Aligning Public-Private Partnership Contracts with Public Objectives for Transportation Infrastructure

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Abstract

With its central role in the development of public-private partnership (PPP) contracts, procurement structure has a significant influence on the economic and policy success of privately-financed toll roads throughout their lifecycle. Following a review of PPP fundamentals and the public-policy differentiation between public interest and public objectives, several approaches for establishing the key contract strategies of toll pricing, concession length, and risk mitigation are explored. These underpinnings motivate the central research question: Given specific policy objectives for road pricing, how should public owners select PPP contract strategies which support these outcomes?

Through qualitative comparative analysis (QCA), a recently-developed method for evaluating qualitative data quantitatively, patterns of PPP contract strategies which correspond to three common policy objectives—achieving a specific toll rate, managing congestion, and minimizing state subsidy/maximizing revenue—are identified through evaluation of 18 domestic and international projects. Three practical decision-making tools resulting from this work are illustrated through application to current PPP procurements: (1) a traffic-risk worksheet, which provides a rapid estimate of a toll-financed project's viability; (2) analytical QCA results, which offer guidance for structuring PPP contracts based on the desired pricing objectives; and (3) case-library comparisons, which enable drawing parallels between proposed procurements and established PPP projects. Additional insights explore the nature of risk in this study, which concludes with thoughts on the appropriate role of PPPs in infrastructure delivery.

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Chapter 1 INTRODUCTION

Public-private partnerships (PPPs) in transportation have garnered much attention as a potential solution to critical infrastructure funding shortfalls (Grimsey and Lewis 2004). Yet the function of these contracts is not simply to provide or maintain facilities, but to do so in a manner which accommodates a diverse array of stakeholder objectives. That this latter function is often more challenging than the former is evidenced by recent PPP procurements which have experienced considerable public opposition, been restructured or cancelled prior to award, or required subsequent renegotiation of contract terms (Garvin and Bosso 2008).

What factors influence a PPP's success or failure in meeting stakeholder goals? To identify the procurement design as a key element seems unremarkably obvious, but a closer examination of the sometimes-conflicting objectives underlying a toll-facility procurement reveals the complex interaction of a contract's decision components—such as pricing strategies, length, and risk/reward allocation—with external factors such as user demand. Identifying which patterns of these elements support specific objectives is the focus of this study, whose motivation and approach are outlined in this opening chapter.

1.1. Infrastructure Funding: The Historical Context

Transportation, and with it the requirement to construct and maintain public roads, is among the earliest concepts of civilization. The primary sources of funding to support this infrastructure have traditionally been taxes and tolls: Sharp et al. (1986) noted the history of road tolls dates back to pre-Christian times. In Britain, the 1285 Statute of Westminster and the 1555 Highways Act regulated the upkeep of public roads, with the latter act securing the necessary resources by requiring several days' labor annually from local residents—a form of taxation (Levinson 2005).

But Adam Smith (1776), in his writings on transportation infrastructure, questioned the propriety of funding roads through taxes on the general population:

> It does not seem necessary that the expense of those public works should be defrayed from [taxes].[1] The greater part of such public works may easily be so managed as to afford a particular revenue sufficient for defraying their own expense, without bringing any burden upon the general revenue of the society. A highway, a bridge, a navigable canal, for example, may in most cases be both made and maintained by a small toll upon the carriages which make use of them.

Smith noted an advantage of funding infrastructure via tolls rather than taxes is that tolls, being dependent on user demand, efficiently stimulate construction of transportation facilities only in locations and only to the extent that users are willing to support. Tax-supported infrastructure, on the other hand, is equally viable whether built in locations of greater or lesser benefit.

Although fuel taxes are more directly related to transportation facilities than are general taxes, Gramlich (1994) observed tolls are still a more economically efficient means of infrastructure funding: direct user fees impact only those who use a roadway, while fuel taxes also burden those who do not cause wear and tear to the facility. Vickrey (1963) noted tolls, unlike taxes, can also be used as a tool for managing traffic congestion, a concept whose implications are examined in greater detail below.

Recognizing some roads cannot be sustained by tolls, though, Smith noted such infrastructure is best provided and maintained by regional governments, so that local residents can receive the benefit of the taxes they pay to support these roadways. Even though these charges are levied on some who may not use the facility, such residents still benefit indirectly from the lower cost of goods enabled by the existence of the local road.

In US history, both tolls and taxes have been used extensively for supporting transportation infrastructure. In the early twentieth century, many major roads were built and maintained by state turnpike authorities, which recovered their costs through tolls on these facilities. Such construction largely ceased when the 1956 Federal Aid Highway Act established the toll-free interstate highway system, which was 90% funded by federal grants from fuel-tax revenues.

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[1] In the original: “that public revenue, as it is commonly called, of which the collection and application is in most countries assigned to the executive power.”

Although tolls are common for long-distance highways in some countries (e.g., Japan and Chile), this concept was not adopted in the US. According to Sharp et al. (1986):

> [T]he network concept makes it inappropriate to charge for the use of specific links in the system. The aim is to foster a national market for goods within a spatially integrated market. More pragmatically, the Clay Committee, which examined road finance in 1955, explicitly rejected tolls for the interstate system, because it estimated that some 10 to 20 percent of the mileage would not meet financial evaluation criteria and thus "toll financing on a sound financial basis" would meet only a portion of the requirement.

With the expansion of the fuel-tax-funded interstate highway network, motorists' perception of the link between tolls and infrastructure support lessened. Those limited facilities which continue to maintain tolls face constant pressure to defer rate increases or to remove these charges altogether, even as inflation continuously decreases the real value of fees collected. Fuel taxes, generally levied at a constant nominal rate per gallon, are experiencing similar erosion in their purchasing power, while recent increases in vehicles' fuel efficiency simultaneously decrease the revenues raised through per-gallon taxes.

Despite these economic considerations and historical choices of taxes and tolls, private-sector involvement in infrastructure provision is not inherently dependent on a particular funding mechanism, as discussed by Fayard (2005). Nevertheless, a toll system is admittedly more conducive to and efficient for private financing, since the collection and allocation of user fees can be administered entirely by the private party. Taxes, on the other hand, must be levied and disbursed by the state, adding a further layer of coordination for private infrastructure financing.

1.2. Private Involvement in Infrastructure Provision

Private finance of transportation infrastructure in the US is not a recent development. As early as the 1790's, individual citizens had successfully petitioned the government for franchises to construct and toll frontier roads and river crossings. Land grants were issued in the 1850's to encourage privately-operated railroads in the Midwest, and even New York's 1890's subway construction resembled a modern-day public-private partnership (Garvin 2007).

Along with the growth of the interstate highway system, post-WWII legislation steered new infrastructure projects increasingly toward the separately-phased design-bid-build procurement method, which effectively decoupled finance and construction, and this model was used almost exclusively for delivery of transportation facilities over the next half century. Not until the late 1980's and early 1990's did private involvement in infrastructure finance resume, with state legislation in California and Virginia permitting experimentation with early forms of PPPs which bundled finance, design, and construction into a single contract.

Around the same time, a series of economic reforms in the UK led to the 1992 establishment of the country's Private Finance Initiative (PFI), which laid the foundation for a wide range of PPPs for infrastructure including schools, hospitals, highways, and utilities. Although the PFI program was initially motivated by concerns about the government's ability to fund infrastructure improvements, the program subsequently shifted its focus to the benefits of improved risk allocation and operational efficiency (Sawyer 2005). PFI implementation expanded rapidly, and by 2007, the Urban Land Institute (2007) estimated 16 percent of the UK's infrastructure expenditures involved PPP delivery. Commonwealth countries such as Australia, Canada, and New Zealand developed their own private infrastructure-finance programs in parallel with or in close succession to the UK's efforts.

Other recent developments in private transportation finance include advances in Spain, where simple toll-road PPPs were first implemented in the 1960's (Albalate and Bel 2009) and significantly influenced the subsequent expansion of this procurement method in continental Europe. In the early 1990's, Chile pioneered the delivery of privately-financed transportation facilities in South America (Vassallo and Sánchez-Soliño 2006).

1.3. PPP Contract Structures

This confluence of road-tolling history with the modern-day resurgence of private infrastructure finance has given rise to a wide array of contract structures grouped together under the PPP heading. A brief review of terminology and common project types helps provide context for the subsequent discussion.

The almost-continuous spectrum of PPP procurement forms may be categorized by the nature of the financing arrangements, level of new construction required, and/or type of facility involved. Frequently PPPs are also characterized by the mechanism through which the private sector receives revenue for its services: user fees, public-sector payments, or hybrids of these two.

1.3.1. Project Types

The term PPP is often construed to cover a broad array of innovative contracting and finance strategies, including A+B (price-plus-duration) design-bid-build procurements, design-build contracting, and developer-financed projects. For this study, greenfield PPPs are defined more narrowly in accordance with the US Department of Transportation's description of DBFO (design-build-finance-operate) procurements, under which "the private sector is responsible for all or a major part of project financing as well as facility design, construction, operation, and maintenance. Typically the facility reverts to the State after 25+ years. Revenues to the private sector can come from direct user charges, payments from the public sector, or both" (USDOT 2004). Brownfield projects, or operating leases of existing facilities, involve little new construction but are also a common form of PPPs. Contractual considerations differ significantly for greenfield and brownfield projects, with the former requiring recovery of construction costs and often involving significant demand uncertainties, while the latter generally entail neither.

Although the PPP procurement model is used for a wide variety of infrastructure projects, including hospitals, schools, and prisons, this study focuses on PPPs for tolled transportation facilities. Debande (2002) notes several fundamental differences between transportation projects and those in other sectors: "(i) the magnitude of the construction and operation risks (market risks, limited ability for transferring of operational risk to specialized subcontractors given their limited number, and revenue stability depending on the toll road mechanisms); (ii) the structure of the payment mechanism; (iii) the potential for mitigating operational risks; and (iv) the existence of exclusivity rights for the use of the asset."

1.3.2. Revenue-Transfer Mechanisms

The primary mechanisms for compensating the private sector for its role in infrastructure provision include direct tolls, availability payments, and shadow tolls. Each of these methods, as well as hybrids, may be used for both greenfield and brownfield projects.

1.3.2.1. Direct Tolls (Market Risk)

Under the direct-toll model, which in the US is used almost exclusively, facility operators charge drivers a fee for each vehicle's use of the roadway. Although concessionaires plan for a certain level of revenue from these tolls, they typically bear the market risk that actual traffic levels may fail to meet initial forecasts. With the historical difficulty of accurately predicting greenfield traffic demand, the private sector includes large contingencies to cover market risk in such projects.

Market-risk tolls also have demand-side effects which can be structured to promote more efficient use of available roadway capacity. Due to tolls' direct impact on users, some drivers prefer to avoid the tolled facility and choose less costly neighboring routes, even if these roadways are lengthier or more congested. The higher the toll rate, the greater this level of diversion. Transportation planners have taken account of this behavior in developing congestion-pricing schemes, which raise toll rates in particularly congested areas during peak-usage periods to encourage drivers to distribute their trips more evenly throughout the day. Systems for real-time variable tolling—which continuously monitor congestion levels and adjust toll rates accordingly to promote free flow of traffic—are in their early stages in the US. The I-495 HOT Lanes concession in northern Virginia presents one example of this strategy.

1.3.2.2. Public-Sector Payments

Instead of providing revenue solely from user fees, a PPP arrangement may compensate the private sector through direct payments from the state. This compensation structure can take multiple forms, the most common of which are availability payments and shadow tolls. Although these contract types (if not also coupled with direct tolls) are not the focus of this study, their structure is outlined here for completeness' sake.

Under the availability-payment model, concessionaires receive their revenue through periodic transfers from the public sector. These payments' base level and duration are negotiated as part of the contract terms, and amounts are reduced for any deficiencies in agreed-upon operating standards, such as timely pothole repair or debris removal. Availability payments are generally independent of the number of vehicles using the facility, though they may sometimes be indexed for unexpectedly heavy traffic volumes. The state may or may not impose a toll on the facility.

The FHWA (2007b) notes several advantages of the availability-payment model:

- It creates an incentive for timely completion of project construction (since payments do not begin until the facility opens);
- It provides an incentive for continued high operating and maintenance standards; and
- It lowers the concessionaire's cost of capital by eliminating traffic risk.

Though availability-payment PPPs are more common abroad, Florida is pioneering this model in the US with a variety of toll structures. The Port of Miami Tunnel, for instance, will not be tolled: the concessionaire will receive monthly payments over a 30-year term after facility opening, with deductions for not meeting specified performance and service criteria. In contrast, the I-595 improvements in southern Florida will incorporate reversible express lanes tolled with variable congestion pricing; the state will retain the toll revenues throughout the 30-year concession and provide availability payments to the developer. In these projects, though, the concessionaire assumes a measure of appropriations risk, since these disbursements must be approved annually by the state legislature.

A second state-administered option for revenue transfer, shadow tolls, is frequently used for international transportation projects but has not yet been applied in the US. Under this model, which is in some ways a hybrid of the previous two, the public owner provides the concessionaire a fixed fee (potentially reduced for service deficiencies) per vehicle which uses the facility. No diversion or congestion-pricing considerations arise, since drivers are not charged directly. "This eliminates the need to install tolling equipment and collect tolls directly from the users of the facility, while encouraging the concession team to operate and preserve the highway at high performance standards to ensure the availability and use of the roadway" (FHWA 2007a).

Spain's PPP program illustrates simultaneous use of the direct-toll and state-administered revenue-transfer options. Of the country's 4300 km of national highways, 3800 km are direct-tolled, with the remainder shadow-tolled. Shadow tolls are used only when the government anticipates a facility's traffic volumes will not be high enough to yield sufficient compensation for the private developer. Portugal similarly favors direct tolling but sometimes applies a hybrid scheme combining the two approaches when expected traffic levels are low (FHWA 2009).

1.4. Sector Choice and Risk Assessment

Given this variety of contract structures, owners face increasing complexity in evaluating private-finance alternatives as options in their capital-budgeting decisions. Even before the question is posed about which type of PPP to use, though, a more fundamental issue is whether to use one at all. Overshadowing the details of individual PPP delivery methods is the matter of whether the public or the private sector ultimately delivers greater lifecycle value in developing and operating a transportation facility.

Among the key determinants in answering this question is risk allocation: if one of these parties is better suited to manage risks which influence concession value, this advantage is appropriately recognized in considering the assignment of a project to one sector or the other. These risks include a broad range of potential issues ranging from the procurement phase (e.g., political or financial-market instability) to the construction phase (e.g., discovery of hazardous materials or unexpected subsurface conditions) to the operations phase (e.g., lower-than-anticipated demand for a facility or changes in project-relevant legislation). A summary of literature addressing such risk-related issues is presented in Appendix A (Box 5: Risk Management).

A common adage is that project risks should be allocated to the party best able to manage them: superior ability to mitigate certain risks may give one party a competitive advantage over the other. To provide a tool to convert these risks into up-front costs, the Value for Money (VFM) analysis was developed to quantify the public and private sectors' risk-management capabilities. Typically the analysis is coupled with evaluation of the Public Sector Comparator (PSC), a hypothetical present-value equivalent of the public owner's cost to provide and operate a facility. The PSC "represents the most efficient public procurement cost.... This benchmark is used as the baseline for assessing the potential value for money of private party bids in projects" (Canada 2003). A "shadow bid" reflecting private-sector costs is also developed for comparison in order to identify the higher-value provider, and PPP delivery is selected only if the private-sector cost is favorable.

PSC values depend on variables including capital and operations expenditures, discount rates, annual escalation, transaction costs, and taxes. The resulting amount is only one component of the VFM analysis, which also considers qualitative factors such as service quality and broader social goals. The analysis also adjusts for analysts' tendency toward excessive optimism due to neglecting unlikely or ill-defined risks (UK 2007).

Although the VFM approach is widely used in the UK and Commonwealth countries, Russell and Nelms (2006) identify several weaknesses of such PSC comparisons. Most serious is their difficulty in accurately assessing the private sector's measurement and pricing of risk, which can differ widely from the public sector's perceptions. This deficiency can limit the practical value of VFM analysis for sector-choice decisions.

Nevertheless, efforts to convert risks into up-front costs can still indicate which party is better positioned to manage these uncertainties. Under the Australian approach, for instance, PPP risks are assigned to the private sector unless it is specifically determined they should be retained by the government (Australia 2006). The analysis can also help identify third-party options for risk transfer: "Many risks which are transferred from the public sector to the private sector under PPP deals are potentially insurable. The availability of insurance should be a consideration when risk allocation is being negotiated" (Canada 2003).

Quantifying the cost of such risks can have other implications. It may be, for instance, that the state cannot afford the resulting project-cost increase of assigning certain risks to the private sector, and thus must retain exposure to risks which it would not otherwise have kept. Alternately, a project may no longer be financially feasible once its risk costs become explicit upon assignment to the private sector. With demand risk as one of a project's potentially most costly unknowns, the US PPP market is beginning to re-examine its traditional assignment of this risk to the private sector, as evidenced for instance by the 2008 award of the country's first availability-payment concession, Florida's I-595 express lanes.

1.5. PPP Contracts and Public Interest

Once the decision is made to involve the private sector in a facility's financing and development, the PPP contract's treatment of risk is key in determining the distribution of potential project profits between the state and concessionaire. Given this importance of risk-allocation decisions and a growing awareness of their long-term impact, strategies for safeguarding public interests in PPP contracts are a common topic in the literature, with selected contributions summarized in Appendix A (Box 8: Public-Sector Considerations).

Many of these authors treat "public interest" as a concept which needs no definition, regarding it broadly as that which promotes the general welfare, or considering it synonymous with public policy. Yet there is benefit in considering public interest more specifically and in recognizing two distinct facets of the term: one which represents its public-policy aspects, and another which corresponds to universal best practices for public procurement.

The public-policy goals for a PPP often vary depending on an administration's priorities, while best practices for procurement and capital programming remain 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 which the city's inspector general censured for inadequate transparency and asset valuation.[2]

Yet the satisfaction of public-policy objectives, in addition to procurement principles, is an equally vital requirement for successful transportation PPPs. These objectives are the concrete

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[2] "Report of Inspector General's Findings and Recommendations: an Analysis of the Lease of the City's Parking Meters," City of Chicago, June 2, 2009.

aims that an owner intends to achieve through a project; as such, they do not represent a static goal or single ideal which one optimal contract structure can satisfy. Rather, the public-policy objectives which may be addressed, particularly through toll pricing of an infrastructure project, 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, yet 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 public interests and dynamic public objectives is crucial to this study’s central research question, which recognizes differing policy objectives require differing PPP contract structures to ensure these goals are satisfied.

1.5.1. Separating Public Objectives and Contract Structure

In this context, one challenge in studying public objectives for PPPs is the frequent temptation to evaluate the contract structure independently from the motivating policy, as illustrated in the well-intentioned debates over PPP concession length (a primary element of contract structure) and its impact on the public interest. Given the typical profitability of PPP toll facilities in their steady-state phase, some authors question the propriety of allowing concessionaires to reap decades of potentially generous returns at minimal risk, noting such returns could be more appropriately collected by public agencies and re-invested in other infrastructure needs. Other observers highlight a related concern about the state’s loss of control of its revenue-producing assets for extended periods. Though frequently couched in language of “public interest,” such issues of concession length are more specifically ones of public-policy objectives.

One example is provided by the 99-year operating lease of the Chicago Skyway in 2005 to a private operator for a $1.83 billion up-front payment. Due to the concession’s lengthy term and aggressive toll-escalation structure, the contract was criticized for failing to protect the public interest (PIRG 2009). But since Chicago’s goal for the procurement had been to raise cash for municipal needs (Bel and Foote 2009), this PPP was correspondingly structured to attain the highest up-front fee for the city. Bel and Foote calculated that, all other factors and growth assumptions being equal, the same concession with only a 23-year term would have yielded 58% of the 99-year amount, a payment of $1.06 billion. Further, a 23-year concession coupled with more moderate toll and traffic growth would have yielded only $446 million, or 24% of the achieved amount. Whether the city's goal of revenue maximization was ultimately "in the public interest" is a question which primarily involves Chicago's public-policy objectives, not the procurement's structure. The concession's length and toll-escalation rates, having been tailored to meet the city's goals, were simply a consequence of policy decisions which would perhaps have been a more appropriate subject for critics' attention.

Other public-interest concerns raised in conjunction with long-term concessions are also more specifically policy issues, linked to the goals of a particular administration, rather than procurement-related practices. Among these concerns is the application of proceeds gained through "monetization" of an existing revenue-producing asset, such as the Chicago Skyway. Public agencies may be tempted to use these substantial amounts for popular short-term needs: Chicago programmed $100 million of the Skyway proceeds to support five years of social services such as home heating assistance, children's after-school activities, and Meals on Wheels.[3] Such decisions, in effect, incurred a debt to be paid off by future generations of Skyway users who will see little benefit from the city's earlier spending. Though such policy concerns indeed arise as a result of funds provided by a long concession term, these issues are ultimately based on public-sector priorities and are not caused by the PPP procurement structure itself.

An incomplete understanding of the public-interest distinction between policy issues and procurement practices and structure can lead to excessive regulation. Targeting lengthy concessions as a cause and not an effect, some state legislators have sought to restrict PPP durations universally.[4,5] But longer concession terms are not without benefits and may be a

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[3] "Skyway Lease a Good Deal for Chicago Residents, Daley Says," Chicago mayor's press office, Jan. 31, 2006.

[4] Virginia General Assembly 2010, SB605 summary: Legislation "requires approval of the General Assembly before any lease for longer than 10 years or sale of the Virginia ports is permitted."

[5] Virginia General Assembly 2010, SB140 summary: "Any leases, concession agreements, or similar type of agreements...for a period longer than 20 years at a time are prohibited. Any such leases, concession agreements, or similar type of agreements under 20 years shall be approved by the Governor." Neither SB140 nor SB605 passed.

useful option to support certain policy goals. In addition to higher up-front revenues or reduced state subsidies, greater PPP durations can also offer tax advantages and facility lifecycle-cost benefits: an increased period of operational responsibility may incentivize an operator to provide higher-quality improvements which last for a longer contract period. When policy objectives do justify longer concession terms, contracts can be structured to address concerns about potential private-sector “super-profits”: Mayer (2007) recommends revenue-sharing arrangements in lieu of strict limits on concessionaires’ upside benefit, since such caps can reduce private-sector incentives for efficiency, a potential advantage of PPP delivery.

