Elizabeth River have been crucial to the region's development as a naval and shipping hub, they also pose significant transportation challenges for linking the area's roads across these waterways. To help connect the cities of Norfolk and Portsmouth, the two-lane Downtown and Midtown Tunnels were built under the Elizabeth River in 1952 and 1962, respectively. Although the Downtown Tunnel was expanded to four lanes in 1987, the Midtown remained at its original configuration and became the busiest two-lane road in Virginia, carrying over 35,000 vehicles per day.

Shortly after passage of Virginia's Public-Private Transportation Act in 1995, the state received several unsolicited proposals to add a second two-lane tube to the Midtown Tunnel, upgrade the Downtown Tunnel and construct a freeway extension linking the two. Approval from the Norfolk and Portsmouth city councils was necessary before evaluation could proceed, and Portsmouth voted against the proposed tolls in 1999, scuttling the effort. Five years later, the Virginia Department of Transportation revived the project as a PPP, requesting expressions of interest from the private sector in 2004 and soliciting conceptual proposals in 2008.

An interim agreement was signed with the sole proposer in 2010, and this PPP is currently grappling with the challenge of developing a contract approach which satisfies its pricing goals. The application of QCA findings is demonstrated to explore combinations of contract strategies which may be effective in structuring this procurement to achieve public-sector objectives.

Identification of pricing objective

Although the Midtown Tunnel's solicitation for conceptual proposals listed multiple project objectives—increasing capacity, providing safe operations, mitigating environmental impact, coordinating with adjacent land uses and supporting traffic growth, for instance—none of these goals were pricing outcomes which could be influenced meaningfully by the PPP contract elements investigated as conditions in this study. It was necessary to probe deeper to identify which of the three primary pricing objectives, as defined previously, was targeted for this procurement.

MINMAX, the outcome which seeks to minimize public subsidy or maximize up-front payment from the concessionaire, was not a likely prospect: a regional toll-feasibility study indicated the project, at its then-current scope and estimated costs, would not require a subsidy.[5] Nor was an up-front payment of significant interest to the public sector: at most, the ideas in the study considered applying any excess Midtown revenues to improving other nearby facilities.

Another possible objective was maximizing throughput (the FREEFLOW goal): a reasonable option, since the existing Midtown Tunnel corridor was heavily congested at peak travel times. But since the project scope would already double the facility's available lanes, the very nature of this expansion would provide a substantial contribution towards relieving (though perhaps not completely eliminating) traffic delays, even without this outcome being specifically prioritized as a pricing goal.

The objective of achieving affordable tolls (TOLLRATE) offered another possibility. Although the 2008 private-sector proposal for this project estimated initial tunnel tolls between \$2.00 and \$3.00, public officials promoted a target rate of \$1.50 to enable greater affordability for users.[6] The ultimate pricing objective for this procurement remains in flux: this situation is a by-product of using an interim project agreement, since PPP objectives *and* conditions are typically negotiated through an iterative process between the public and the private partners. Current indications, however, suggest the pricing objective of achieving tolls at a specific level is likely to govern the other options, making it worthwhile to consider how this outcome might be supported through application of the QCA findings.

QCA recommendations for contract structure

Table 4 illustrates the three distinct patterns of contract strategies for previous PPP cases which also targeted an affordable toll (TOLLRATE = 1 outcome). Although these combinations are not a recipe for achieving procurement outcomes, they provide guidance by distilling common characteristics of projects which have pursued this same goal in the past. For a PPP such as the Midtown Tunnel which also targets affordable tolls, these patterns offer a point of comparison for defining contract strategies. The selection among (or combination of) the three options above is influenced by the individual circumstances of a procurement.

For instance, average-cost pricing sets toll rates at the minimum feasible level to cover a project's costs; if this level is still higher than the targeted toll rate, public subsidies may be added, or the alternate strategy of downside risk protection can be considered: this approach essentially reduces a project's cost by decreasing its risk and can be applied either in conjunction with or separately from average-cost pricing. A further approach supporting affordable tolls is to use long concession durations for projects with high traffic-demand risk. Since the Midtown Tunnel procurement has a low risk score on the traffic-risk worksheet, one might conclude attention to concession length is less relevant in this case. Yet findings from the QCA method are not to be applied mechanically, but rather combined with contextual insight. Even though this third approach makes no specific recommendations about *low-risk* PPPs, a concession length greater than 50 years could in fact be beneficial for the Midtown Tunnel, especially if the value of the resulting tax benefits helped achieve a desired toll rate.

In addition to these primary solutions for targeting a specific toll level, the more complex QCA expression for the TOLLRATE = 1 outcome (see Equation 1) yields further insights on options for contract structuring. One strategy which appeared in many of the cases with this outcome, though it was neither necessary nor sufficient by itself to support the achievement of a desired toll rate, was the absence of upside revenue-sharing provisions (UPSIDE = 0). The logic is understandable, since an opportunity for a greater upside benefit can potentially offset a lower toll rate. Although this contract strategy may or may not be suitable for the Midtown Tunnel, its frequency in the data set makes it worth considering as a complement to the primary solutions above.