Ortiz and Buxbaum (2008) note additional public-policy issues which can be associated with long concessions. Particularly in the US, where much of the public sector has limited experience with the complex financial and legal elements of PPP contracts, they note state agencies may not yet be sufficiently qualified to evaluate contract-structure options efficiently. In such a case, longer concession terms could magnify the impact of any missteps in the procurement process.

1.5.2. Structuring Contracts to Achieve Public Objectives

These considerations clarify the distinctions between static best-practice procurement principles, variable public-policy objectives, and the role of PPP contract structures in accommodating both. Given the significance of policy outcomes in shaping procurements and the variety of possible 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* favor under various conditions, such a focus is beyond the scope of this inquiry. The following investigation seeks instead to probe which PPP contract strategies support specific objectives, providing public-sector decision-makers a tool to identify those means which most efficiently accomplish the desired ends.

This effective structuring of PPP contracts is not a straightforward matter. Unlike the Chicago Skyway, which successfully achieved the city’s unpopular objective to obtain maximum revenue from the procurement, other contracts have failed to realize their goals due to ineffective contract strategies. Mexico’s 1989-1994 highway-concession program provides one example: a major objective of these PPP contracts was to transfer development costs for an aggressive highway-expansion program to the private sector. Yet the state eventually assumed billions of dollars of obligations by restructuring dozens of struggling concessions, largely due to ineffective contracts which led to toll revenues being much lower than anticipated:

> Instead of using objective demand criteria to determine toll levels, measures were selected with a view to minimizing the term of each concession. Relatively short concession periods were obtained by charging high fares to the users, disregarding the principles of economic efficiency. The average length of the 22 concessions granted during the first stage of the program was about 12 years, although extreme cases were also observed with terms of only 5 years. (Landa and Rogozinski 1998)

In the pursuit of structuring PPP contracts to achieve public-policy objectives, the question also arises how private-sector interests are accommodated to enable "balancing 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 contract can be taken as implicit confirmation that the concessionaire sees profit potential, and thus the achievement of its goal, in the project.

Given this relative homogeneity in private industry, this investigation focuses on the more complex contract-structuring decisions necessary in the public sector. This emphasis is further supported by owners' dominant role in contract formation and their responsibility to tailor the content of procurement documents to accomplish their specific aims. Among the contract elements most effective in shaping PPPs to achieve such outcomes are these contracts' pricing and duration strategies, as explored further in the following chapter.

1.6. Research Pursuit

This preceding review lays the foundation for the central research question: *Given specific policy objectives for road pricing, how should public owners select PPP contract strategies which support these outcomes?*

To investigate this question, the subsequent chapters are organized as follows:

Chapter 2 presents a detailed examination of contract strategies as tools in the toolbox for shaping a PPP contract, or recipe ingredients for formulating contracts with specific objectives. Pricing and duration approaches form two of the key building blocks for structuring a PPP toll-road contract, and the practical and theoretical underpinnings of these strategies are described.

With this foundation, Chapter 3 introduces the research methodology. Because traditional quantitative and qualitative methods both present significant challenges for an investigation of this nature, a middle-ground approach is outlined. Qualitative comparative analysis, though infrequently applied in construction research to date, combines elements of quantitative and qualitative methods to offer a robust approach for probing the question above.

Chapter 4 details the analysis and results of this undertaking. Eighteen case studies, representing domestic and international PPP procurements for tolled transportation facilities, are characterized according to five contract strategies and three public objectives—achievement of a specific toll rate, congestion management, and revenue maximization. Patterns of contract strategies which support these objectives are identified, interpreted, and validated.

Chapter 5 demonstrates three practical tools resulting from this research by applying them to the US Route 460 and Midtown Tunnel procurements in Virginia. A traffic demand risk worksheet offers a summary assessment of a toll-financed project's viability, while the previous chapter's research findings provide guidance for structuring PPP contracts with specific pricing objectives. In addition, the 18 projects studied above are presented as a "case library," enabling comparison of these established PPPs with proposed procurements having similar analytical characteristics.

Chapter 6 discusses further thoughts based on this work. Patterns among case-study procurements sharing the same public objectives are identified, as are geographical and chronological trends in project risk characteristics. General observations on PPP risk also provide guidance for interpreting traffic-demand risk and allocating contingency in renegotiation scenarios.

In conclusion, Chapter 7 summarizes six major contributions of this research and presents specific guidance for policy and practice, along with suggestions for future work.

The appendices include a compendium of nearly 450 PPP publications, categorized by topic, in addition to case-study data and material supporting the method’s development and application.

The elements of toll pricing and concession duration are key factors in structuring a PPP to meet specific public objectives, and the practical approaches and theoretical underpinnings for these contract strategies are examined below. Appendix A (Box 2: Contract Design) offers a summary of resources which investigate these decision factors and their relationships in detail.

2.1. Toll Pricing Approaches

The decision factor of contract pricing can take several forms, depending on the type of project: it may be a toll rate schedule for a greenfield concession, an up-front fee offered to the public sector for a brownfield operating lease, or a proposed availability payment for either type of PPP. All of these provide an objective evaluation factor for contract award, but the methods used to specify these amounts vary considerably. These approaches are reviewed for the cases of market-risk, availability-payment, and duration-dependent contracts.

2.1.1. Price as PPP Competition Factor

2.1.1.1. For Market-Risk Contracts

Competition by toll rate is one available scheme for awarding concessions, though it requires a tightly defined scope (e.g., technical proposals meeting a specified level of qualifications) to ensure proposers can be evaluated on an equal basis.

Yet Guasch (2004) observes from his experience with concessions in Latin America:

> Tariffs [tolls] are “soft” anchors for concession awarding. They are vulnerable, because they constitute a parameter that, at least every so often, automatically appears at the table for modifications and review, even in the best of circumstances, and at that opportunity if not before, it can be subject to modifications, compensation, and rent extraction. Tariff bids have the major disadvantage that the winning tariff will almost always be less than the long-run marginal cost of providing the service, and they are likely to be changed very quickly—mostly through renegotiation or review.

As Guasch subsequently notes, though, this disadvantage can be addressed with term-structure regulations: “The salient option to award a concession that minimizes those problems is first to establish an appropriate level and structure of tariffs before a concession is awarded, together with clear rules for tariff readjustment and revision.”

Competition by lowest proposed toll rate was at one time standard procurement practice in Chile. Although this model was generally effective in limiting the prospect of monopoly-style profits, it simultaneously exposed concessionaires to substantial demand risk and burdened road users with concessionaires’ traffic-risk contingency markups (Engel et al. 1997; Engel et al. 2002).

2.1.1.2. For Availability Contracts

Contracts can also be awarded on the basis of lowest proposed availability payments: Peru’s 2003 and 2005 procurements for portions of the Northern Amazon Hub road network both used this model. Developers bid separate amounts for two annual payments: one for construction (distributed over a 15-year concession), and one for operations/maintenance services (issued up to 25 years). The proposer with the lowest sum of these two payments received the contract (Matsukawa and Habeck 2007).

In 2007 and 2008, Florida developed a hybrid application of this structure for the Port of Miami Tunnel and I-595 procurements. In these competitions, 45% of each proposer’s overall score depended on the specified availability payment each concessionaire required, with the remainder of the evaluation based on technical and other factors. Not surprisingly, the consortia with the lowest proposed payments were selected for both projects.

A variation on this competition model is Guasch’s suggestion (2004) that “in the event of a negative concession, which is one that is not financially viable (such as some toll roads), the concession should be awarded to the qualified bidder willing to accept the lowest subsidy, given a specified toll fee.” This structure was proposed for Texas’s I-635 LBJ Freeway, a market-risk congestion-priced project, and would also lend itself well to the availability-payment model.

2.1.1.3. For Duration-Dependent Contracts

Although the variable-length concession model typically involves the public sector selecting a preferred value for toll rates and allowing the concession term to float, another option is to have the concessionaire propose values for both items as bid variables.

One example is the 2004 concession for the EastLink highway and tunnels in Melbourne, Australia. The procuring agency asked candidates to propose both toll rates and concession term length as bid variables, and the agency then applied a public-sector-comparator approach to determine the resultant value-for-money for each bidder's package. Based on this analysis, the contract was awarded to a concessionaire offering a low toll rate—in fact, the lowest per-kilometer rate in Australia—in combination with a relatively lengthy 39-year concession term.

2.1.2. Rate-Adjustment Mechanisms

Most toll-based PPP competitions stipulate a particular mechanism for adjusting toll rates over time, which can also influence a contract's achievement of certain policy objectives. Table 2-1 illustrates a variety of structures specified in the US to set and adjust toll levels, showing little consensus exists in establishing unified structures for this important contract parameter. Some of these projects treat the gross domestic product (GDP) and the consumer price index (CPI, or inflation) as interchangeable rates, for instance, even though these indices historically vary significantly and are not necessarily related to a concessionaire's cost growth for operating a toll road. Escalating tolls by GDP typically results in higher rate increases than does CPI escalation.

The private sector can reap significant benefits from generous toll increases over long-term concessions. As indicated in Figure 2-1, much of the value for the 99-year Chicago Skyway lease accrued not so much from anticipated traffic growth but from aggressive toll increases. In the first 12 years of this concession, the contract permitted doubling passenger-vehicle tolls from $2.50 in 2005 to $5.00 in 2017, after which rates would increase by the greatest of GDP, CPI, or 2% annually. The tolls for seven-axle trucks more than tripled in the same 12-year timeframe.[6]

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[6] Chicago Skyway Concession and Lease Agreement (Schedule 6, Section 3: "Tolling Level Requirements"), Journal of the Proceedings of the City Council of the City of Chicago, Illinois, October 27, 2004, pp. 33532-6.

Project	User Fee Structure
Dulles Greenway	User fees follow a predefined schedule of escalation through 2012, after which the concessionaire may escalate fees annually, upon request, at the consumer price index (CPI) rate plus 1%.
California AB 680 Program	Under a regulated rate-of-return model, concessionaire is to contribute receipts in excess of stipulated rate of return to debt principal balance or to state highway fund.
Chicago Skyway	Concessionaire may raise user fees by the greater of the CPI or contractually-specified limits to increase toll from $2.50 to $5.00 by 2017. After 2017, annual increases are permitted at the rate of the CPI, nominal GDP per capita, or 2%, whichever is greatest.
Confederation Bridge	Initial user fees were set at the same rates as existing ferry services; concessionaire is subsequently permitted to escalate tolls at an annual rate not to exceed 75% of the CPI.
Highway 407 ETR	
Phase I	User fees specified by public owner.
Phase II	A market-based approach was established during peak travel periods with penalties for the concessionaire's failure to balance throughput and the market price; a detailed schedule governs user fees in off-peak periods.
I-495 HOT Lanes	Variable tolling was specified to manage congestion. If concessionaire exceeds targeted equity internal rates of return, 5% to 30% of excess revenues will be shared with public owner.
Pocahontas Parkway	
Phase I	A user-fee schedule was established for the first two years, after which the public owner held the right to adjust tolls subject to covenants in the bond indenture.
Phase II	A specific tolling schedule was defined in the agreement through 2016, after which the concessionaire may increase annual toll rates by the greater of the rise in GDP, the CPI, or 2.8%.

Table 2-1: Toll Establishment and Adjustment Strategies

(based on Garvin 2007)

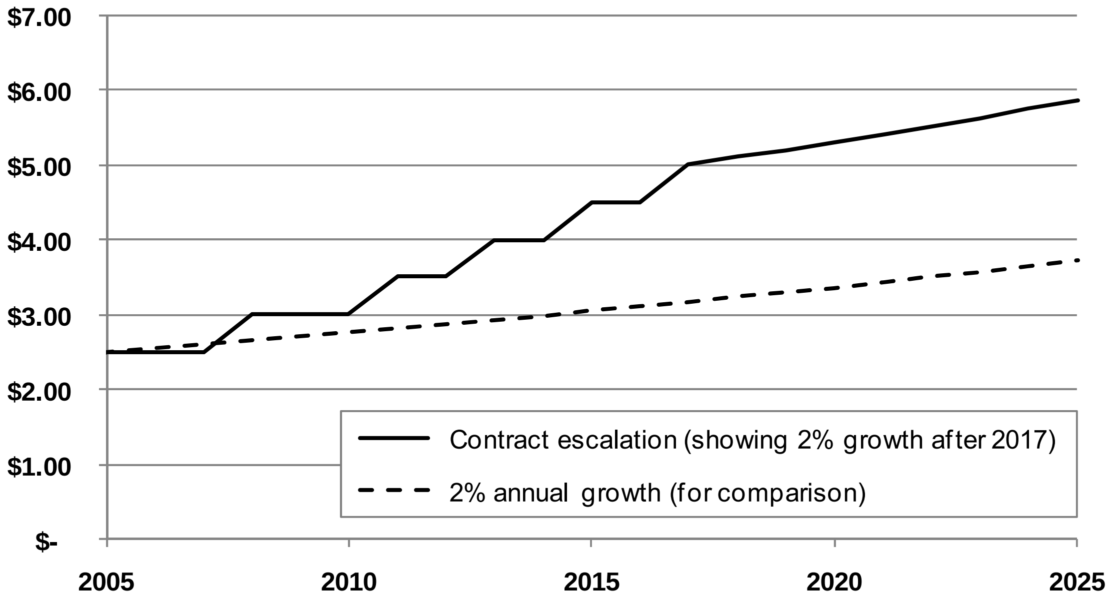


Figure 2-1: Chicago Skyway Toll Escalation

(from Chicago Skyway Concession and Lease Agreement)

These practical applications of toll pricing and escalation are based on an extensive body of underlying economic theory which provides a more complete understanding of the motivation for selecting specific toll structures. From the perspective of transportation economics, road pricing and its relation to tolls are next considered, followed by an examination of monopoly-pricing theories as applicable to brownfield concessions. A summary of literature in this field is given in Appendix A (Box 7: Economic Elements).

2.2. Economic Underpinning of Road Pricing

Road-pricing structures can generally be classified as supply-based or demand-based. In the former category are average-cost pricing models, which set user fees at a level just adequate to cover a facility's long-term average costs, including ongoing operations and maintenance expenses (as well as capital expenditures, if not already recovered). These rates are typically lower than those under marginal-social-cost and revenue-maximizing pricing models, which fall into the demand-based category. In setting user fees, these two latter approaches take into account the elasticity of user demand, often in relation to roadway congestion levels. The following review examines fundamental economic principles underlying all three toll-rate structures, along with their strengths and weaknesses in practical application, in the context of concessions for which tolls are the private sector's sole source of operational revenue.

2.2.1. Average Cost Pricing (Maintenance-Cost Models)

"...in no other major area are pricing practices so irrational, so out of date, and so conducive to waste as in urban transportation," wrote economist and later Nobel laureate William Vickrey in 1963. The issues surrounding average cost pricing—the seemingly logical establishment of toll rates at levels exactly covering the economic cost of road provision—show Vickrey's observation still has merit today.

From a theoretical standpoint, Sharp et al. (1986) agreed tolls for uncongested roadways should generally be set equal to the facility's operating costs but not include construction expenses, since these higher rates would create economic distortions and artificially decrease demand for the roadway. Ragazzi (2005) noted linking user fees to actual road costs (whether with or without construction expenses) would contribute to an irrational patchwork of toll levels throughout a country, as illustrated by the case of 24 highway concessionaires in Italy charging between 4.6 and 14 euro cents per kilometer. For a publicly-administered highway system, Oh et al. (2007) countered this concern by calculating and proposing an average per-mile cost-recovery fee which could be imposed state- or nationwide.

As these divergent perspectives indicate, implementing tolls for true average-cost pricing can be difficult from a practical standpoint. One challenge lies in defining the span of time over which long-term average costs are evaluated, thus determining which expenditures are incorporated in the average. "Alligator Alley," a 78-mile stretch of I-75 in Florida, for instance, requires only 26% of toll revenues for ongoing operations and maintenance, even though this roadway has (at 3.2¢ per mile) one of the lowest unit toll rates in the US (Samuel 2008). Although this road's toll might seem overpriced from a short-term perspective, consideration of a longer time span would absorb periodic rehabilitation costs as well.

Specifying a PPP concession length provides one definition for the long term over which to measure average cost. Yet this economic cost includes not only tangible outlays for facility operations and maintenance, but also an additional amount covering investors' opportunity cost of capital. Because this rate of return corresponds to the operator's economic breakeven point, average cost pricing for a PPP can be implemented under the structure of a regulated monopoly, as outlined by Brown and Heal (1983). Under such a scenario, the facility's pricing structure and the operator's permissible rate of return are specified such that long-term average costs are just covered, giving the private sector the incentive to operate the roadway as efficiently as possible.

This scenario assumes average costs can be estimated with considerable certainty, indicating a minimal level of risk. In practice, a regulated-monopoly implementation of average cost pricing would likely include a higher rate of return than the pure opportunity cost of capital in order to allow for a degree of risk and entice private-sector participation. Other monopoly and regulation issues are explored further below.

2.2.2. Marginal Social Cost Pricing (Congestion-Cost Models)

Marginal social cost pricing, a demand-based fee structure, recognizes tolls' ability to influence traffic congestion and thus addresses a shortcoming of the average cost pricing model, whose economic justification applies only to uncongested facilities. These congestion-cost models seek to quantify overcrowded roadways' economic costs, such as increased delay and pollution, and to hold drivers accountable for these impacts through establishment of corresponding user fees. Another perspective is that those who use a road during peak hours and cause it to be congested are those driving the need for an eventual facility expansion, and therefore these road users (who need the additional capacity) are appropriately charged to fund such upgrades. Because average cost pricing recognizes only the relatively constant costs incurred by the facility operator, this model is not suited to account for the varying environmental impacts imposed by road users. Further, the fixed pricing inherent in average-cost schemes restricts tolls' ability to influence drivers' behavior or help allocate limited capacity when demand for a roadway exceeds supply.

This relationship between tolls and traffic demand received little attention until the 1960's; until then, the standard solution for congestion had been constantly to increase capacity, primarily by building additional roads (Thomson 1998). But the Smeed Report (UK 1964), a seminal publication in transportation economics, proposed more efficient use of existing roadway capacity by charging drivers for the impacts (or “marginal social costs”), particularly congestion, which they imposed on their surrounding environment.

Because precise measurement of these costs, given the temporal and spatial variations in congestion throughout a transport network, was prohibitively difficult, economists developed numerous “second-best solutions” for road pricing. These studies sought to optimize social benefits under various constraints on time-of-day variations, spatial tolling limits, or vehicle-category differentiation (de Palma et al. 2005). Other authors (Chu and Tsai 2004; Newbery 1989) investigated the feasibility of combining the average-cost and marginal-cost pricing approaches by considering operations and maintenance costs as a type of environmental impact caused by driving. They proposed developing an optimal toll level by adding an average-cost operations component to the previously-derived marginal social cost.

Although the Smeed Report authors recognized the systems of their day could not assess continuously-variable user charges, more recent advances in tolling technology now enable continuous monitoring of congestion levels and regulation of toll rates to influence driver demand and promote free flow of traffic. This real-time adjustment of congestion-based tolls approximates the constantly-changing marginal social cost of roadway usage. One mechanism for setting these variable tolls is illustrated by the I-495 High Occupancy/Toll (HOT) Lanes concession in northern Virginia, whose operator will monitor traffic speed and raise toll rates when congestion decreases the express lanes’ average speed below 45 mph. Hence users with inelastic demand can choose to pay a variable toll to drive on uncongested lanes, while drivers with more elastic demand travel on the heavier-traffic lanes for free. The effectiveness of this strategy awaits confirmation by northern Virginia drivers once the facility opens.

2.2.3. Revenue-Maximizing Pricing

Although revenue-maximizing pricing is also a demand-based tolling structure, it differs from marginal social cost pricing by decoupling the link between tolls and congestion (or environmental impact) 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 revenue for the operator. These models predict the extent to which tolls will divert travelers to less direct but less costly routes, based on the value of drivers' time and vehicle operating costs, as well as the characteristics of these alternate routes (HRPDC 2005).

Except in the uncommon case when demand is perfectly elastic, Ubbels and Verhoef (2008) note the revenue-maximizing toll necessarily exceeds the welfare-maximizing, or marginal social cost, charge. The result, economically speaking, is an underutilized road with unused capacity. Yet in some cases, public agencies choose to specify revenue-maximizing PPP procurements to accommodate other goals. Even when public agencies prefer a throughput-maximizing pricing structure, the revenue-maximizing toll calculations can still be used to determine the bounds of a candidate PPP project's financial feasibility.

As outlined above, the choice of toll structure is nevertheless a significant factor in concession length determination: higher revenue conceptually allows the private sector to accept a shorter lease term to recoup its investment. This tradeoff highlights one of the complex linkages between the cost and time variables of PPP agreements.

2.3. Economic Theory: Monopoly Pricing

A second province of economic theory pertinent to evaluating PPP procurement strategies is the body of knowledge related to monopolies. Although market constraints and public-interest elements effectively restrict the formation of true economic monopolies for PPPs, the related theory is helpful in understanding the forces which affect the competition and pricing aspects relevant to awarding brownfield concessions.

Demsetz (1968) was among the first to explore the unique economic aspects of competition for furnishing public-utility services, a market very similar to PPP operating leases for transportation facilities. Although such competition is *for* the field in its entirety, rather than *in* the field, he concluded the single winning firm nevertheless cannot employ monopoly pricing levels after a properly structured competition. With increasing numbers of contestants, he noted, the winning bid price approaches the cost of providing the service; and this natural competition reduces the need for external regulation. Ponti (2005) explored the effect of such “Demsetz competition” on roadway concession length. For operating leases which are periodically re-bid, he cautioned long-term concessions can pose risks of information asymmetry and “capture” by the current operator. D’Alpaos et al. (2006) further noted the private sector’s increased flexibility in investment timing decisions enabled by longer lease terms can, but does not necessarily, increase a concession’s up-front value.

If brownfield transportation concessions may be analyzed as a form of monopoly, then the economic concepts of monopoly pricing can also be relevant in determining toll rates. The Ramsey pricing model, sometimes termed Ramsey-Boiteux pricing, was developed in the 1920’s “to identify the prices to be charged by a natural monopoly to maximize consumer welfare while meeting revenue requirements” (Hartman et al. 1994). For a transportation (or any) monopoly, though, these two pursuits are in conflict. Maximizing consumer welfare, the “first-best solution,” would mean charging each user the concessionaire’s marginal cost of providing the roadway; but since this marginal cost declines with each additional user, the concessionaire would necessarily lose money under such a structure. Under a monopoly, on the other hand, the concessionaire can maximize his revenue by setting toll levels in inverse proportion to users’ elasticity of demand. Ramsey pricing provides a “second-best solution” which balances these two conflicting aims while permitting the concessionaire some specified level of profit. This model thus incorporates elements of both the marginal-cost pricing and the revenue-maximizing pricing approaches discussed above.

In practice, though, some economists dispute the efficacy of Ramsey pricing. Sheehan (1991) and Hartman et al. (1994) point out the model does not account for the prospect of some users’ resulting avoidance of the monopolized facility altogether, such as by choosing alternate means to accomplish their travel needs. Further, since brownfield toll rate schedules must be approved by the roadway’s public owner, opportunities for concessionaires to establish a true monopoly in the US market are negligible, limiting the practical need to develop applications of Ramsey pricing. Other factors besides pricing also involve these potential issues of private-sector market control, as examined in the following section.

2.4. Concession Length Approaches

Unlike toll pricing, the contract strategy of concession length has a uniform meaning for both greenfield and brownfield projects, though its implications vary substantially for these project types. Following a review of contract-duration issues, this element's role in structuring fixed-length and variable-length concessions is examined. The discussion below limits its focus to finite agreements, rather than contracts in perpetuity: although privately-owned facilities may also offer a viable option for infrastructure delivery in some cases, they fall outside this study's definition of PPPs, whose facilities remain under public-sector ownership. A selection of literature on this topic is categorized in Appendix A (Box 4: Contract Design).

2.4.1. Contract-Length Considerations

Greenfield and brownfield concessions have distinctly different sensitivities to the factor of contract duration. For a greenfield project, several years after facility opening are necessary for traffic levels to stabilize as drivers become accustomed to using a new roadway. This initial "ramp-up period" entails considerable risk for concessionaires, since it reveals whether their initial traffic forecasts—a core element of financial models—are accurate. Once traffic levels reach this equilibrium phase, after which growth continues at a generally constant rate, the concessionaire's risk level decreases substantially, and the project is considered a mature infrastructure investment which will yield stable, low-risk returns for the remainder of the concession period.

For US greenfield concessions, contract terms typically range from 35 years (California's SR-125 South Bay Expressway) to 80 years (Virginia's I-495 HOT Lanes). Although the bulk of these long durations generally corresponds to the steady-state phase outlined above, predicting with certainty the point at which a facility will reach this steady-state phase is nearly impossible. Numerous examples exist of projects, such as Virginia's Dulles Greenway, in which forecasted traffic levels and growth rates were far too optimistic, forcing developers to carry facilities at a loss until traffic eventually materialized or until the projects reached bankruptcy. Hence the value to a concessionaire of a 75-year lease versus a 50-year lease, for example, lies primarily not in the increased value of gross toll receipts over time, since the present value of the terminal years' revenue is negligible. Rather, developers favor longer greenfield concessions because the additional time also provides a buffer to smooth out the historically-common problems with traffic demand. The engineering literature has proposed various approaches, including fuzzy simulation models (Ng et al. 2007) and Monte Carlo simulation (Zhang and AbouRizk 2006), to manage these risks and develop optimal greenfield concession lengths.

Brownfield concessions, on the other hand, generally entail lesser revenue risk, since fairly accurate demand forecasts can typically be developed from historical traffic counts at the existing facility. One consideration which has influenced brownfield PPP lengths in the US is the public sector's interest in the higher up-front concession payments resulting from longer terms. Longer durations also make these revenue-generating operating leases more attractive as assets for investment and pension funds seeking stable long-range returns.

For both greenfield and brownfield contracts, Vassallo (2004) notes several procurement disadvantages of long PPP durations: not only are traffic levels and technological improvements difficult to forecast far in the future, but long concessions also increase the risk that a concessionaire will effectively assume monopoly control of a facility. While Vassallo also highlights potential drawbacks of short PPP terms, such as decreased incentive for the private sector to invest in facility upkeep, he notes these issues can be largely contained with carefully-written contract specifications.

One particular disadvantage of short-term greenfield concessions is the limited time available to collect sufficient direct-toll revenue to cover facility construction costs. As one solution, Vassallo (2004) presents the concept of a "reversion fee," an amount paid to the developer at the end of a concession to capture the difference between the private sector's investments and the facility's remaining value. This amount may be specified by bidders as a competition factor up front, or calculated at the end of the concession term based on pre-determined factors such as actual traffic demand levels. The state can obtain funding for the reversion fee, if desired, by subsequently soliciting bids for a follow-on brownfield concession for facility operation. Spain's first reversion-fee PPP, a 25-year contract, was awarded for construction of a new access road to the Madrid airport in 2003.

Relative to the 25- to 30-year PPP terms common internationally, US contract durations are typically very long: most start at 50 years and range up to 75 or even 99 years. Due to features of the US tax code, such length enables significant financial advantages for the private sector:

> Another important consideration for having such long leases has to do with tax benefits. Chief among the federal tax benefits is accelerated depreciation. Although the lessee (concessionaire) is not the owner of the existing toll road, if the term of the lease exceeds the remaining design life of the asset at the time of the transaction, barring other countervailing factors, the IRS will treat the concessionaire as owner for tax purposes. Tax ownership qualifies the lessee to depreciate the portion of its upfront payment allocated to the tangible physical assets over 15 years for a highway, as opposed to the full term of the lease. ...
>
> Another portion of the upfront payment is allocated to the right to impose and collect tolls [an intangible asset]. This portion of payment is amortized over 15 years on a straight line basis. A third portion of the upfront payment may be treated as pre-paid rent that is amortized over the full term of the lease. (US House of Representatives 2007)

FHWA (2007c) further notes "IRS rules require [in] lease contracts of 50 years or more for the lessee to be considered the effective operating owner, thereby granting the lessee the ability to take depreciation tax credit against the value of the asset." These tax advantages, which amount to a federal subsidy of private infrastructure finance and thus are not a true social benefit (Small 2010), cannot be realized by the tax-exempt public sector. Goldman Sachs (2005) has estimated such tax-depreciation benefits are worth 1.0 to 1.5% of a $1 billion infrastructure concession.

In addition to the above procurement issues involving concession length, there are also public-policy aspects to the matter, as outlined in the preceding chapter. The next section considers various award strategies which include contract duration as a PPP decision factor.

2.4.2. Duration as PPP Competition Factor

The possibility of using concession length as a proposal evaluation factor was employed in the late 1980's and early 1990's in Mexico, "where the franchise procedure awarded concessions to the firm that consented to build the road and operate it for the shortest period. The result was highway tolls as high as $35. Because parallel (although congested) freeways were available, the toll highways had little traffic. The government was pressured into bailing out the franchises (and the banks that lent to them), at a cost of at least $8 billion" (Engel et al. 2002).

A different procurement strategy based on contract length is the two-period concession presented by Ye and Tiong (2003). These procurements specify separate contract lengths for a project's construction and operations phases. If the construction work is completed early, the concessionaire is typically permitted to retain any operational revenues collected before the formal start of the operations phase; these funds can be shared with the contractor as an early-completion incentive. Although this model provides a useful structure for containing PPP construction delays, this issue has not been a significant problem in PPP procurements to date.

Another duration-based award strategy is linked to the steady-state nature of brownfield projects. If a public agency wishes to retain greater control over a roadway's operations at the tradeoff of a lower up-front concession fee, it can specify shorter lease terms and re-bid the concession more frequently, thus encouraging competition and limiting the possibility of long-term PPP monopoly leases. Klein (1998) provides the illustration of Argentina's mandatory re-bidding of electricity-distribution concessions (analogous to brownfield transportation leases) after the first 15 years and subsequently every ten years.

2.4.3. Variable-Length Concessions

A relatively new award strategy is the variable-length concession, which is significant enough to merit a more detailed discussion. These contracts end when certain financial targets are met, such as debt coverage, rate of return, or present value of revenues collected; and the primary advantage of these contracts is the reduction of demand risk for both the public and private sectors. This model is in increasing use in Europe and South America.

Among the first examples of a variable-length concession was the contract for the Queen Elizabeth II toll bridge across the river Thames, which was awarded in 1993 for a "concession period of 20 years or such earlier date as the Contractor accumulates sufficient revenue to exceed the total debt outstanding" (Walsh 2003). In this case, high demand for the project enabled toll revenues to reach that level within ten years, though the developer's recourse in the case of abnormally low traffic demand was apparently minimal.

A common type of variable-length concession is the least present value of revenue (LPVR) auction, which was first used in Chile. There the concession term for the Santiago-Valparaíso-Viña del Mar toll road was limited to 300 months or the point at which toll revenues reached the concessionaire's pre-specified level, whichever occurred sooner. The project was awarded in 1998 to the bidder accepting the least present value of revenue, given a fixed toll structure and discount rate (Matsukawa and Habeck 2007).

The variable-length LPVR structure is championed by Engel et al. (2002) for its elimination of fixed concession lengths, which are inflexible to actual demand. A drawback of LPVR auctions, though, is that they contain little incentive for concessionaires to maintain transportation facilities (e.g., through expeditious pothole repair or snow removal) to minimize demand-reducing deficiencies. Yet this issue can be addressed by contractually-stipulated maintenance standards and inspections (Engel et al. 1997; Engel et al. 2001).

Guasch (2004) notes other disadvantages of the LPVR structure can include complications in arranging financing due to the uncertain concession length, as well as the necessity for the public and private parties to agree on an appropriate discount rate for LPVR calculation. De Rus and Romero (2004) find LPVR pricing does not adequately account for operating costs which are solely duration-dependent and not proportional to traffic demand (e.g., roadway lighting expenses). They recommend the slightly modified least present value of net revenue (LPVNR) model, with a separate bid variable for time-dependent costs, to address this concern.

Mayer (2007) observes these present-value-of-revenue contract structures are much simpler to audit than the debt-based or IRR concessions. Further, an attractive public-policy consideration is the relative ease with which the public sector can change toll rates if circumstances require, since the target revenue total is not affected: the concession length automatically adjusts to the new toll levels (Nombela and de Rus 2004).

Based in part on the success of the earlier LPVR contracts, Spain introduced a new concession law in 2003 which allows modifications to contract durations as well as toll rates based on the relation of the accumulated present value of revenue to pre-defined targets (Vassallo and Gallego 2005). Under these procurements, private-sector offers are evaluated based on the targets they propose. Similarly, Portugal and the UK can adjust concession lengths when private-sector revenues differ significantly from initial projections (FHWA 2008).

2.5. Summary

The above discussion both outlines the function of tolls and concession lengths in PPPs and highlights the strengths and weaknesses of these strategies' implementation in current practice. This array of procurement structures provides an ample toolbox of strategies for aligning PPP contracts to satisfy specific public objectives for road pricing. But because relationships among these elements are often not superficially apparent, the following chapter details a research approach for identifying patterns of contract strategies which meet these goals.

Chapter 3 RESEARCH METHODOLOGY

The foregoing summary of contract strategies presented a wide variety of pricing and duration options for structuring a PPP agreement, and combinations of these elements can be tailored to support diverse public-policy goals as outlined in the opening chapter. Yet the potent role of PPP contract variables in achieving these objectives is not universally understood. Over half the state agencies surveyed in McGraw-Hill's market report (2009), for instance, considered "unacceptable profits by private entities at expense of users" as the largest single factor negatively impacting the use of PPPs. Yet this possibility of excessive private-sector returns can be effectively addressed through appropriate contract structuring, if this objective is prioritized during procurement. To help clarify the relationship of these elements, the central research question emerges: *Given specific policy objectives for road pricing, how should public owners select PPP contract strategies which support these outcomes?*

Following a brief discussion of potential approaches for investigating this question, a research design using qualitative comparative analysis is outlined. The method is explained and applied to a selection of PPP procurements to identify patterns of contract strategies which correspond with specific pricing-related outcomes. A subsequent application chapter illustrates several helpful tools to assist decision-makers in applying these findings to policy and practice.

The use of these tools presumes the PPP delivery method has already been determined as the most appropriate contracting form for a given infrastructure project. As cautioned by Miller (2000), owners must consider the full range of project-delivery options in the planning process, avoiding the temptation to pre-select a specific procurement strategy independent of a facility's characteristics and then forcing the project to fit that method.

The scope of the following investigation is expressly limited to direct-tolled transportation PPPs, thus excluding shadow-tolled facilities and untolled availability-payment projects. The effect of toll charges on drivers' behavior is an important factor in influencing demand for PPP facilities, which in turn affects the achievement of many public-policy objectives for these procurements.

3.1. Selection of Research Method

Taylor et al. (2009) noted research in the construction industry often encounters methodological challenges not present in many other fields. The magnitude and expense of large construction ventures, such as those procured through PPPs, limits the number of projects available for evaluation, and the resulting high-complexity, small-size data sets are difficult to investigate meaningfully using experimental and quantitative methods. Although case-study and interview-based research, on the other hand, can accommodate these issues by enabling analysis of small sample sizes and complex relationships, extensive collection of case data is necessary to enable a thorough understanding of the factors involved. For PPPs, though, such detailed project data are often commercially sensitive and difficult to obtain. Further, qualitative approaches are also susceptible to methodological challenges with rigor and replication, if not carefully applied.

An alternative for construction investigations is the middle-ground option provided by a family of research methods collectively known as qualitative comparative analysis (QCA), which is capable of analyzing both small and large populations. QCA shares aspects of both quantitative and qualitative methods, as reflected by the method’s French name, *Analyse Quali-Quantitative Comparée.* As with the case-study approach, QCA retains a contextual sensitivity to interactions among variables, unlike statistical methods which analyze variables in isolation. Yet QCA also incorporates the systematic analysis and fixed rules characteristic of quantitative methods, thus adding rigor and strengthening its replicability and transparency. Due to its emphasis on case histories and the researcher’s judgment at decision points throughout the process, QCA is considered closer to the qualitative end of the research-methods spectrum (Figure 3-1).

QCA is a relatively new approach, first propounded by sociologist Charles Ragin in 1987, but its principles have since been applied extensively, primarily in the fields of sociology and political science but also in management and economics. Although construction researchers have not yet made substantial use of this method, QCA is attractive for the current study because it relaxes the constraints inherent in purely quantitative or qualitative approaches, as noted above, which complicate the application of these methods to PPP research.

Figure 3-1: Spectrum of Research Methods

The subsequent choice among several variants of QCA depends on the research question and the data available. Ragin's initial formulation of QCA (now also termed *crisp set QCA*, or csQCA) required the conversion of qualitative data into strictly dichotomous variables, with individual characteristics quantified into binary categories as 1 (attribute is present/high) or 0 (absent/low) values. Concerns about the resulting loss of information led to the subsequent development of *multi-value QCA* (mvQCA) and *fuzzy-set QCA* (fsQCA) variants, which respectively accommodate stepped and continuous gradations of non-binary variables, such as cost and time. Each of these approaches has domains for which it is best suited, as indicated in Figure 3-2.

In the current investigation, several of the proposed condition variables—presence or absence of revenue-sharing, for instance—lend themselves well to the binary structure with minimal loss of contextual information, making csQCA potentially an attractive option. Yet other variables, such as economic pricing rationale, are more complex and cannot be labeled simply "present" or "absent." Consequently, mvQCA emerges as a suitable approach for this investigation, since it also easily accommodates binary values where no further detail is needed. This accords with Figure 3-2, which indicates mvQCA preserves greater richness in a data set than does strictly-binary csQCA.

Figure 3-3 provides a summary of QCA's application in this investigation, as described in the following section.

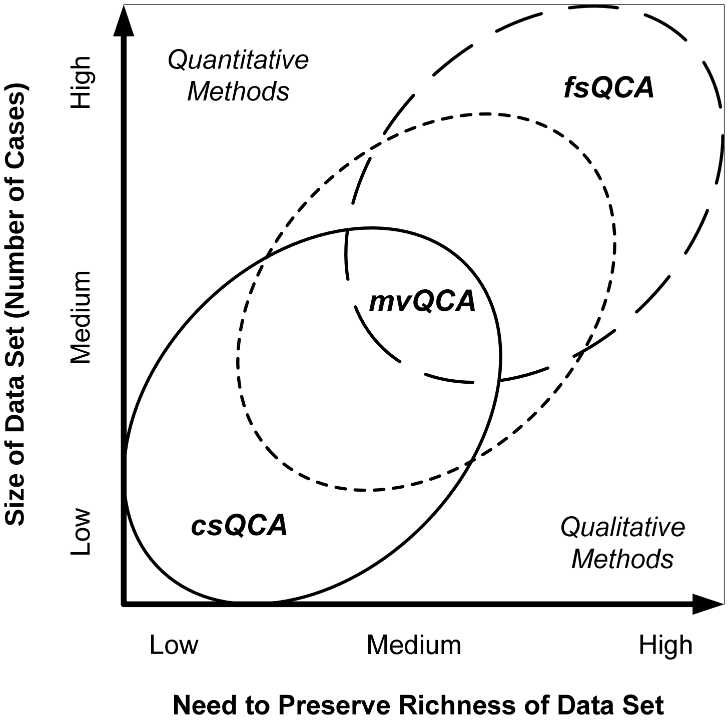


Figure 3-2: Comparison of QCA Methods

from Herrmann and Cronqvist (2009)

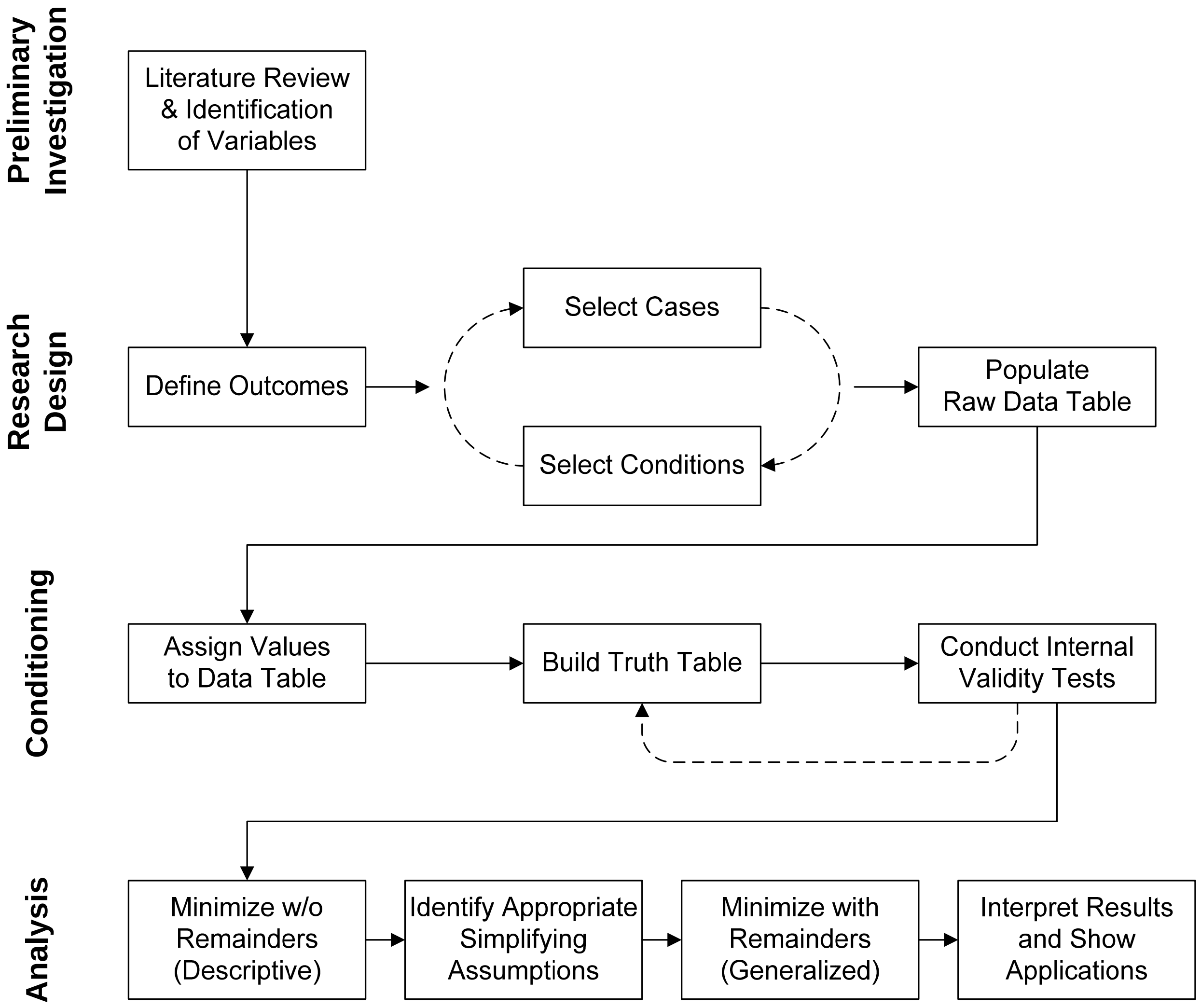
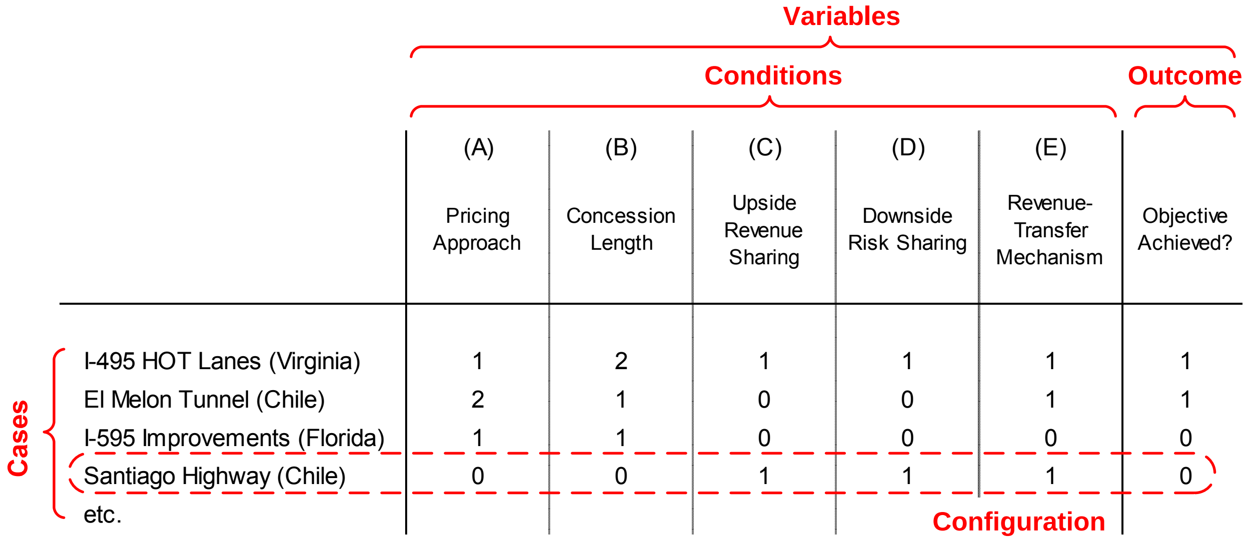


Figure 3-3: Research Structure

3.2. Application of Qualitative Comparative Analysis

In summary, QCA involves identifying a specific outcome of interest, along with conditions which are posited to affect that outcome. The conditions and outcomes for multiple cases are quantified and tabulated, and patterns in the resulting data array are identified to highlight combinations of conditions which support a given outcome.