In summary, if the pricing objective for the Midtown Tunnel is to achieve a specific toll rate, then decision-makers might consider structuring the contract with one or both of the following conditions in accordance with QCA guidance:

1. Toll rates at the minimum feasible level to cover the project's costs. (Public subsidies may be necessary if this level is still higher than the desired toll rate.)
2. Contract provisions for downside risk protection, potentially in combination with the absence of upside revenue-sharing.

Conclusions

Although toll-road PPPs share many characteristics with other large civil-engineering projects for which cost, schedule and safety performance are primary objectives, the impact of toll road charges on the traveling public poses additional pricing-related issues to evaluate before such projects can be deemed to have met their goals. Among these unique characteristics are the public sector's objectives in structuring the toll policy, which may include outcomes such as achieving a specific toll rate, managing congestion and minimizing required state subsidy or maximizing income.

To develop a framework for assessing how PPPs measure up to these intended goals, the method of QCA was introduced, as one of its first applications in the engineering project field, to integrate the structure of quantitative methods with the contextual sensitivity of qualitative approaches. Through this method, the toll rate, duration and revenue/demand risk characteristics of 18 global PPP toll roads were standardized and evaluated for patterns corresponding to the achievement of these outcomes.

This investigation yielded clear patterns linking specific contract strategies to individual pricing objectives, and this correlation furnishes a practical decision-support tool for shaping future PPP procurements. For affordable tolls, the recommendations included structuring PPP agreements with downside risk-sharing provisions and longer concession terms. Contract strategies for efficiently managing congestion involved variable pricing, shorter concession lengths and absence of downside risk-sharing provisions. And when low subsidy or high income is sought, contracts with revenue-maximizing pricing and no downside risk-sharing support that goal.

Future initiatives for extending this work include (1) introducing new conditions into the QCA structure and (2) expanding the PPP case set. Inclusion of additional conditions, or contract strategies, could lend new insights into other factors which may be significant in influencing procurement outcomes. Some elements may be specific to certain regions or types of projects, and thus not fully considered in this current study. In addition, the benefit of developing further cases for the core data set would provide a greater array of projects against which to compare future procurements with similar QCA configurations, strengthening the predictive aspects of this decision-support framework and thus its usefulness to PPP stakeholders in both the public and the private sectors.

Acknowledgements

This work was funded by grant CMMI-0629260 from the National Science Foundation, whose support is gratefully acknowledged. Any opinions, findings, conclusions or recommendations expressed in this paper are those of the writers and do not necessarily reflect the views of the National Science Foundation.

Notes

1. 'Report of Inspector General's Findings and Recommendations: an Analysis of the Lease of the City's Parking Meters', City of Chicago, 2 June 2009.
2. Evidence of the public sector's desire to achieve a specific or affordable toll rate was found in: (1) case toll-structures like the Confederation Bridge (Canada) and Skye Bridge (UK), which aligned the original toll rates for new river crossings with the previous charges for ferry service and (2) project data—'From the outset, Norfolk has maintained that a toll of $1.50 per crossing must be the goal of this process'. (Excerpted from 'Midtown Tunnel Public-Private Transportation Act (PPTA) Proposal', Letter from Norfolk Mayor Paul Fraim to Virginia Governor Robert McDonnell, 26 July 2010.)
3. Evidence of the public sector's desire to manage congestion through pricing was found in: (1) case toll-structures like the SR-91 Express Lanes project (California), which was the first toll road in the US to use variable pricing to manage congestion, with tolls depending on the time of day and (2) project data—'Main objectives for P3 implementation: optimize mobility in the [I-595] corridor'. (Excerpted from 'I-595 Corridor Improvements', Presentation at Florida Department of Transportation Design Conference, Session 73, Ian Biava and Phil Schwab, 29 July 2008.)
4. Evidence of the public sector's desire to maximize revenue or minimize subsidy was found in: (1) case selection criteria such as Canada's second 407 ETR procurement, which awarded a 99-year concession for the facility based on the highest up-front payment offered to the state and (2) project data—'The city's goal is to maximize the up-front transaction payment'. (Excerpted from 'Five Teams Qualified to Bid on Skyway Concession', Press release (quote by city comptroller Tariq Malhance), City of Chicago, 20 May 2004.)
5. Toll Feasibility Study prepared for Hampton Roads Planning District Commission, 28 October 2005.
6. 'Midtown Tunnel Public-Private Transportation Act (PPTA) Proposal', Letter from Norfolk Mayor Paul Fraim to Virginia Governor Robert McDonnell, 26 July 2010.

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