The application of QCA involves numerous methodological considerations which are addressed below in the context of the central research question. To illustrate the nomenclature used in this discussion, Figure 3-4 provides a sample data table labeled with these terms. For this study, various pricing objectives serve as the QCA outcomes, while PPP contract strategies are the conditions posited to influence these outcomes.



	(A) Pricing Approach	(B) Concession Length	(C) Upside Revenue Sharing	(D) Downside Risk Sharing	(E) Revenue-Transfer Mechanism	Objective Achieved?
I-495 HOT Lanes (Virginia)	1	2	1	1	1	1
El Melon Tunnel (Chile)	2	1	0	0	1	1
I-595 Improvements (Florida)	1	1	0	0	0	0
Santiago Highway (Chile)	0	0	1	1	1	0
etc.						

Figure 3-4: Sample Configuration Table with QCA Nomenclature

3.2.1. Identifying Outcomes of Interest

The first step of the QCA investigation, even prior to case selection, is to define the outcome(s) under consideration. This step facilitates the selection of cases with sufficient representation of each outcome, since the analysis will be less robust if the conditions and outcomes under study exhibit little variation.

This characterization of outcomes is specifically limited to PPP objectives which are related to pricing decisions. Other valid public goals may also be classified as policy objectives, such as delivering facilities which integrate highway and transit, providing access to certain communities, or achieving specific maintenance or safety standards. But since these goals are, at best, modestly related to toll-pricing elements, they cannot effectively be addressed with these contract-strategy tools and are not evaluated here.

Based on a review of academic literature, institutional documents, and individual projects, the following initial set of public objectives for PPPs was identified:

- Minimizing state exposure to traffic risk
- Minimizing state subsidy
- Maximizing up-front revenue
- Achieving a specific toll rate
- Managing congestion

Closer evaluation of these five proposed QCA outcomes indicated the first entry, minimizing state exposure to traffic risk, is not primarily a pricing-related objective. Though it can be influenced by certain contract-structure variables (e.g., absence of downside risk-sharing provisions), this outcome is much more directly controlled by larger-scale procurement decisions, such as the selection of direct tolls instead of availability payments as a PPP's revenue-transfer mechanism. Further, this objective is ultimately more an effect than a cause: efforts to minimize traffic-risk exposure typically support the more fundamental goal of containing a project's impact on the public budget—an objective which is even less affected by contract-specific pricing elements. Based on these conclusions, this initial outcome was removed from further consideration.

Examination of the next two objectives, minimizing state subsidy and maximizing up-front revenue, showed these two are not functionally independent of each other. Because both goals pursue the most favorable result for the state's budget, they incorporate the same contractual strategy: to provide greater latitude in a PPP toll structure's "degrees of freedom" to enable the concessionaire to deliver the most advantageous financial offer. In essence, then, these two outcomes differ only according to the relationship of a project's cost to its anticipated toll revenues, and they were accordingly combined for subsequent evaluation in this study.

The last two proposed objectives, achieving a specific toll rate and managing congestion, were evaluated and found to be both pricing-related and functionally independent. The final list of PPP objectives selected as QCA outcomes was thus as follows:

1. Achieving a specific toll rate
2. Managing congestion
3. Minimizing subsidy or maximizing revenue

Most projects' pricing goals intuitively fall into one of these three categories. For instance, efforts to align the toll rates for a new river crossing with the previous level of charges for ferry service would indicate the first objective above, while a concession awarded on the basis of the highest up-front payment (such as the Chicago Skyway) would correspond to the third objective, since this procurement approach rewards bidders who can implement a procurement's intended toll structure to generate the greatest possible revenue throughout the life of the contract.

To test the validity of this selection, the above outcomes were reviewed with senior public-sector officials who have extensive experience in structuring PPP procurements. They concurred these three objectives accurately characterized the public sector's major pricing goals, noting that the prioritization of these outcomes in practice was often challenging and could easily differ at the federal, state, and local levels.

3.2.2. Selecting Cases

3.2.2.1. Type of Cases

In applying QCA, as noted above, identification of cases exhibiting the greatest possible variety of configurations is desirable. Although the conscious selection of cases with certain conditions and outcomes might appear to be an improper manipulation of the data set, this practice is appropriate under QCA because the method's logic is not probabilistic: that is, it does not consider whether few or many cases exhibit certain characteristics. Of interest is rather the existence at all of specific combinations of contract strategies and objectives. Hence, the identification of cases exhibiting maximum heterogeneity of condition and outcome values contributes to the richest possible explanations of relationships among the widest array of data.

3.2.2.2. Number of Cases

As indicated in Figure 3-2, different QCA variants are more suited to certain data-set sizes. In the process of identifying patterns in the data table, the basic QCA algorithm supplements the observed configurations with hypothetical cases (termed *logical remainders*) in order to fill the data table with configurations representing absent combinations of variables. The greater the number of conditions and possible values, the larger the data space which must be filled, whether by real or hypothetical cases. A csQCA analysis (whose variables can assume only the binary values 0 or 1) involves 2^n total such configurations, where *n* is the number of conditions. For mvQCA, the calculation depends on the number of values possible for each condition: the current study involves two three-value conditions and three two-value conditions, for example, resulting in a data space with 3 × 3 × 2 × 2 × 2 = 72 possible configurations.

Logical remainders are not inherently objectionable, since it is infeasible or impossible to locate cases exhibiting every possible configuration, and the QCA algorithm can produce robust results even with large amounts of "empty data space." Even so, these non-observed cases can contribute to less concise explanations of data patterns, as Berg-Schlosser and De Meur (2009) note:

> The number of possible logical combinations can quickly exceed the number of cases, and the empirically observed cases will occupy only a tiny proportion of the potential "logical space"...This is the *limited diversity* problem: the observed data are far less rich than the potential property space delineated by the conditions. ...In the extreme, only a *description* of the cases—of each separate case—will be obtained, rather than a genuine explanation. (p. 27)

These authors therefore recommend limiting the ratio between the number of conditions and the number of cases. This caution agrees with Figure 3-2's indication of larger data sets for mvQCA and fsQCA studies, which entail larger data spaces due to the additional values permitted for each condition. Although QCA literature avoids rigid definition of data-set sizes, authors have variously suggested "intermediate-N" investigations lie within ranges such as 5-40 or 10-100 cases, with "small-N" and "large-N" data sets being those outside these limits (Berg-Schlosser and De Meur 2009; Ragin and Rihoux 2004). For this study's mvQCA application, the number of cases falls into this intermediate-N range, which is appropriate for the number of conditions selected (see next section). Further, the majority of the mvQCA condition variables selected have binary values, thus also limiting the size of the analytical data space.

Another consideration in determining data-set size is the researcher's ability to maintain close knowledge of cases: "When pondering how many cases you can manage, ask yourself whether you can gain sufficient familiarity (empirical 'intimacy') with each case" (Berg-Schlosser and De Meur 2009). Though data collection for QCA investigations is not as detailed as for case-study analyses, this familiarity—the ability to “dialogue with the cases”—is crucial for selecting explanatory conditions and operationalizing them meaningfully, as well as for identifying any contextually-sensitive adjustments necessary for subsequent iteration.

This study initially identified 18 PPP cases, recognizing the number and identity of cases cannot be rigidly fixed at the outset, since the data-analysis stage may indicate logical inconsistencies in the resulting explanation which must be further probed, in some instances by iteratively adding cases to the analysis.

3.2.3. Selecting Conditions

As noted above, conditions are the variables which distinguish one case from another—in this study, the contract strategies for toll pricing and concession length. Careful consideration is necessary for establishing both the number and identity of conditions in a QCA investigation.

3.2.3.1. Number of Conditions

Although there is no established method for determining an ideal number of QCA conditions, a general principle is that more conditions add complexity to the logic model and can obscure the identification and interpretation of the resulting patterns. Berg-Schlosser and De Meur (2009) offer the following guidance:

> A good balance must be reached between the number of cases and the number of conditions. The ideal balance is not a purely numerical one and will most of the time be found by trial and error. A common practice in an intermediate-N analysis (say, 10 to 40 cases) would be to select from 4 to 6-7 conditions.

Based on this guidance, five conditions are used in this investigation, which involves 18 cases. The initial number of conditions may be adjusted during the analysis process.

3.2.3.2. Identity of Conditions

QCA literature has identified six strategies for selecting initial conditions (Amenta and Poulsen 1994; Yamasaki and Rihoux 2009):

1. The *comprehensive* approach, where the full array of possible factors is considered in an iterative process
2. The *perspective* approach, where a set of conditions representing two or three theories are tested in the same model
3. The *significance* approach, where the conditions are selected on the basis of statistical significance criteria
4. The *second look* approach, where the researcher adds one or several conditions that are considered as important although dismissed in a previous analysis
5. The *conjunctural* approach, where conditions are selected based on joint interactions among theories which predict multiple causal combinations for a certain outcome
6. The *inductive* approach, where conditions are mostly selected on the basis of case knowledge and not on existing theories

This study applied the sixth approach, inductively selecting initial conditions based on prior literature review and case investigations. As with the QCA outcomes, a preliminary list of contract strategies posited to affect public-sector objectives for PPPs was first established:

- Pricing approach
- Concession length
- Revenue-transfer mechanism
- Upside revenue-sharing
- Downside risk-sharing
- Existence of parallel facilities
- Level of congestion
- User tolerance for tolls

The first two conditions were well established in Chapter 2 as significant influences on pricing-related PPP outcomes. But the third proposed QCA condition, the revenue-transfer mechanism, presents an “apples and oranges” comparison: not only does it involve an earlier-stage contract-structuring decision than the other conditions, but some of its values are not applicable to certain values of other variables. For instance, shadow tolling (a revenue-transfer mechanism) and marginal social cost pricing (a pricing approach) are mutually exclusive. For these reasons, this study was restricted to direct-tolled projects, as noted above, and this proposed condition was excluded from further consideration.

The next entries on the list, revenue and risk sharing in the event of a contract's over- or under-performance, are clearly related to a contract's pricing and duration variables; but since they function independently of these decisions, they are appropriate for study as QCA conditions. The final three elements, though, pose a challenge: each addresses a different but important aspect of traffic-demand risk. Although this risk is an external factor in the project environment, not a contract variable, it nevertheless has a substantial impact on PPP contract structure. Further deliberation identified an approach (detailed in Section 3.3) for combining these three elements into a single variable, which was included in the final group of QCA conditions:

1. Pricing approach
2. Concession length
3. Upside revenue-sharing
4. Downside risk-sharing
5. Traffic-demand risk

As with the QCA outcomes, this resulting list of conditions was reviewed with experienced public-sector officials. They agreed these contract strategies, along with the risk environment, are appropriate and highly significant factors influencing the achievement of PPP objectives. In addition, they suggested a reasonable direction in which to expand the study could involve considering specific internal-rate-of-return thresholds for upside revenue-sharing. Although such an investigation would require more detailed contractual data than gathered in the current study, it offers a worthwhile direction for future research.

3.2.4. Assigning Values to Conditions and Outcomes

Table 3-1 represents the final selection of variables for this study, along with the assignment of values for each condition and outcome. Among the reasons the QCA approach is well suited for this investigation is the clearly dichotomous nature of many of the conditions: revenue-sharing provisions, for instance, are either present or absent in a PPP contract. Little information is lost in converting these contract characteristics to binary values. As demonstrated here, mvQCA can accommodate both binary and multi-valued variables simultaneously: the multi-valued PRICING condition is also discrete and clearly defined.

For continuous variables, such as LENGTH and RISK, careful attention (potentially including sensitivity analysis) is necessary in specifying cutoff values to convert continuous data sets to discrete values, since the choice of these thresholds can materially affect QCA results. The 50-year threshold for dividing short and long concession lengths represents one such cutoff value, substantively chosen due to the favored tax treatment of US concessions longer than 50 years. The RISK traffic-demand variable, which represents a crucial incorporation of external project factors influencing PPP demand risk, is addressed in detail in Section 3.3.

Conditions	**Variable Name**	**Meaning**	**Value**
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 to 2.2)	0
		High risk (Index = 2.3 to 5.0)	1

Outcomes	**Variable Name**	**Meaning**	**Value**
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

Table 3-1: mvQCA Variables (Conditions and Outcome) and Values

3.2.5. Constructing and Reviewing the Data Table

Once the QCA outcomes, conditions, values, and cases are established, case data are tabulated for each objective under study, resulting in a configuration table such as that shown previously in Figure 3-4. (For csQCA studies with their binary variables, this same array is termed a *truth table*.) Numerical values are assigned to the conditions and outcome for each case, according to the classifications in Table 3-1. For outcomes, the zero value ("objective not achieved") does not indicate a failure of the PPP procurement represented or of its component contract strategies, but rather serves as a neutral statement of fact that a certain outcome did not occur with the strategies under consideration.

One logic issue which may become apparent at this point is that of contradictory configurations—cases for which all condition values are identical, but whose outcomes are different. Such cases must be addressed before proceeding with the analysis, for instance by adding or replacing conditions, reconsidering the scope of the outcome variable, or examining whether the conflicting cases should indeed be classed within the same population (Rihoux and De Meur 2009). Such adjustments are not arbitrary trial-and-error manipulations, but rather must be theoretically or empirically grounded.

Distilling appropriate outcomes, cases, and conditions into a data table is not an insignificant milestone: "Analyzable truth tables are not the starting point of comparative research; rather, they are formed near the end of a long process of case-oriented comparative investigation" (Ragin and Rihoux 2004).

3.2.6. Analysis, Interpretation, and Refinement

Once a contradiction-free configuration table is established, the next step is to condense or minimize the table to highlight patterns of conditions which correspond to the 0 and 1 outcomes. Although this logic process can be performed manually, use of software such as Tosmana (To<u>o</u>l for Sma<u>ll</u>-N Analysis) is recommended. This program's algorithm, which first isolates csQCA or mvQCA configurations with the desired outcome and then seeks the most logically succinct combinations of conditions necessary and sufficient to produce that outcome, is explained in detail by its developer Cronqvist (2007).

This minimization process is performed for each outcome, resulting in logical formulae which summarize patterns in the data. A simple such pattern might be, “PPP Outcome 1 is observed when Conditions 2 and 4 are present, or when Conditions 1 and 4 are present but 3 is absent.” Such an expression is purely descriptive: it preserves maximum richness of the data set but does not extend beyond the bounds of the existing data. For some purposes, these summaries may be entirely appropriate.

It is possible, though, to obtain more concise expressions in subsequent iterations of the analysis by generalizing the observed data to include simplifying assumptions. Based on case knowledge, the researcher may consider which assumptions would be appropriate and include logical remainders (non-observed cases) in the analysis along with the observed data. This step typically results in a more succinct expression of data patterns and offers further insights into the phenomena under study.

This step of adding hypothetical data to the analysis is not initially intuitive and merits additional explanation. De Meur et al. (2009) characterize such generalization as a necessary element of any research method:

> To be qualified as “scientific,” research must go beyond the mere description of observed phenomena. It must contain a complementary step: *inference,* not in the narrow, statistical sense, but in its more general meaning—moving beyond observed data, to that which is not directly observed. ... Any generalization necessitates going beyond the observed cases and therefore—necessarily—the use of some form of non-observed cases. This is often done unconsciously or at least without being made explicit in many different types of research.

Ragin (1987) regards QCA’s explicit acknowledgement of such non-observed cases as a strength of the method: “Direct consideration of combinations of causal conditions that do not exist in the data...forces the investigator to confront the theoretical assumptions that permit more general causal statements.” From the more immediate standpoint of data analysis, De Meur et al. (2009) offer further reassurance: “Logical remainders that receive an outcome value and subsequently become simplifying assumptions are, structurally, *never in contradiction* with the observed cases. In other words, the inclusion of the logical remainders does not change anything about the properties of the empirical (observed) cases."

With this guidance for targeted use of simplifying assumptions, the initial contract-strategy patterns are generalized, as appropriate, into *minimal formulae* which represent the core of the proposed decision-making support tool. These patterns "allow the researcher to ask more focused 'causal' questions about ingredients and mechanisms producing (or not) an outcome of interest, with an eye on both within-case narratives and cross-case patterns" (Rihoux and De Meur 2009).

This process of analysis, interpretation, and refinement is repeated independently for each of the policy outcomes under consideration. Although a traditional QCA application would also involve repeating the full analysis for each zero outcome ("objective not achieved") to identify strategy patterns tending *not* to support each public-policy goal, the practical value of these findings is limited, and the zero-outcome analysis is not performed in this instance.

3.2.7. Application

Not only does QCA yield generalized patterns of contract strategies which support certain outcomes, but it also enables developing a data set or library of procurements corresponding to each QCA configuration. Other PPP projects can be evaluated to establish their QCA condition and outcome values, thus producing configurations of their own which can be compared to the set of existing case studies. Further insights into these additional procurements can be gained not only through the process of determining their QCA values, but also in comparing them to "library projects" with similar configurations, yielding qualitative insights as to how the new projects may develop. Such an application is demonstrated as part of this study.

3.3. Special Discussion of RISK Condition

Of the five condition variables in Table 3-1—Pricing, Length, Upside, Downside, and Risk—the last one is unique in that it does not evaluate a PPP's contractual aspects, but rather considers external characteristics influencing the project's sensitivity to traffic-demand risk. As such, this condition is more complex than the others, and further discussion is merited here.

3.3.1. Project Settings

Exploring PPP cases in the context of QCA's application to the research question indicated that not all projects respond the same way to the same contract strategies. Rather, procurements are influenced by external characteristics which modify how they respond to various toll-pricing and concession-length approaches. To provide a structure for accommodating these project-specific characteristics, the concept of "project settings" was initially defined to measure PPPs according to distinguishing factors, such as the following, identified from review of literature and practice:

Congestion level. This condition addresses whether a roadway typically experiences traffic delays for some portion of the day. Since congestion indicates insufficient supply of transportation capacity, it usually suggests a different set of pricing strategies than for an uncongested facility.

Demand certainty. New facilities, such as greenfield PPPs, offer no historical data to estimate traffic volumes and thus involve significant demand uncertainty. This often results in large risk contingencies when developers' revenues are based on direct tolls.

Parallel facilities. The presence or subsequent construction of a competing free road can seriously impact the revenue of a toll facility.

Capital expenditures. Some PPPs require significant one-time capital outlays for construction of new facilities, while other projects primarily involve costs only for routine operations and maintenance.

User tolerance. In some cases, the toll rate which would otherwise be suitable for a road is infeasible due to users' inability or unwillingness to pay that fee level.

The initial plan envisioned separating the data set of PPP cases into numerous categories representing different values of these project settings, then repeating the QCA procedure for each of these values to characterize projects' varying responses to contract strategies in these different settings. Yet this plan not only complicated the analysis but also decreased the number of cases available for each QCA iteration, reducing the robustness of the method's results. To address these issues, an alternate strategy for accommodating these differentiating factors was identified.

3.3.2. Traffic Risk Index

Because all these above-listed elements are ultimately components of demand risk for a PPP transportation facility, a single metric was proposed instead to accommodate the influence of projects' external characteristics on the performance of contract strategies. This metric, the RISK variable in Table 3-1, is developed from a modified version of the Standard & Poor's traffic risk index: Table 3-2 illustrates the full index, and Table 3-3 represents the condensed version used in this study. The original table was modified to omit decision options, such as tolling strategies and traffic-survey approaches, in order to focus on facility-specific elements (such as the above) which influence demand. The modified table also adds quantitative risk scoring, as proposed by Bain (2009), with the equally-weighted average of each factor's risk level rounded to one decimal place yielding the overall demand-risk score for each PPP case.

The characterization of Table 3-3's risk score as "low" or "high," with the corresponding assignment of the QCA condition variable RISK as 0 or 1, deserves further discussion. As mentioned above, QCA results are sensitive to the threshold-setting strategy for continuous variables such as this, and the development of an appropriate cutoff point between low-risk and high-risk scores is discussed in the following chapter.

<table>
<tr><th>Project Attribute</th><th colspan="2">0</th><th colspan="2">1</th><th colspan="2">2</th><th colspan="2">3</th><th colspan="2">4</th><th colspan="2">5</th><th colspan="2">6</th><th colspan="2">7</th><th colspan="2">8</th><th colspan="2">9</th><th colspan="2">10</th></tr>
<tr><td>Tolling regime</td><td colspan="11">Shadow tolls</td><td colspan="11">User-paid tolls</td></tr>
<tr><td>Tolling culture</td><td colspan="11">Toll roads well established: data on actual use are available</td><td colspan="11">No toll roads in the country, uncertainty over toll acceptance</td></tr>
<tr><td>Tariff escalation</td><td colspan="11">Flexible rate setting/escalation formula; no government approval</td><td colspan="11">All tariff hikes require regulatory approval</td></tr>
<tr><td>Forecast horizon</td><td colspan="11">Near-term forecasts required</td><td colspan="11">Long-term (30+ year) forecasts required</td></tr>
<tr><td rowspan="13">Toll facility details</td><td colspan="11">Facility already open</td><td colspan="11">Facility at the very earliest stages of planning</td></tr>
<tr><td colspan="11">Estuarial crossings</td><td colspan="11">Dense, urban networks</td></tr>
<tr><td colspan="11">Radial corridors into urban areas</td><td colspan="11">Ring roads/beltways around urban areas</td></tr>
<tr><td colspan="11">Extension of existing road</td><td colspan="11">Greenfield site</td></tr>
<tr><td colspan="11">Alignment: strong rationale (including tolling points and intersections)</td><td colspan="11">Confused/unclear road objectives (not where people want to go)</td></tr>
<tr><td colspan="11">Alignment: strong economics</td><td colspan="11">Alignment: strong politics</td></tr>
<tr><td colspan="11">Clear understanding of future highway network</td><td colspan="11">Many options for network extensions exist</td></tr>
<tr><td colspan="11">Stand-alone (single) facility</td><td colspan="11">Reliance on other, proposed highway improvements</td></tr>
<tr><td colspan="11">Highly congested corridor</td><td colspan="11">Limited/no congestion</td></tr>
<tr><td colspan="11">Few competing roads</td><td colspan="11">Many alternative routes</td></tr>
<tr><td colspan="11">Clear competitive advantage</td><td colspan="11">Weak competitive advantage</td></tr>
<tr><td colspan="11">Only highway competition</td><td colspan="11">Multi-modal competition</td></tr>
<tr><td colspan="11">Good, high-capacity connectors</td><td colspan="11">Hurry up and wait</td></tr>
<tr><td rowspan="6">Surveys/data collection</td><td colspan="11">“Active” competition protection (e.g., traffic calming, truck bans)</td><td colspan="11">Autonomous authorities can do what they want</td></tr>
<tr><td colspan="11">Easy to collect (laws exist)</td><td colspan="11">Difficult/dangerous to collect</td></tr>
<tr><td colspan="11">Experienced surveyors</td><td colspan="11">No culture of data collection</td></tr>
<tr><td colspan="11">Up to date</td><td colspan="11">Historical information</td></tr>
<tr><td colspan="11">Locally calibrated parameters</td><td colspan="11">Parameters imported from elsewhere (another country?)</td></tr>
<tr><td colspan="11">Existing zone framework (widely used)</td><td colspan="11">Develop zone framework from scratch</td></tr>
<tr><td rowspan="7">Users: private</td><td colspan="11">Clear market segment(s)</td><td colspan="11">Unclear market segments</td></tr>
<tr><td colspan="11">Few key origins and destinations</td><td colspan="11">Multiple origins and destinations</td></tr>
<tr><td colspan="11">Dominated by single-journey purpose (e.g., commute, airport)</td><td colspan="11">Multiple-journey purposes</td></tr>
<tr><td colspan="11">High-income, time-sensitive market</td><td colspan="11">Average/low-income market</td></tr>
<tr><td colspan="11">Tolls in line with existing facilities</td><td colspan="11">Tolls higher than the norm: extended ramp-up?</td></tr>
<tr><td colspan="11">Simple toll structure</td><td colspan="11">Complex toll structure (local discounts, frequent users, variable pricing, etc.)</td></tr>
<tr><td colspan="11">Flat demand profile (time-of-day, day-of-week, etc.)</td><td colspan="11">Highly seasonal and/or “peaky” demand profile</td></tr>
<tr><td rowspan="4">Users: commercial</td><td colspan="11">Fleet operator pays toll</td><td colspan="11">Owner-driver pays toll</td></tr>
<tr><td colspan="11">Clear time and operating cost savings</td><td colspan="11">Unclear competitive advantage</td></tr>
<tr><td colspan="11">Simple route choice decision making</td><td colspan="11">Complicated route choice decision making</td></tr>
<tr><td colspan="11">Strong compliance with weight restrictions</td><td colspan="11">Overloading of trucks is commonplace</td></tr>
<tr><td rowspan="3">Macro-economics</td><td colspan="11">Strong, stable, diversified local economy</td><td colspan="11">Weak/transitioning local/national economy</td></tr>
<tr><td colspan="11">Strict land-use planning regime</td><td colspan="11">Weak planning controls/enforcement</td></tr>
<tr><td colspan="11">Stable, predictable population growth</td><td colspan="11">Population forecast dependent on many exogenous factors</td></tr>
<tr><td rowspan="2">Traffic growth</td><td colspan="11">Driven by/correlated with existing, established, and predictable factors</td><td colspan="11">Reliance on future factors, new developments, structural changes, etc.</td></tr>
<tr><td colspan="11">High car ownership</td><td colspan="11">Low/growing car ownership</td></tr>
</table>

Table 3-2: Standard & Poor’s Traffic Risk Index
from Bain (2009)

Project Attribute	**Traffic Risk Index**					**Toll Facility**	
	1	2	3	4	5	Risk Score	Comments
Tolling Culture	Toll roads well established: data on actual use are available			No toll roads in the country; uncertainty over toll acceptance			
Toll Facility Details	Estuarial crossings; radial corridors into urban areas			Dense, urban networks; ring roads/beltways around urban areas			
	Extension/expansion of existing road			Greenfield site			
	Stand-alone (single) facility			Reliance on other, proposed highway improvements			
	Highly congested corridor			Limited/no congestion			
	Few competing roads			Many alternative routes			
Users	High-income, time-sensitive market			Average/low-income market			
Traffic Growth	Driven by/correlated with existing factors			Reliance on future growth factors, new developments, etc.			

Sum of Risk Scores: ...

Average Risk Score: ... ➔ Low/High Risk

Table 3-3: Risk Worksheet with Modified Traffic Risk Index

based on Bain (2009)

Chapter 4 ANALYSIS AND RESULTS

Building on the framework established in the previous chapter, the analysis now investigates the relationship of contract strategies and public objectives based on patterns drawn from 18 cases. These represent 16 projects, two of which were re-procured and thus were included in the data set twice. They cover a wide array of PPP delivery strategies and span eight countries on four continents, as shown in Figure 4-1.

The cases were limited to projects for which tolls were charged directly to users (excluding shadow-toll and some availability-payment contracts) and for which the public sector targeted at least one pricing-related outcome (excluding PPPs such as Canada's Golden Ears Bridge, a design-build-finance-operate contract in which the state retained revenue risk and emphasized a functional outcome—providing a fixed link between two riverside communities—rather than a pricing-related goal).

The analysis presented in this chapter was carried out using Tosmana software version 1.3, produced by mvQCA developer Lasse Cronqvist and available as freeware from www.tosmana.net.

4.1. Data Collection and Conditioning

Table 4-1 provides a brief overview of the 18 case studies. Additional detail is given in Appendix C, which outlines each project's background in relation to contract strategies and includes a table of the corresponding values for each QCA condition variable. Although the RISK variable for traffic demand is included in these summaries, its calculation is detailed separately in Appendix D's worksheets (see also Table 3-3) due to this variable's complexity. Table 3-1 describes the operationalization of the condition and outcome variables, linking their numerical values with specific contract strategies and public objectives. The qualitative facts representing case conditions and outcomes were converted to quantitative QCA values through application of the rubrics in Appendix B.

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(map template)

Figure 4-1: Map of Case-Study Locations

Project	Location	Year of Contract	ID	Description
Route 460 Corridor Improvements	USA (Virginia)	--	ROUTE460	Proposed new highway with parallel free route; procurement terminated 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.

Table 4-1: Overview of Project Cases

Table 4-2 summarizes the resulting values of these conditions and outcomes, with conditions (contract strategies) tabulated in the first five numerical columns, followed by data for the three outcomes under investigation. As the sole continuous variable, RISK is recorded in the raw data table as the risk index calculated in Appendix D and is subsequently converted into dichotomous QCA values with the aid of Tosmana's threshold setter.

ID	PRICING	LENGTH	UPSIDE	DOWNSIDE	RISK	TOLLRATE	FREEFLOW	MINMAX
ROUTE460	2	0	1	0	3.4	0	0	1
I-595	1	1	0	0	1.3	0	1	0
I-495	1	2	1	1	1.8	0	1	0
SKYWAY	2	2	0	0	1.8	0	0	1
SR91	1	1	1	0	1.4	0	1	0
SH121	1	2	1	1	1.4	1	1	0
WARNOW1	0	1	0	0	3.4	1	0	0
WARNOW2	2	2	0	0	2.6	1	0	1
HERREN	0	1	0	0	3.0	0	0	1
SKYE	0	0	0	1	2.4	1	0	0
LISBON	0	0	0	0	1.6	1	0	0
MADRID	0	1	0	0	2.1	1	0	0
ELMELON	2	1	1	0	2.8	0	0	1
SANTIAGO	2	0	0	1	1.3	1	0	0
407ETR1	1	1	0	0	2.9	0	1	0
407ETR2	2	2	0	0	1.9	0	1	1
CONFED	0	1	0	1	2.4	1	0	0
CROSCITY	2	1	0	0	3.0	0	0	1

Table 4-2: QCA Raw Data Table

The only difference between this raw data table and the final configuration table is in the RISK variable. The project evaluations in Appendix D yielded numeric scores on a scale of 1 (low traffic-demand risk) to 5 (high risk), but it was necessary to convert these scores to dichotomous values prior to the QCA investigation. To aid in setting a meaningful threshold between low-risk (RISK = 0) and high-risk (RISK = 1) projects, the raw data values (risk scores) were plotted for the 18 projects using Tosmana's threshold-setter function, as shown in Figure 4-2.

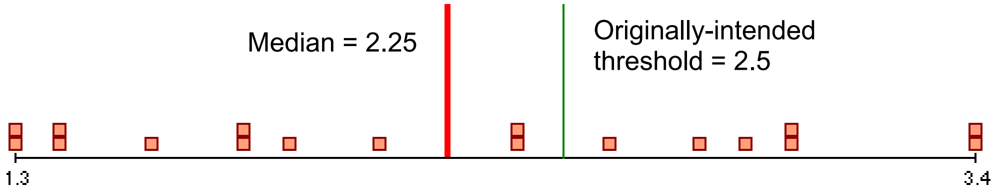

Figure 4-2: Distribution of Project Risk Scores

Although the threshold between low- and high-risk projects was originally anticipated at 2.5, an estimated midpoint in the data array, the plot of project risk scores indicated the median of 2.25 as a more reasonable threshold: not simply because half the points fell on either side, but also because this limit corresponded to a wider natural gap in the existing data set. Hence projects with risk scores of 2.2 or lower were assigned a RISK value of 0, while those with scores 2.3 and above were classed with a RISK value of 1, resulting in the QCA configurations in Table 4-3. A subsequent sensitivity analysis was performed to consider alternate threshold values.

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	1	0	0 ***A***	1	0
SKYWAY	2	2	0	0	0	0	0 ***B***	1
SR91	1	1	1	0	0	0	1	0
SH121	1	2	1	1	0	1 ***A***	1	0
WARNOW1	0	1	0	0	1	1 ***C***	0	0 ***C***
WARNOW2	2	2	0	0	1	1	0	1
HERREN	0	1	0	0	1	0 ***C***	0	1 ***C***
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	1 ***B***	1
CONFED	0	1	0	1	1	1	0	0
CROSCITY	2	1	0	0	1	0	0	1

Table 4-3: Preliminary QCA Configuration Table
(contradictory configurations highlighted)

4.2. Internal Validity Testing

4.2.1. Intermediate QCA Tests

Development of the QCA configuration table, a milestone in the study, enabled an intermediate quality check to help ensure the robustness of the subsequent analysis. The criteria proposed by Rihoux and De Meur (2009) were evaluated through a brief scan of the table:

1. Ensure more-than-minimal representation of both positive and negative outcomes.
2. Avoid counterintuitive configurations (e.g., cases in which all causal conditions are absent but the specified outcome is present).
3. Ensure cross-condition diversity (i.e., that condition pairs do not display the same values across all cases).
4. Ensure sufficient variation for each condition: "a variable must vary." A general rule is that each dichotomous value should appear in at least one third of the cases.

The above table satisfied these criteria well,[7] underscoring the previously-noted importance of selecting cases deliberately to achieve maximum diversity. Projects with identical values across all QCA variables—a situation encountered in pilot testing for this study—yield no additional benefit in the analysis, which seeks to examine the range of as many combinations as possible.

Despite the table's robust level of variation, a preliminary inspection also revealed three pairs of contradictory configurations. These were projects with identical condition values but dissimilar outcomes, such as the I-495 and SH-121 cases (highlighted as ***A*** above), which shared the same condition values but differed in their TOLLRATE outcome. Similarly, the Chicago Skyway and second 407 Express Toll Route contract (pair ***B***) were identical except for varying FREEFLOW outcomes; the initial Warnow Tunnel procurement and the Herren Tunnel project (pair ***C***) also agreed in all their condition and outcome values except for TOLLRATE and MINMAX.

Such contradictory configurations, although a frequent occurrence in QCA studies, pose a logic problem for the analysis, which requires each combination of conditions to correspond to a unique outcome. Identical sets of conditions linked to different outcomes may indicate several

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[7] The zero-value conditions and positive outcome for the LISBON project do not conflict with Criterion 2, since the null values for the PRICING and LENGTH conditions represent types of contract strategies, not their absence.

issues: (a) errors in operationalizing the variables, (b) an insufficiently defined outcome, (c) a lack of suitably descriptive conditions, or (d) the inclusion of a case which does not fit in the same population as the others. As noted previously, solutions for contradictory configurations include re-evaluating the cases and correcting inaccurately-coded variables, refining outcome definitions, adding or modifying conditions to help differentiate the cases, or dropping one of the conflicting cases from the analysis altogether.

For the contradictions above, the operationalization of variables was first re-evaluated. Although both I-495 and SH-121 had identical configurations and included the FREEFLOW = 1 outcome, a conflict resulted from SH-121's additional outcome of TOLLRATE = 1 due to the specific toll charges incorporated in the project's concession agreement. One element which stood out upon reviewing the projects' variables was the asymmetry of I-495's upside and downside provisions: although the upside revenue-sharing clause was based on the concessionaire's overall rate of return, the downside protection was quite limited, covering only a specific revenue-shortfall scenario (high usage by toll-exempt high-occupancy vehicles). In recognition of the functionally limited protection provided by this clause, especially in contrast to the much broader downside coverage of other projects for which DOWNSIDE was coded as 1, I-495's DOWNSIDE variable was re-coded to zero, thus resolving the contradiction with SH-121.

The configurational conflict between the Chicago Skyway and second 407 ETR procurement was next addressed. These projects exhibited the same condition values and the same outcome on the revenue-maximizing variable (MINMAX = 1), but the 407 ETR also listed an additional pricing outcome of throughput maximization (FREEFLOW = 1). Although the 407 ETR contract did include requirements for setting tolls to manage congestion (see project description in Appendix C), substantial similarities exist between throughput-maximizing and revenue-maximizing pricing strategies. Since both are based on users' elasticity of demand, a project which maximizes revenue is necessarily also controlling congestion. Closer examination of the contract's structure (notably its long concession term and unlimited upside) indicated the state considered congestion management a desirable but lesser goal relative to revenue maximization, and the FREEFLOW variable was accordingly re-coded as zero. This resulted in fully identical configurations for both the Skyway and 407 ETR contracts. This is intuitively reasonable: both projects were long-term brownfield operating leases for which the public sector sought to obtain the maximum up-front payment.

Finally, the conflicting configuration for the Herren and Warnow Tunnels was considered. It was found that PRICING for the Herren Tunnel should have been coded as 2 instead of 0: even though the facility's initial toll rate was primarily intended to cover the concessionaire's costs (PRICING = 0), the charge was almost immediately increased to revenue-maximizing levels (PRICING = 2), as permitted by the contract. Re-coding this variable eliminated the contradiction but gave the Herren Tunnel the same QCA configuration as the Cross City Tunnel, which is intuitively reasonable in retrospect, given the considerable similarities in the projects' development and traffic-demand history. Nevertheless, like the Skyway/ETR 407 re-coding, this change also decreased the variation in the data pool, leaving 16 distinct project configurations and two duplicate configurations, which are retained in the modified conflict-free QCA table (Table 4-4).

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

Table 4-4: Final QCA Configuration Table
(changes highlighted)

4.2.2. Inter-Rater Reliability Test

To ensure the assignment of values to the QCA variables was indeed robust and replicable, an inter-rater reliability test was conducted to evaluate the rubric used for converting qualitative project data to quantitative form. Through independent raters' review and feedback, the initial rubric was iteratively refined and re-tested, with the final version as shown in Appendix B.

For this purpose, eight of the 18 project cases were evaluated in three sets, as follows:

1. I-495 HOT Lanes } Set 1
2. Skye Bridge
3. Route 460 } Set 2
4. Second Tagus Crossing
5. El Melon Tunnel
6. 407 ETR – first procurement } Set 3
7. 407 ETR – second procurement
8. Cross City Tunnel

These eight cases were selected based on the following factors:

(a) their geographical coverage (projects from six of the eight countries in the case set are represented);

(b) the fairly good distribution of values: for all variables except DOWNSIDE, each value (for each condition and outcome) appeared at least twice; and

(c) the availability of English-language source documents for the raters' use.

The initial rubric was provided to the reviewers, along with the same project documentation as used for the QCA scoring above. These raters were then asked to evaluate these documents according to the rubric and assign values to the five conditions and three outcomes using the scoring worksheet given at the end of Appendix B. Their scores were subsequently compared to the values above, and the reviewers were queried for their rationale in assigning these scores; this feedback provided guidance for clarifying and expanding on the initial rubric. Following the review of Set 1, the process was repeated for Set 2 and then Set 3 projects, applying the iteratively refined rubric each time.

Two raters independently evaluated the first two case sets. Because their findings after the second iteration were in substantial agreement, a single rater was employed for scoring the third set of projects.

The reviewers' comments identified several areas of the rubric which required refinement. The initial rubric included only a summary explanation of coding the PRICING variable, for instance, obliging the raters to use supplemental literature beyond the rubric and project documents to interpret this variable. Following iterative expansion of the "How to code these elements" field within the PRICING rubric, the Set 3 rater agreed the final description was sufficiently complete to use as standalone guidance.

The correlation of raters' scores with the above QCA values improved with their evaluation of sequential project sets. Although they observed this was due in part to intermediate clarifications of the rubric, they noted a significant portion of this improvement was also due to their increased familiarity with applying the rubric to a greater range of case data as the test progressed. One challenge in particular lay in scoring the eight attributes on the RISK-variable worksheet at first, especially for scaled elements such as "high-income/low-income market." Without experience in scoring projects at varying points along such a spectrum, the raters noted initial difficulty in calibrating their evaluations of project data. As the raters gained experience throughout the test, their RISK scores increasingly converged on the worksheet values in Appendix D.

For the RISK-variable worksheet, which was scored on a scale of 1 to 5, raters' values within one unit of the Appendix D worksheet values were considered functionally equivalent. For the QCA variables (scored as 0, 1, and in some cases 2), exact correspondence was targeted. By the completion of the Set 3 project evaluation, the rater's scores were in close agreement with those presented in this work, substantiating the relative robustness of the final QCA rubric as presented in Appendix B.

4.3. Minimization of the Data Table

With a tested and conflict-free data table established, the next step was to distill from it patterns which link recurring condition values, or groups of values, to each of the three outcomes. This process was carried out by Boolean minimization, a procedure which reduces or summarizes the data table into "prime implicants"—combinations of condition values which are necessary and sufficient to produce the outcome under consideration. As expressed by Ragin (1987), "If two Boolean expressions [or mvQCA configurations] differ in only one causal condition yet produce the same outcome, then the causal condition that distinguishes the two expressions can be considered irrelevant and can be removed to create a simpler, combined expression." The algorithm, which is automated by the Tosmana software, essentially asks: Which conditions are always present when a certain outcome is achieved? Does that outcome always occur when a certain condition is present by itself, or only when that condition is simultaneously present with others?

To answer these questions, the minimization process can either use solely the existing cases to achieve a descriptive summary of the data set, or it can supplement these observed cases with consistent but non-observed cases to enable more concise generalizations about the phenomena at hand. The methodological validity of these hypothetical cases, or "logical remainders," was addressed previously, and the quantity of such cases in an analysis depends on the number of conditions and condition values.

For this investigation, the array of conditions in Table 4-4 corresponded to a logical "data space" with 72 configurations (3 × 3 × 2 × 2 × 2, the product of possible values for each of these five conditions). With 16 distinct observed cases, the analysis thus incorporated a large amount of unfilled data space, as is common in QCA investigations: it is highly unlikely that actual cases representing all, or even most, possible configurations can be observed.[8] Yet the analysis of 16 cases with five conditions was well within the accepted range of QCA research designs, as outlined in the previous chapter.

For each outcome, the analysis examined both the descriptive data-set summaries and the more concise solutions including the non-observed cases necessary to generalize the QCA relationships.

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[8] A common political-science application of QCA involves comparing international characteristics to identify contributing factors to social or political developments. The number of cases available for such a study of (say) Latin American or European phenomena is undeniably limited by the number of countries in these regions.

4.4. Results

The data minimization process was performed twice, both excluding and including logical remainders, for the three separate outcomes under consideration. (Sample Tosmana analysis menus, as well as the complete output, are provided in Appendix E.) As might be anticipated, the solutions with remainders were considerably more succinct than those without; these combinations are interpreted and discussed in the following section.

The first row in each output table below indicates the QCA solution, with each cell in this row containing a prime implicant—the most concise expression able to explain the case(s) in the row beneath. As is standard practice for QCA output, the results are given in Boolean notation, in which addition represents OR and multiplication represents AND. For instance:

Expression:	PRICING{0} + DOWNSIDE{1} + LENGTH{2} RISK{1}
Translation:	PRICING = 0 or DOWNSIDE = 1 or (LENGTH = 2 and RISK = 1)
Interpretation:	Either average-cost pricing is used, or downside-risk protection is present, or a concession 50 years or longer exists with high traffic-demand risk.

4.4.1. TOLLRATE Outcome: Achieving Specific Toll Levels

The effort to identify patterns of contract strategies which correspond to the TOLLRATE = 1 outcome (achieving specific toll rates) produces an extremely unwieldy expression if these patterns are sought only from existing data, without considering supplemental cases. One indicator of the strength of a prime implicant is the number of cases it can explain, yet the implicants in Table 4-5 below are barely useful in defining cross-case patterns: all but the first two can explain only a single case. Further, the last five expressions contain as many terms as there are conditions in the analysis, indicating no summarization or reduction was possible. In fact, these expressions are identical to the configurations in the original data table.

Expression (from Tosmana output):	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}
Cases explained by this expression:	(WARNOW1+ CONFED)	(WARNOW1+ MADRID)	(SH121)	(WARNOW2)	(SKYE)	(LISBON)	(SANTIAGO)

Table 4-5: Analysis of TOLLRATE = 1 (without remainders)

When non-observed cases are included in the TOLLRATE = 1 analysis, the solution is much more concise, and each implicant except the last is able to explain multiple cases (Table 4-6). To avoid the "black box" pitfall of adopting such a tidy solution without acknowledging its underlying logic, though, it is crucial to understand the substantial generalizations involved. Sheet 1B in Appendix E lists the 44 hypothetical cases, or simplifying assumptions, which were necessary to enable this summary. Although this number is relatively large, it does not invalidate the summary, but such a quantity of hypothetical cases indicates the pattern is not as strong as the succinct expression below might indicate.

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

Table 4-6: Analysis of TOLLRATE = 1 (with remainders)

4.4.2. FREEFLOW Outcome: Maximizing Throughput

The FREEFLOW = 1 minimization based on existing case data (Table 4-7) is far more concise than that that for the previous TOLLRATE outcome. Each implicant is capable of explaining multiple cases and has fewer terms than the number of conditions in the analysis. In addition, each shares the PRICING = 1 element; several other conditions also appear in two of these three implicants, indicating a more meaningful level of summarization.

Expression:	PRICING{1} * LENGTH{1} * DOWNSIDE{0} * RISK{0} +	PRICING{1} * LENGTH{1} * UPSIDE{0} * DOWNSIDE{0} +	PRICING{1} * LENGTH{2} * UPSIDE{1} * RISK{0}
Cases Explained:	(I-595+SR91)	(I-595+407ETR1)	(I-495+SH121)

Table 4-7: Analysis of FREEFLOW = 1 (without remainders)

Not only can the FREEFLOW = 1 solution with logical remainders be summarized to a single term (Table 4-8), but Sheet 2B in Appendix E indicates this expression required 19 simplifying assumptions—fewer than half as many as for the TOLLRATE solution.

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

Table 4-8: Analysis of FREEFLOW = 1 (with remainders)

4.4.3. MINMAX Outcome: Minimizing Subsidy or Maximizing Revenue

Without inclusion of hypothetical cases, the MINMAX = 1 minimization (Table 4-9) is able to provide limited summarization of the case data: two of the three terms explain more than one case, though the third implicant simply repeats an entire configuration from the data table.

Expression:	PRICING{2} * LENGTH{2} * UPSIDE{0} * DOWNSIDE{0} +	PRICING{2} * LENGTH{1}* DOWNSIDE{0} * RISK{1} +	PRICING{2} * LENGTH{0} * UPSIDE{1} * DOWNSIDE{0} * RISK{1}
Cases Explained:	(SKYWAY,407ETR2+ WARNOW2)	(HERREN,CROSCITY+ ELMELON)	(ROUTE460)

Table 4-9: Analysis of MINMAX = 1 (without remainders)

The analysis for the MINMAX = 1 outcome, including simplifying assumptions, yields another single-implicant solution (Table 4-10). This generalization requires only 7 logical remainders, as listed on Sheet 3B in Appendix E, indicating a strong pattern in the data.

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

Table 4-10: Analysis of MINMAX = 1 (with remainders)

4.5. Descriptive Metrics and Sensitivity Analysis

Since the conversion of qualitative data into quantitative values can introduce a degree of subjectivity into an investigation, two tests are carried out to validate key elements of the work and strengthen its replicability: an inter-rater reliability test for assigning values to the QCA conditions and outcomes, and a sensitivity analysis on the threshold between 0 and 1 scores for the RISK variable.

4.5.1. Descriptive Metrics

Before these solutions are formally interpreted, a summary evaluation of their "goodness of fit" provides further insights into the applicability of the results. Two quantitative metrics have been established for assessing the level of correspondence between QCA conditions and the outcomes which they are posited to support (Ragin 2006).

The first of these measures, consistency, evaluates a condition's necessity for achieving a particular outcome. Once the conflict-free QCA table is developed, it can be calculated as follows (Rihoux and De Meur 2009):

$$\text{Consistency} = \frac{\text{number of cases for which both a given condition and outcome are present}}{\text{number of cases for which only the outcome is present}}$$

Values close to 1, or ideally at least 0.75, are desirable to indicate a meaningful relationship between conditions and outcomes (Ragin 2006). But because this measure depends on the presence or absence of a condition, it can be applied only to csQCA and fsQCA data, since mvQCA conditions do not necessarily indicate presence or absence of a phenomenon (e.g., PRICING and LENGTH) as in csQCA and fsQCA.

Coverage, the second descriptive metric for evaluating the relationship between conditions and outcomes, is calculated following the development of QCA summary expressions and is valid for all QCA variants. This metric is a practical indicator of the effectiveness or comprehensiveness of each solution term in explaining the outcome:

$$\text{Coverage} = \frac{\text{for a given outcome, number of cases containing a given solution term}}{\text{total number of cases with the given outcome}}$$

Although values closer to 1 denote a solution term which accounts for a greater proportion of cases with a certain outcome, lower coverage values are also helpful in indicating the relative strength of a correlation between contract strategies and PPP objectives. To illustrate this comparison, Table 4-6, Table 4-8, and Table 4-10 are reproduced below with the coverage values calculated for each solution term.

Table 4-6 (TOLLRATE = 1):

Expression:	PRICING{0} +	DOWNSIDE{1} +	LENGTH{2}RISK{1}
Interpretation:	Average cost pricing	Downside risk protection	Concession 50+ years and high traffic-demand risk
Cases Explained:	(WARNOW1+SKYE+LISBON +MADRID+CONFED)	(SH121+SKYE+SANTIAGO +CONFED)	(WARNOW2)
Coverage:	5/8 = 63%	4/8 = 50%	1/8 = 13%

Table 4-8 (FREEFLOW = 1):

Expression:	PRICING{1}
Interpretation:	Marginal social cost pricing
Cases Explained:	(I-595+I-495+SR91+SH121+407ETR1)
Coverage:	5/5 = 100%

Table 4-10 (MINMAX = 1):

Expression:	PRICING{2}DOWNSIDE{0}
Interpretation:	Revenue-maximizing pricing with no downside-risk protection
Cases Explained:	(ROUTE460+SKYWAY,407ETR2+WARNOW2+HERREN,CROSCITY+ELMELON)
Coverage:	5/5 = 100%

These coverage values simply indicate, for each outcome, the proportion of projects which contain a given expression. Although the high coverage values for the FREEFLOW and MINMAX outcomes indicate a strong relationship between these QCA expressions and their respective outcomes, smaller coverage values (such as for the TOLLRATE outcome) do not signify inferior QCA solutions. Rather, the coverage metric is especially valuable in these situations to show the relative explanatory strength of each sub-expression, since these could otherwise appear on equal footing with each other. Although these coverage values were calculated above for primary QCA solutions, the metric is also useful for evaluating and comparing the relative explanatory ability of expressions in non-primary solutions, such as those given in Table 4-5, Table 4-7, and Table 4-9.

4.5.2. Sensitivity Analysis

As noted above, the initial threshold separating low- and high-traffic-risk projects was taken as 2.25, the median value of the RISK scores in this data set. For the sensitivity analysis, two additional threshold scenarios were considered, as shown in Figure 4-3.

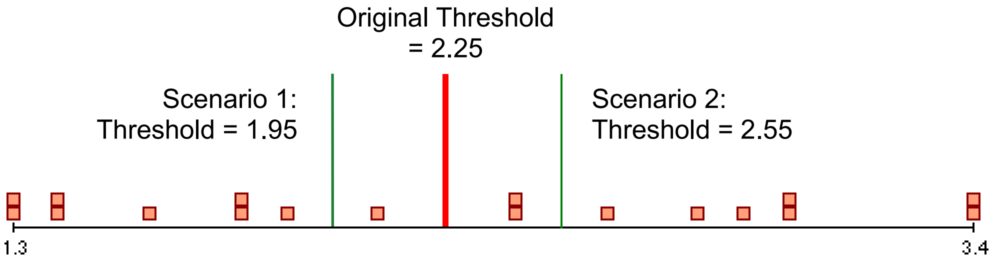


Figure 4-3: RISK Thresholds for Sensitivity Analysis

4.5.2.1. Scenario 1: Threshold = 1.95

Under the first scenario, projects with an overall risk score of 1.9 or less were classed as RISK = 0 (low traffic risk), and those scoring 2.0 or above were categorized as RISK = 1 (high risk). As Figure 4-3 indicates, only one project was affected by moving the threshold leftward from its original position. This case was the Autopista M-12, Madrid's airport-access road, whose risk-worksheet score was calculated at 2.1. The new QCA configuration became as follows:

ID	PRICING	LENGTH	UPSIDE	DOWNSIDE	RISK	TOLLRATE	FREEFLOW	MINMAX
MADRID	0	1	0	0	0 → 1	1	0	0

This change in the RISK variable transformed the Madrid project into the same 0 / 1 / 0 / 0 / 1 → 1 / 0 / 0 configuration as the first Warnow Tunnel procurement. Since this Warnow Tunnel configuration had already been considered in the preceding QCA investigation, Scenario 1 of the sensitivity analysis produced no new information for evaluating the TOLLRATE = 1 outcome. Relative to the original Table 4-5 expression (reproduced below for comparison), the removal of the previous Madrid configuration from the analysis eliminated one of the seven terms in the solution (Table 4-11), although this change has minimal practical impact.

Expression (from Tosmana output):	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}
Cases explained by this expression:	(WARNOW1+ CONFED)	(WARNOW1+ MADRID)	(SH121)	(WARNOW2)	(SKYE)	(LISBON)	(SANTIAGO)

Table 4-5: Original Analysis of TOLLRATE = 1 (without remainders)

Expression (from Tosmana output):	PRICING{0} * LENGTH{1} * UPSIDE{0} * RISK{1} +	x	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}
Cases explained by this expression:	(WARNOW1, MADRID+ CONFED)	x	(SH121)	(WARNOW2)	(SKYE)	(LISBON)	(SANTIAGO)

Table 4-11: Revised Analysis of TOLLRATE = 1 (without remainders)

The sensitivity analysis also yielded no impact on the TOLLRATE = 1 solution with remainders, though it now involved 45 simplifying assumptions instead of 44.

Of secondary note in this scenario is the curiosity that a slight adjustment of the RISK threshold should give a promising facility such as the Madrid airport road the same configuration as the Warnow Tunnel, a project which significantly underperformed initial traffic expectations and had its contract renegotiated after only three years. Initial project documents (and the road's Spanish name, Eje Aeropuerto) emphasized the facility's role as the primary access road to a new airport terminal, a situation which would improve its traffic demand and which contributed to favorable scoring in the risk worksheet. But subsequent evaluation of original-language M-12 reports indicated the project was not nearly as promising as these factors had indicated: much of the road's forecast traffic volume was based on its location as an outer-beltway option around Madrid, even though the alternate routes were untolled. Initial traffic was less than 40% of the projected volume and remained sluggish; similar to the Warnow Tunnel procurement, the M-12 concessionaire requested rebalancing of the contract after only three years of operation.

Although re-evaluation of the Madrid project was not an anticipated outcome of this review, the robustness of the analysis is nevertheless underscored by the minimal resulting impact on the QCA findings from even a project for which incomplete information initially led to an overly-optimistic risk score.

4.5.2.2. Scenario 2: Threshold = 2.55

Under the second scenario for the sensitivity analysis, projects with an overall risk score of 2.5 or less were categorized as RISK = 0 (low risk), and those scoring 2.6 or above were classed as RISK = 1 (high risk). The two projects affected by this rightward shift of the threshold (see Figure 4-3) were the Confederation Bridge and Skye Bridge, both with risk scores of 2.4.
Their new QCA configurations became as follows:

ID	PRICING	LENGTH	UPSIDE	DOWNSIDE	RISK	TOLLRATE	FREEFLOW	MINMAX
CONFED	0	1	0	1	1 → 0	1	0	0
SKYE	0	0	0	1	1 → 0	1	0	0

Neither of these duplicated existing configurations in the case set. Since these cases both had the same objective of targeting a specific toll level, only the TOLLRATE outcome was considered in evaluating the impact of this revised RISK threshold. Again comparing the TOLLRATE = 1 expression (without remainders) from Table 4-5:

Expression (from Tosmana output):	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}
Cases explained by this expression:	(WARNOW1+CONFED)	(WARNOW1+MADRID)	(SH121)	(WARNOW2)	(SKYE)	(LISBON)	(SANTIAGO)

Table 4-5: Original Analysis of TOLLRATE = 1 (without remainders)

After reclassification of the Confederation Bridge and Skye Bridge risk scores, the total number of component expressions declined from seven to six, and the number of expressions explaining only a single case also decreased from five to three (Table 4-12). As before, this change has little practical impact.

Expression (from Tosmana output):	PRICING{0} * LENGTH{1} * UPSIDE{0} * DOWNSIDE{0} +	PRICING{0} * LENGTH{0} * UPSIDE{0} * RISK{0} +	PRICING{0} * LENGTH{1} * UPSIDE{0} * RISK{0} +	PRICING{1} * LENGTH{2} * UPSIDE{1} * DOWNSIDE{1} * RISK{0} +	PRICING{2} * LENGTH{2} * UPSIDE{0} * DOWNSIDE{0} * RISK{1} +	PRICING{2} * LENGTH{0} * UPSIDE{0} * DOWNSIDE{1} * RISK{0}
Cases explained by this expression:	(WARNOW1+MADRID)	(SKYE+LISBON)	(MADRID+CONFED)	(SH121)	(WARNOW2)	(SANTIAGO)

Table 4-12: Revised Analysis of TOLLRATE = 1 (without remainders)

For the TOLLRATE = 1 solution including logical remainders, this scenario of the sensitivity analysis had no effect, and the number of simplifying assumptions remained unchanged at 44.

In summary, both scenarios of the sensitivity analysis (with alternate RISK thresholds at 1.95 and 2.55) had a slight influence on the expanded solutions omitting simplifying assumptions, and no impact on the generalized solutions. This finding supports the use of the 2.25 median score as a threshold between the RISK = 0 and RISK =1 values in this study. For instances in which an individual project is compared with others in the case library, though, it may still be beneficial to consider the wider range of thresholds if risk-worksheet scores fall between 2.0 and 2.5.

4.6. Interpretation

The next step in a QCA study is to evaluate the concrete meanings of the expressions developed in the analysis above and consider whether these patterns provide meaningful guidance which can be applied to other cases outside the original data set. This step focuses primarily on the outputs which incorporate simplifying assumptions, due to the greater generality and broader applicability of these expressions.

4.6.1. TOLLRATE Outcome: Achieving Specific Toll Levels

With logical remainders, the summarized expression of contract strategies corresponding to the TOLLRATE = 1 outcome is PRICING{0} + DOWNSIDE{1} + LENGTH{2}RISK{1}. This signifies "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 high traffic-demand risk and a concession term 50 years or longer."

These implicants are considered individually whether they seem sensible. The first element, the suitability of average-cost pricing in achieving a specific toll level, is 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. But this element's presence in the TOLLRATE = 1 expression is to be expected and verifies the method can accurately identify contract strategies which correspond to certain outcomes.

The next implicant in the solution, the presence of downside risk-sharing, is 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 is similarly reasonable: when the private sector is 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 contract 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 down-side risk sharing and a longer concession term, as sound options in structuring a PPP agreement.

4.6.2. FREEFLOW Outcome: Maximizing Throughput

The minimized expression for the FREEFLOW = 1 outcome, PRICING = 1, has a fully logical interpretation: “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 less general solution in Table 4-7 above to seek additional patterns in the data. Prior to the inclusion of simplifying assumptions, two of the three implicants in the expression include LENGTH = 1, DOWNSIDE = 0, and RISK = 0.

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 elements 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 he can thus recoup his costs during a shorter concession period than otherwise.

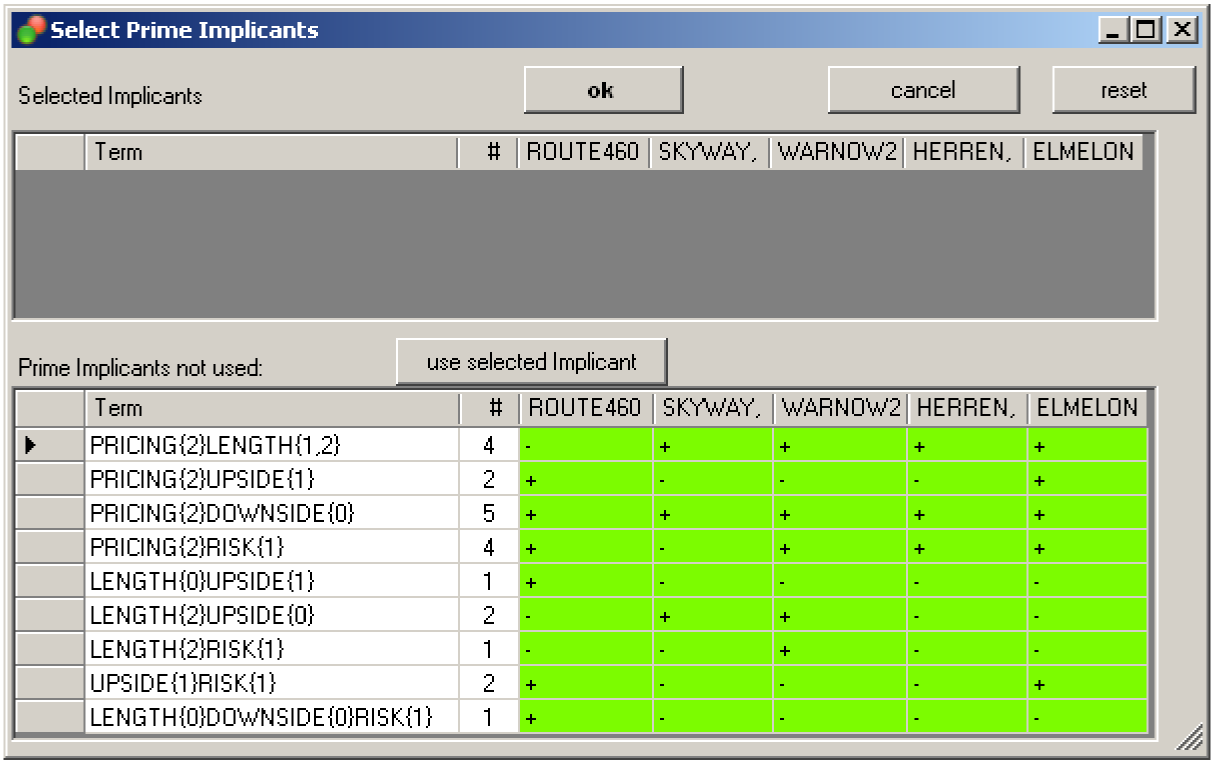
An application of these concepts might include strengthening the public sector’s negotiating position for PPP contracts on facilities for which congestion-control pricing is targeted, in that the established demand reduces the need for long concessions or traffic-risk-sharing provisions.

4.6.3. MINMAX Outcome: Minimizing Subsidy or Maximizing Revenue

As with the previous outcome, the MINMAX = 1 objective produced a succinct QCA solution: "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 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.

The inconclusive guidance from the MINMAX solution allows exploring an additional facet of the QCA evaluation which was not available for the two previous outcomes. The Tosmana analysis automatically selects the most concise expression explaining each set of configurations, and in some cases (such as the TOLLRATE and FREEFLOW analyses), this expression is the only valid summary possible. In other cases, though, additional less-concise solutions are also valid, and the software offers the option to select other combinations of these prime implicants manually.

Such alternative solutions are possible for the MINMAX analysis, whose available prime implicants are shown in Figure 4-4, along with the cases which they explain. It is quickly apparent that the single implicant PRICING{2}DOWNSIDE{0} explains all five configurations. But if less concise expressions are of interest, an alternative result can be manually developed by combining (for instance) the first and fourth rows, which cover all project configurations. The resulting 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 this outcome. As shown in Sheet 3C of Appendix E, these implicants require 12 simplifying assumptions—an indicator that this is not the most concise solution explaining these configurations.



Selected Implicants

	Term	#	ROUTE460	SKYWAY,	WARNOW2	HERREN,	ELMELON

Prime Implicants not used:

	Term	#	ROUTE460	SKYWAY,	WARNOW2	HERREN,	ELMELON
▶	PRICING{2}LENGTH{1,2}	4	-	+	+	+	+
	PRICING{2}UPSIDE{1}	2	+	-	-	-	+
	PRICING{2}DOWNSIDE{0}	5	+	+	+	+	+
	PRICING{2}RISK{1}	4	+	-	+	+	+
	LENGTH{0}UPSIDE{1}	1	+	-	-	-	-
	LENGTH{2}UPSIDE{0}	2	-	+	+	-	-
	LENGTH{2}RISK{1}	1	-	-	+	-	-
	UPSIDE{1}RISK{1}	2	+	-	-	-	+
	LENGTH{0}DOWNSIDE{0}RISK{1}	1	+	-	-	-	-

Figure 4-4: Manual Selection of Prime Implicants

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 pricing 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.

Based on the above analysis and results, the next chapter transitions to the practical application of this research. The QCA expressions established here form one of three decision-support tools developed from this study, and all three approaches are illustrated through application to current PPP procurements.

Chapter 5 APPLICATIONS FOR POLICY AND PRACTICE

The various decision-support elements developed in the course of this study are now applied to demonstrate this work's relevance to policy and practice. This guidance can be distilled into three tools for PPP decision-making: (1) the modified traffic-risk worksheet, which provides a rapid estimate of a toll-financed project's viability; (2) the analytical QCA results, which offer guidance for structuring PPP contracts once the pricing objectives are established or are under consideration; and (3) case-library comparisons, which enable drawing parallels between proposed procurements and established PPP projects.

Each of these three tools is illustrated with respect to current PPP solicitations in Virginia, where contemporary developments have furnished well-suited opportunities to apply this research. The Route 460 and Midtown Tunnel projects, both under procurement as PPPs in mid-2010, are introduced and evaluated below.

5.1. Traffic-Risk Worksheet

The proposed US Route 460 expansion in southeastern Virginia (Figure 5-1) provides an outlet for applying the traffic-risk worksheet which was developed in Chapter 3 and which serves as the basis of the RISK variable. Its initial procurement is one of the case studies in the data set.

5.1.1. Route 460 Project History

As indicated in Figure 5-2, improvements to Route 460 were the focus of state legislation in 2003. The proposed scope involved developing a tolled 55-mile highway parallel to an existing free route which had lower speed, capacity, and safety standards. Since no public funds were available, the project had to support itself through its own revenue stream. The February 2006 solicitation for conceptual proposals drew a cautious private-sector response due to concerns about low demand, particularly through traffic diversion to the free parallel route. Even though the draft concession agreement offered the first US variable-length PPP in an effort to reduce project risk, no responses were received to the December 2008 request for detailed proposals.

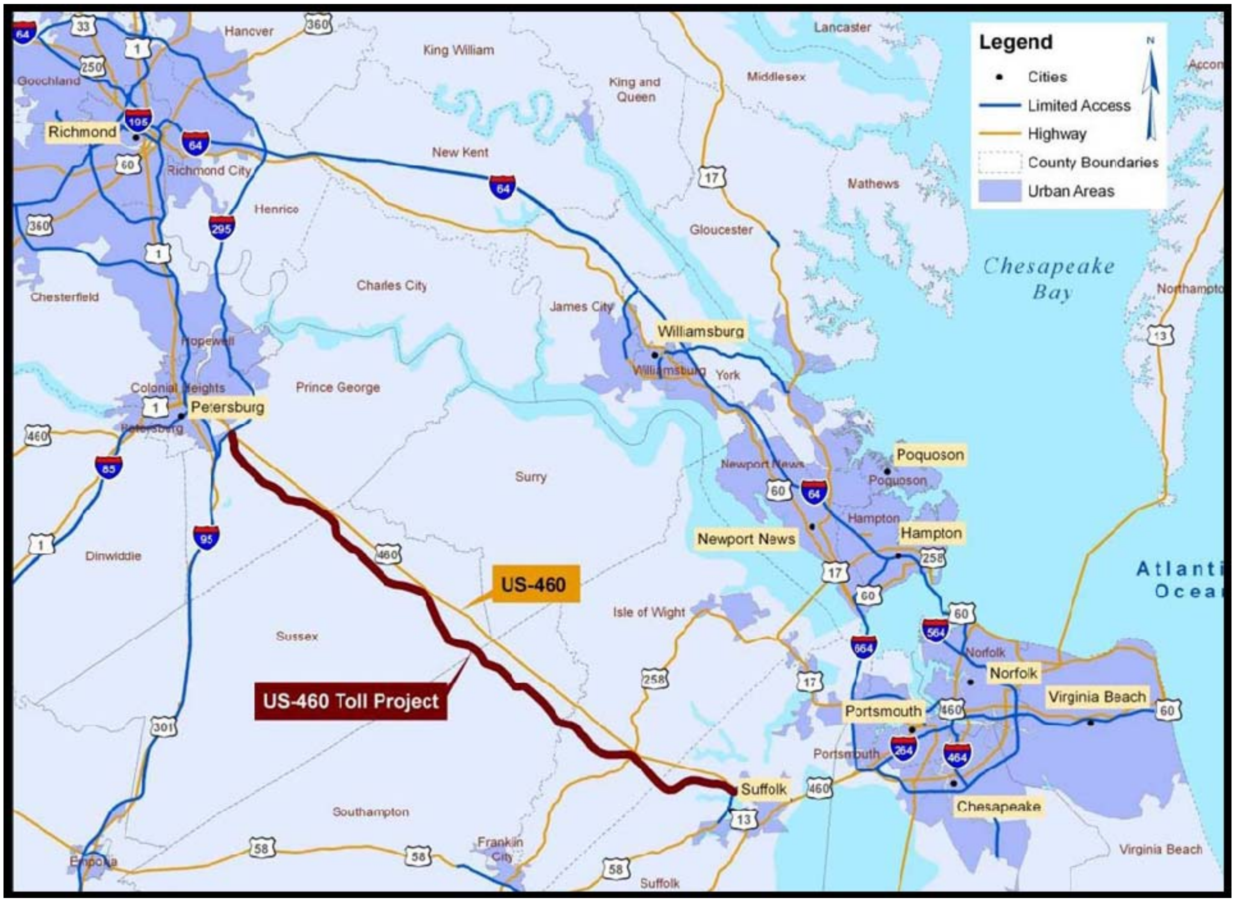


Figure 5-1: Route 460 Location Map
(Source: Virginia Department of Transportation)

2003 – Virginia legislation requires PPP solicitation

Feb 2006 – Solicitation for conceptual proposals

Sep 2006 – Three conceptual proposals submitted

Dec 2008 – Solicitation for detailed proposals

May 2010 – Procurement cancelled; new solicitation
July 2010 – Revision of new solicitation

Figure 5-2: Route 460 Procurement Timeline

Given this lukewarm response, along with changes in the economy, the state terminated the original Route 460 procurement in May 2010 and issued a new solicitation for conceptual proposals.[9] The physical scope of the project remained similar—to develop the 55-mile highway alongside the existing route—but proposers were allowed additional flexibility in structuring financial plans, including the opportunity to incorporate non-toll revenues such as those from commercial development. The concession duration also was changed from a variable length to a fixed length, with a maximum of 75-99 years.

5.1.2. Risk Score

As shown in Table 5-1, an evaluation of the eight elements in the risk-index worksheet indicated none of these attributes had changed significantly under the new procurement: a logical outcome, since the worksheet factors are linked primarily to a facility's physical and demographic characteristics at a given time, not to contract specifics. But the new solicitation's traffic assumptions appeared to rely more heavily on future growth factors, as evidenced by its suggestion (Section 3.1.1.2) that proposers consider potential revenues from new commercial development: "The Comprehensive Agreement will include provisions to address a number of commercial issues, including...support for the development of commercial facilities determined to be essential for the transportation of persons or goods...." The increased uncertainty related to this future development produced a slight uptick in the attribute score for traffic growth, yielding an overall risk index of 3.5—still decisively in the high-risk project category.

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[9] Virginia Department of Transportation. (2010a). Solicitation for Conceptual Proposals: U.S. Route 460 Corridor Improvements Project through the Public-Private Transportation Act (issued May 5, 2010).

<table>
<tr><th rowspan="2"><i>Project Attribute</i></th><th colspan="10">Traffic Risk Index</th><th colspan="3">Route 460 Risk Scores and Comments</th></tr>
<tr><th colspan="2">1</th><th colspan="2">2</th><th colspan="2">3</th><th colspan="2">4</th><th colspan="2">5</th><th>#1</th><th>Comments</th><th>#2</th></tr>
<tr><td><i>Tolling Culture</i></td><td colspan="5">Toll roads well established: data on actual use are available</td><td colspan="5">No toll roads in the country, uncertainty over toll acceptance</td><td>4</td><td>Few tollroads in region; prospect of toll facilities unpopular with majority of drivers</td><td>4</td></tr>
<tr><td rowspan="5"><i>Toll Facility Details</i></td><td colspan="5">Estuarial crossings; radial corridors into urban areas</td><td colspan="5">Dense, urban networks; ring roads/ beltways around urban areas</td><td>1</td><td>Radial connector between Richmond and Hampton Roads metropolitan areas</td><td>1</td></tr>
<tr><td colspan="5">Extension/ expansion of existing road</td><td colspan="5">Greenfield site</td><td>3</td><td>Parallel route to existing road</td><td>3</td></tr>
<tr><td colspan="5">Stand-alone (single) facility</td><td colspan="5">Reliance on other, proposed highway improvements</td><td>1</td><td>Contract to include all necessary connections to existing routes</td><td>1</td></tr>
<tr><td colspan="5">Highly congested corridor</td><td colspan="5">Limited/no congestion</td><td>5</td><td>Existing parallel facility occasionally congested, e.g. at stoplights</td><td>5</td></tr>
<tr><td colspan="5">Few competing roads</td><td colspan="5">Many alternative routes</td><td>5</td><td>Free existing parallel route (460); free interstate alternative (I-64)</td><td>5</td></tr>
<tr><td><i>Users</i></td><td colspan="5">High-income, time-sensitive market</td><td colspan="5">Average/low-income market</td><td>4</td><td>Average-income users; significant commercial/ freight traffic component</td><td>4</td></tr>
<tr><td><i>Traffic Growth</i></td><td colspan="5">Driven by/ correlated with existing factors</td><td colspan="5">Reliance on future growth factors, new developments, etc.</td><td>4</td><td>Relies on future growth of Hampton Roads port/freight traffic
Relies on future commercial development</td><td>5</td></tr>
</table>

Sum of Risk Scores:	27	28

Average Risk Score: 3.4 → High Risk ← 3.5

Table 5-1: Risk Worksheet for Route 460

5.2. Application of QCA Guidance for Structuring Procurements

The second decision-support tool resulting from this research stems from the QCA findings in the previous chapter. These combinations of contract strategies which support specific pricing outcomes can be applied to procurements in development, as illustrated below by Virginia's Midtown Tunnel PPP.

5.2.1. Midtown Tunnel Project History

The Hampton Roads region of southeastern Virginia both benefits and suffers from the numerous waterways crisscrossing 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 two more lanes to the Midtown Tunnel, upgrade the Downtown Tunnel, and construct a freeway extension linking the two (see Figure 5-3 and Figure 5-4). Approval from the Norfolk and Portsmouth city councils was necessary before evaluation could proceed, but Portsmouth voted against the proposed tolls in 1999, scuttling the effort. Five years later, the Virginia Department of Transportation (VDOT) revived the project, requesting expressions of interest from the private sector in 2004 and soliciting conceptual proposals in 2008.

Although an interim agreement was signed with the sole proposer in 2010, 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.

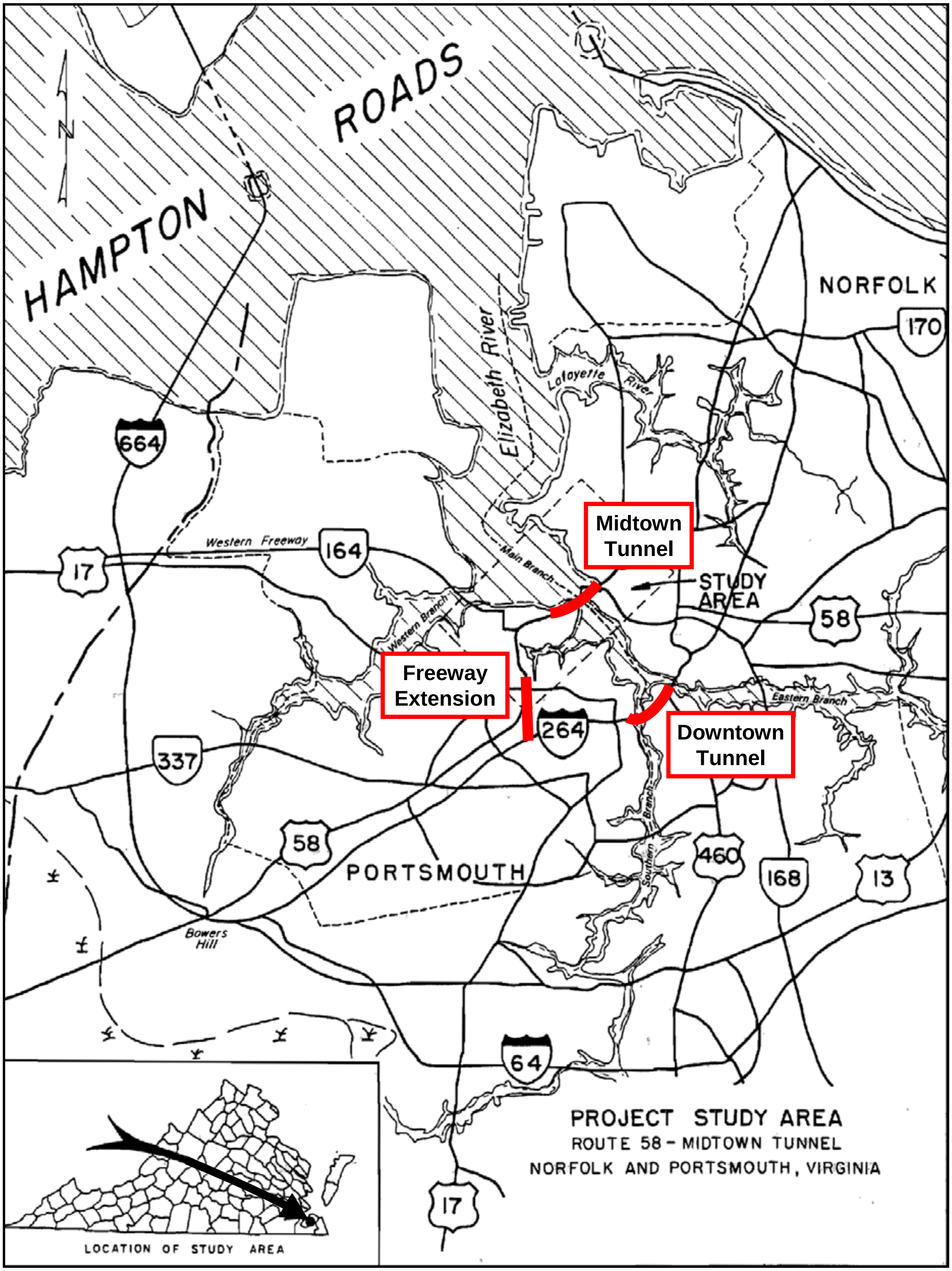

Figure 5-3: Midtown Tunnel Location Map
(Source: Virginia Department of Transportation, 1996 FEIS)

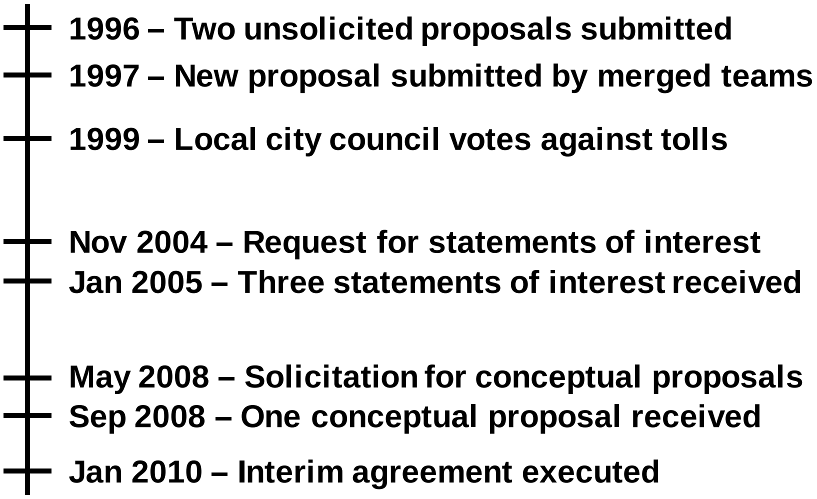

Figure 5-4: Midtown Tunnel Procurement Timeline

5.2.2. 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 structure. 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 (HRPDC 2005) indicated the project, at its then-current scope and estimated costs, would not require a subsidy. 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 FREEFLOW—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 toward relieving (though perhaps not completely eliminating) traffic delays, even without this outcome being specifically prioritized as a pricing goal.

The TOLLRATE objective offered another possibility. Although the 2008 private-sector proposal for this project estimated initial tunnel tolls between $2.00 and $3.00, public officials have promoted a target rate of $1.50 to enable greater affordability for users.[10] The ultimate pricing objective for this procurement remains in flux; this is a by-product of using an interim agreement for a PPP project, since project objectives *and* conditions are typically negotiated through an iterative process between the public and private partners. Current indications, however, suggest that the pricing objective—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.

5.2.3. QCA Recommendations for Contract Structure

Table 4-6 of the QCA study (reproduced below) identified three distinct patterns of contract strategies in the PPP cases which also targeted the 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.

Table 4-6 (TOLLRATE = 1):

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)
Coverage:	5/8 = 63%	4/8 = 50%	1/8 = 13%

For a procurement such as the Midtown Tunnel which may share the TOLLRATE = 1 pricing objective, 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.

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[10] Letter re: "Midtown Tunnel Public-Private Transportation Act (PPTA) Proposal" from Norfolk Mayor Paul Fraim to Virginia Governor Robert McDonnell, July 26, 2010.

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 a different option from the TOLLRATE = 1 solution menu can be chosen. Other procurement scenarios may find the second pattern, provision of downside risk protection, more suitable: this strategy essentially reduces a project's cost by decreasing its risk and can be applied either in conjunction with or separately from average-cost pricing. The third option, in which a PPP having high traffic-demand risk is structured with a long concession term, is not applicable to the Midtown procurement.[11] The traffic-risk worksheet (Table 3-3) yielded a risk score of 1.8 for this project, indicating the Midtown Tunnel falls into the low-risk category.

The percentages in the final row of Table 4-6 indicate what percentage of the TOLLRATE = 1 case population was covered by each pattern, showing the relative frequency of each solution in this data set as additional guidance for comparing contract-strategy options.

In addition to considering these primary solutions, probing deeper into the QCA findings for TOLLRATE = 1 yields further insights on contract structuring. Table 4-5 lists the secondary QCA patterns for this outcome, a step in the process toward developing the summaries above. These lengthier expressions do not incorporate simplifying assumptions, an element discussed in the previous chapter, which provide the more general solutions in Table 4-6.

Table 4-5 (TOLLRATE = 1):

Expression (from Tosmana output):	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}
Cases explained by this expression:	(WARNOW1+ CONFED)	(WARNOW1+ MADRID)	(SH121)	(WARNOW2)	(SKYE)	(LISBON)	(SANTIAGO)

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[11] Due to US tax-code benefits for PPP contracts 50 years or longer, this duration has become an artificial lower limit for some domestic PPPs, regardless of whether these projects' other characteristics necessitate such durations. Since the QCA data set includes PPPs from countries without such a tax structure, the contract-length patterns in the QCA results do not necessarily reflect occasions when 50+ year US contracts would help achieve pricing objectives.

One contract strategy which appeared in many of these eight cases, though it was neither necessary nor sufficient by itself to support the TOLLRATE = 1 outcome, was the UPSIDE = 0 condition; that is, the absence of upside revenue-sharing provisions. The logic is understandable, since an opportunity for increased upside benefit can potentially offset a lower toll rate. Although this contract strategy may or may not be suitable for a given procurement, its frequency in the data set made it worth considering as a complement to the primary solutions above.

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

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.

The QCA solution for TOLLRATE = 1 also includes a third term, suggesting long-term contract durations for projects with high traffic-demand risk. Since the Midtown Tunnel procurement has a low risk score, an initial thought would be that this third QCA term does not apply in this case. But findings from the QCA method are not to be applied mechanically, but rather combined with contextual insight. As indicated in the previous footnote, a concession length greater than 50 years may in fact be advisable for US PPPs, regardless of the project risk level, if the value of the resulting tax benefits would help achieve a desired toll rate.

This approach, which illustrated the use of QCA solutions for structuring a procurement with the TOLLRATE = 1 outcome, can also be applied to help develop contract strategies for PPPs which target the other pricing objectives, FREEFLOW = 1 and MINMAX = 1.

5.3. Comparison with Similar Projects from QCA Case Library

To illustrate the third decision-support tool, the full QCA configuration for the new Route 460 solicitation was developed and compared to the existing case library. A mature "parallel project" with the same configuration was identified, offering a degree of forecasting to suggest potential results of a procurement in its early stage; subsequent project developments are also considered.

5.3.1. QCA Configuration: New Route 460 Procurement

For the May 2010 solicitation, values for the Route 460 condition and outcome variables are summarized in Table 5-2, with the initial procurement shown in the first row for comparison. This procurement emphasized, as previously, the non-availability of public funding. For this $1-billion-plus project to be viable, the concessionaire would need to implement tolls at or near revenue-maximizing pricing levels, resulting in a PRICING = 2 value. The proposed 75- to 99-year length of the new concession produced a LENGTH = 2 value, and the apparent absence of revenue- and risk-sharing provisions in the concession's draft term sheet (Appendix F of the solicitation) corresponded to UPSIDE = 0 and DOWNSIDE = 0. The previously-calculated raw risk score, being greater than 2.25, equated to a value of RISK = 1.

As for the project's QCA outcome, efforts to achieve a specific toll rate were not apparent in the solicitation, nor was congestion management a significant concern for this facility, indicating TOLLRATE = 0 and FREEFLOW = 0. With no public funding available, the implicit pricing-related objective was to maximize not an up-front payment, but rather the project scope which could be achieved with limited toll revenues—a goal which corresponded to MINMAX = 1. But these circumstances also highlighted a procurement inherently in conflict with itself: the private sector's preliminary cost estimates for the minimum project scope were hundreds of millions of dollars greater than the forecast level of toll income.

ID	PRICING	LENGTH	UPSIDE	DOWNSIDE	RISK	TOLLRATE	FREEFLOW	MINMAX
460 #1	2	0	1	0	3.4 → 1	0	0	1
460 #2	2	2	0	0	3.5 → 1	0	0	1

Table 5-2: QCA Configurations for Route 460 Procurements

5.3.2. Case-Library Comparison

This combination of QCA variables for the second Route 460 procurement was next compared to the existing library of case configurations to identify a similarly-configured case and to examine potential parallels between these projects, as was done in the previous chapter's sensitivity-analysis comparison of the Madrid airport road with the identically-configured Warnow Tunnel.

Although QCA configuration is not a strict recipe for project performance, it is nonetheless useful to compare similar procurements to consider whether analogous qualitative results might reasonably arise and to exercise appropriate cautions in project development.

Prior to exploring such similarities, though, it is necessary to establish which project outcomes in the historical data set are considered less preferable. Although more specific descriptors can certainly be defined, a useful qualitative starting point is to characterize the following general results as undesirable: actual traffic demand substantially lower than anticipated levels, contract renegotiation (actual or requested), and/or widespread public backlash against the project.

A review of Table 4-4 indicated the new Route 460 procurement exhibited the same conditions and MINMAX outcome as the renegotiated Warnow Tunnel contract in Rostock, Germany. This project, as detailed in Appendix C, relied on strong demand to support its development, but actual traffic counts lay between half and a quarter of initial forecasts, thus meeting the above criterion of an undesired outcome. A significant driver of the project's disappointing revenue performance was the slower-than-anticipated development of Rostock's port, resulting in a much smaller percentage of commercial traffic (2% instead of the forecast 8%) for which toll rates were 5-6 times higher than for passenger vehicles.

The 2 / 2 / 0 / 0 / 1 configuration was not the originally-intended structure for this project but resulted from a renegotiation of the tunnel's contract, as requested by the concessionaire. The revised contract not only provided the operator greater flexibility in setting toll rates but also lengthened the concession's duration from 30 years to 50 years. The Rostock community agreed to these terms largely because the tunnel's insolvency could have placed the facility in the city's hands, yet the law did not permit the public sector to charge tolls for its operation. As a result, the city would have had to raise taxes or reduce services elsewhere, and more favorable terms for the private operator were seen as the lesser of two evils.

The Warnow Tunnel's situation bears some apparent parallels with the Route 460 procurement. Both depended on development of a strong commercial traffic base to be viable, and both treated concession extensions as appropriate means to absorb project risks. (Section 13.02(f) of the proposed Route 460 term sheet specified contract extensions in lieu of financial payments for any compensation events.) For a contract proceeding on the basis of the May 2010 solicitation for Route 460, it would be reasonable to develop a particularly robust contingency strategy for toll-revenue forecasts, given the Warnow Tunnel's susceptibility to traffic-demand variations.

5.3.3. Epilogue: Addendum to Route 460 Procurement

In July 2010, a substantial revision to the new Route 460 solicitation was released.[12] Among many other changes, the most significant was the announcement that public funding would now be allocated to the project. Instead of developing the road solely as a toll-supported facility, proposers were asked to indicate the minimum subsidy they would require for delivering the specified scope of work—still a MINMAX = 1 outcome. The addendum correspondingly reduced the project's reliance on commercial development, deleting the previously-mentioned Section 3.1.1.2 which had declared the Comprehensive Agreement's "support for the development of commercial facilities," and including instead simply a note that the state would consider any proposed commercial-development options which would help improve the project's feasibility (Section 3.1.1.8).

The revised solicitation also indicated the state's willingness to accept additional construction-phase risk (e.g., for differing site conditions) and to provide limited operations-phase maintenance services if desired by the concessionaire. The prior term sheet was deleted in its entirety, market-precedent conditions for major contract provisions were assured, and previous requirements for small-business participation were relaxed. These modifications combined to reduce the project's cost relative to its earlier scope, terms, and risk allocation.

The direction of this shift in the procurement serves to reinforce the prior conclusions drawn by evaluating Route 460 alongside the Warnow Tunnel. Although the July 2010 addendum appeared after the previous QCA comparisons were drafted, it effectively addressed the central imbalance which was identified as common to both projects—excessive costs in relation to anticipated revenues. The Route 460 procurement is now internally consistent, no longer in

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[12] Virginia Department of Transportation. (2010b). Solicitation for Conceptual Proposals: U.S. Route 460 Corridor Improvements Project through the Public-Private Transportation Act, Addendum #1 (issued July 12, 2010).

conflict with itself: by both reducing cost and increasing revenue, the revised solicitation transformed the project's marketability and attractiveness to concessionaires. Whether these steps will be sufficient to make the Route 460 endeavor ultimately successful remains to be seen.

The conclusions of this case-library comparison, corroborated by subsequent developments, illustrate one of the three decision-making tools resulting from this research. Along with the other two applications—estimating a toll-financed project's viability using the risk worksheet and evaluating QCA patterns for contract-structuring guidance—these approaches provide a practical toolkit to assist decision-makers in planning and evaluating PPP procurements.

Chapter 6 DISCUSSION

The preceding analysis not only indicated distinct patterns of contract strategies corresponding to specific public-policy outcomes, but also shed light on general underlying principles which influence the effectiveness of certain strategies in achieving these objectives. These principles are here probed further through consideration of the data set from other angles, providing additional insights on the relationship of PPP contract structure and outcomes.

These investigations fall under three broad headings. First, the QCA table of configurations for each outcome is studied more closely to identify more subtle trends in the data set. Next, a review and comparison of the cases' risk scores indicates additional patterns not apparent in the previous analysis, which necessarily dichotomized this variable for QCA evaluation but gave up some information in the process. Finally, general observations on the nature of PPP risk are elucidated though closer consideration of the traffic-risk index.

6.1. Further Outcome-Specific Observations

Sorting the cases by outcome and manually reviewing the trends in the conditions offered further insights into the interactions among these variables, in addition to the patterns identified through QCA application. In the following, the RISK variable is shown as its raw traffic-risk score, and the cases for each outcome are sorted from highest to lowest risk score in order to probe possible relationships between risk variations and other conditions.

6.1.1. MINMAX Outcome: Minimizing Subsidy or Maximizing Revenue

Although QCA already identified the correspondence of PRICING = 2 and DOWNSIDE = 0 to the MINMAX = 1 outcome, other more subtle patterns became evident from a review of Table 6-1. In particular, the LENGTH variable was inversely proportional, so to speak, with the risk score; that is, projects with lowest traffic-demand risk generally had the longest concession terms, while those with moderate-to-high risk had short or variable-length terms. Although the correspondence of a longer concession with a less risky project may initially seem contradictory, closer reflection indicates this pair of variables is reasonable for revenue-maximizing projects: since the objective is to achieve the smallest subsidy or greatest possible toll income, this result will logically be achieved by lengthening the concession term. Similarly, for the higher-risk, shorter-term projects such as the Herren, Cross City, and El Melon tunnels, one might reasonably expect a high level of traffic-demand risk would lead to a longer or variable-length concession to buffer this risk. One can only conclude that the architects of these contracts felt the length-to-risk relationship was appropriate.

ID	PRICING	LENGTH	UPSIDE	DOWNSIDE	RISK	TOLLRATE	FREEFLOW	MINMAX
ROUTE460	2	0	1	0	3.4	0	0	1
HERREN	2	1	0	0	3.4	0	0	1
CROSCITY	2	1	0	0	3.0	0	0	1
ELMELON	2	1	1	0	2.8	0	0	1
WARNOW2	2	2	0	0	2.6	1	0	1
407ETR2	2	2	0	0	1.9	0	0	1
SKYWAY	2	2	0	0	1.8	0	0	1

Table 6-1: MINMAX Outcome Sorted by Risk Score

While it is not surprising to encounter revenue-maximizing pricing for projects whose objective is MINMAX = 1 (to minimize public subsidy, to maximize an up-front payment, or generally to provide greater latitude in a PPP toll structure's "degrees of freedom," enabling a concessionaire to deliver the most advantageous financial offer), the consistent appearance of DOWNSIDE = 0 along with this PRICING = 2 condition validates QCA's ability to identify contextual patterns of contract strategies, not merely isolated conditions which support a given outcome. Even though this DOWNSIDE = 0 and PRICING = 2 combination is not necessarily an anticipated solution, it is nonetheless logical and underscores the strength of the QCA approach in highlighting inter-relationships among variables, one of its advantages over many strictly quantitative methods.

6.1.2. FREEFLOW Outcome: Maximizing Throughput

The previous chapter's analysis highlighted the not-unsurprising relationship between PRICING = 1 and the outcome FREEFLOW = 1, with demand-linked toll rates being effective in managing traffic congestion. But another facet of these projects, as shown in Table 6-2, is the absence of variable-length concessions (LENGTH = 0) in conjunction with this outcome. Although this could result from the limited diversity of the data set, it also stands to reason that projects with relatively certain demand can be marketable with fixed-length concessions, a structure which is more familiar to the finance sector, since a primary advantage of variable-term contracts is their ability to absorb demand uncertainties without significantly inflating the project's cost.

ID	PRICING	LENGTH	UPSIDE	DOWNSIDE	RISK	TOLLRATE	FREEFLOW	MINMAX
407ETR1	1	1	0	0	2.9	0	1	0
I-495	1	2	1	0	1.8	0	1	0
SR91	1	1	1	0	1.4	0	1	0
SH121	1	2	1	1	1.4	1	1	0
I-595	1	1	0	0	1.3	0	1	0

Table 6-2: FREEFLOW Outcome Sorted by Risk Score

Another benefit provided by the QCA approach is the ability to examine secondary solutions, prior to inclusion of simplifying assumptions, to identify more subtle relationships among the variables. The FREEFLOW = 1 outcome is no exception: even though its primary solution (PRICING = 1) is not unintuitive, an examination of Table 4-7, reproduced below, highlights other trends as well.

Table 4-7: Analysis of FREEFLOW = 1 (with remainders)

Expression:	PRICING{1} * LENGTH{1} * DOWNSIDE{0} * RISK{0} +	PRICING{1} * LENGTH{1} * UPSIDE{0} * DOWNSIDE{0} +	PRICING{1} * LENGTH{2} * UPSIDE{1} * RISK{0}
Cases Explained:	(I-595+SR91)	(I-595+407ETR1)	(I-495+SH121)

In addition to the expected PRICING = 1 solution for all five cases, the secondary solution shows four of these projects also exhibit the RISK = 0 condition, indicating the close correspondence of the public-sector prioritization of a throughput-maximizing outcome with a low traffic-demand-risk environment. Similarly, the DOWNSIDE = 0 condition appears for four of the five cases, a coverage rate of 80%, suggesting the less-obvious conclusion that PPPs with the PRICING = 1 outcome frequently incorporate no provisions for downside-risk protection. While this finding is less immediately apparent, it is nevertheless a logical result for projects with high traffic demand and underscores again QCA's ability to identify subtle as well as general patterns in data sets.

6.1.3. TOLLRATE Outcome: Achieving Specific Toll Levels

For the TOLLRATE = 1 outcome, fewer clear data trends are evident in Table 6-3 than for the preceding objectives. An element of potential interest is that only one of these eight configurations evidences an UPSIDE = 1 value, and this project (SH121) is the sole case in this class which also has a dual FREEFLOW = 1 outcome. Hence it appears reasonable to conclude that projects for which the sole pricing objective is to target a specific toll rate generally have not included upside revenue-sharing provisions—perhaps a tacit acknowledgement that PPPs with this goal are not expected to generate a significant upside possibility.

ID	PRICING	LENGTH	UPSIDE	DOWNSIDE	RISK	TOLLRATE	FREEFLOW	MINMAX
WARNOW1	0	1	0	0	3.4	1	0	0
WARNOW2	2	2	0	0	2.6	1	0	1
SKYE	0	0	0	1	2.4	1	0	0
CONFED	0	1	0	1	2.4	1	0	0
MADRID	0	1	0	0	2.1	1	0	0
LISBON	0	0	0	0	1.6	1	0	0
SH121	1	2	1	1	1.4	1	1	0
SANTIAGO	2	0	0	1	1.3	1	0	0

Table 6-3: TOLLRATE Outcome Sorted by Risk Score

6.2. Review and Comparison of Risk Scores

6.2.1. Outcome Trends in Risk Scores

One question which arose during the data-collection phase was whether the non-dichotomized traffic-risk scores would correspond significantly with certain pricing outcomes. These data are charted in Figure 6-1; the total number of points is greater than the case population, since some projects evidenced multiple simultaneous outcomes. Not unexpectedly, the MINMAX = 1 projects were significantly riskier, as befits the principle of aligning greater risk with greater reward. Although the TOLLRATE and FREEFLOW outcomes each had a single high-risk outlier (in both cases, the first contract for a PPP which was later re-procured), the remainder of these data sets indicates projects for which the FREEFLOW outcome is prioritized tend to be the least risky, followed by those for which a certain toll rate is targeted. Both these outcomes correspond to lower-risk projects than those seeking to achieve the MINMAX objective.

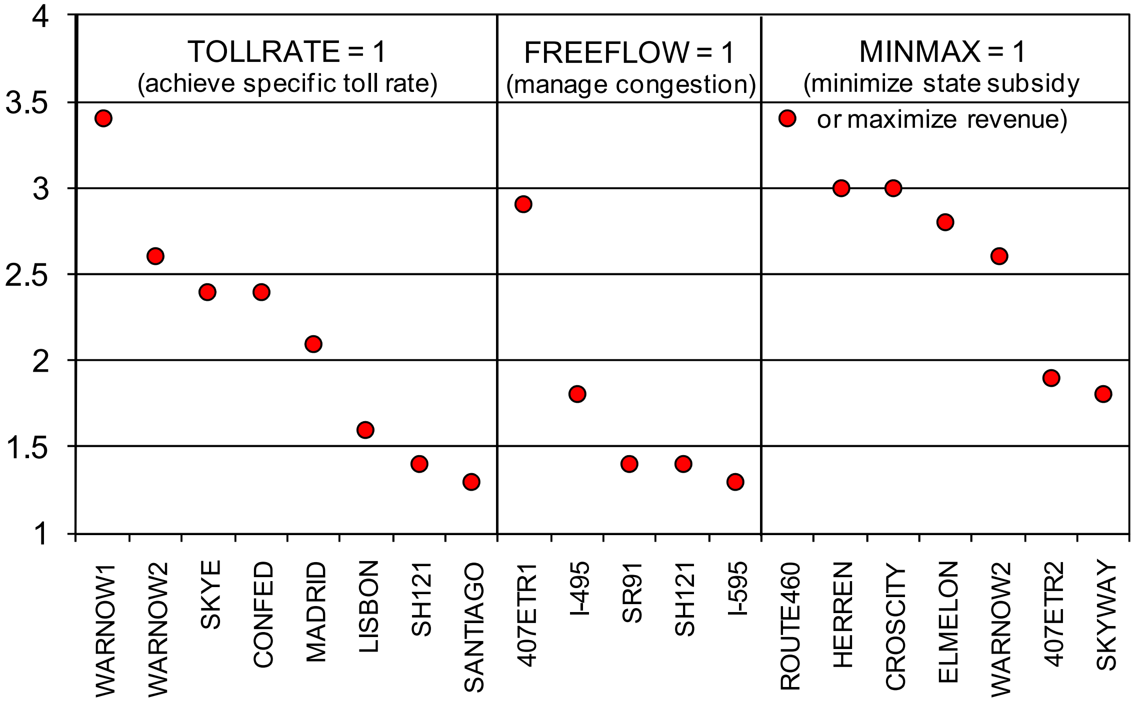

Figure 6-1: Distribution of Risk Scores by Outcome

6.2.2. Chronological Trends in Risk Scores

Another question was whether PPP risk scores would trend differently over time. Figure 6-2 plots each case by the year its concession agreement was executed, except for the Route 460 procurement which was cancelled before award. A slight decrease in these scores over time is evident, perhaps indicating the market's increased understanding of characteristics which tend to support projects' financial success. Although not conclusive, the particularly low risk scores for the most recent procurements may indicate effects of the contemporary financial crisis, with lenders hesitant to support projects with significant traffic-demand risk.

The procurements are classed into first-generation and second-generation PPPs, a somewhat fluid distinction which nevertheless captures a perceptible shift in the sophistication of PPP contracts, both in risk levels and also in closer alignment of projects with market needs. In the following section, this chronological distinction is considered regionally as well.

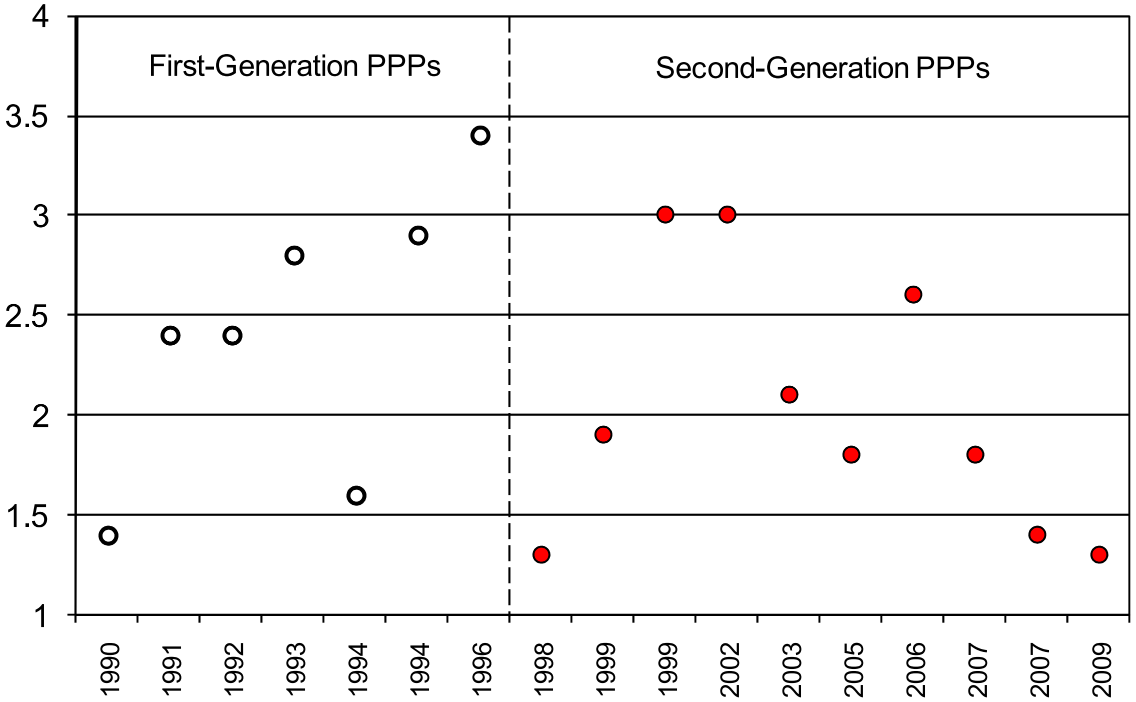

Figure 6-2: Distribution of Risk Scores by Year

6.2.3. Geographic Trends in Risk Scores

The risk scores for each country or region with more than one project in the data set are plotted in Figure 6-3 from highest- to lowest-risk projects within each region, and several trends are apparent from this chart. Germany, whose infrastructure-PPP program is relatively young (having started with the Warnow Tunnel, whose concession agreement was signed in 1996), evidences projects with uniformly higher risk scores than Spain and Portugal, countries with decades of experience in selecting and structuring highway concessions. Canada's PPPs largely span the European range, while the generally recent US projects in this data set tend toward lower risk scores, an indicator of that market's lesser appetite for demand risk.[13] The high-risk Route 460 outlier was indeed not financeable as initially proposed.

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[13] The US is not without its share of high-risk PPPs: earlier procurements such as the Dulles Greenway (opened in 1995) and Pocahontas Parkway (opened in 2002) would have higher risk scores but are not included in this data set.

The first- and second-generation PPPs are again identified in the chart below, indicating regional variations in risk levels over time. As might be expected, risk scores generally decreased over time as countries' PPP markets matured.

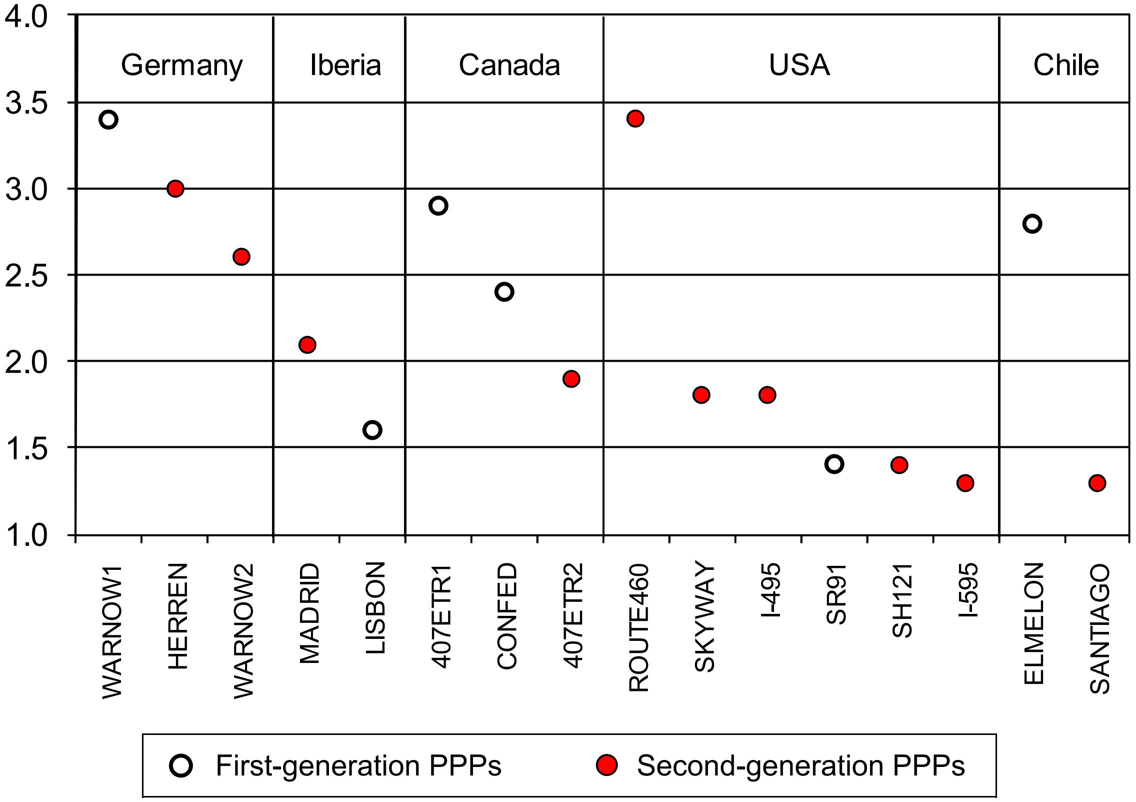

Figure 6-3: Distribution of Risk Scores by Region

6.3. General Observations on PPP Risk

6.3.1. Renegotiation and Contingency Reduction

One observation which arises from comparing the risk levels in the pairs of re-procured projects (i.e., Germany's Warnow Tunnel and Canada's 407 ETR) is that these projects' traffic-demand risk decreased significantly from the original procurement: from 2.9 to 1.9, respectively, and from 3.4 to 2.6. Although this reduction intuitively seems plausible, and authors such as Hart and Moore (1988) note contract renegotiations indeed take place under conditions of reduced uncertainty, the risk table helps quantify the decrease and identifies specific project-risk elements which explain the majority of this shift. For both the Warnow Tunnel and 407 ETR, the most significant areas of risk improvement lay in the knowledge of an area's toll-acceptance culture and of usage patterns for a specific facility, as expressed by the Tolling Culture and Toll Facility Details elements in Table 6-4.

Project Attribute	**Traffic Risk Index**					**Warnow Tunnel**		**407 ETR**	
	1	2	3	4	5	#1	#2	#1	#2
Tolling Culture	Toll roads well established: data on actual use are available				No toll roads in the country, uncertainty over toll acceptance	5	1	5	1
Toll Facility Details	Extension/expansion of existing road				Greenfield site	3	1	4	1

Table 6-4: Experience-Dependent Risk Factors and Scores

Even so, the contrast between 407 ETR and the Warnow Tunnel highlights that a decrease in risk does not automatically make a risky project safe or a loss-making PPP profitable.

Independent of any variations in the other risk elements, these projects' scores for the above two factors decreased to 1 after several years of operations. This decrease holds true even though these PPPs were re-procured for different reasons: while the Warnow Tunnel was renegotiated due to the developer's financial distress, the 407 ETR concession was unilaterally re-procured by the government to achieve a different contract structure. Although this latter transaction was not a renegotiation, strictly speaking, it nevertheless shares a common theme with the Warnow Tunnel in having its contract terms revisited after several years of operational data became available.

Comparison of these projects reveals two discrete elements to be considered in pricing a renegotiation. The more obvious, and more commonly addressed, aspect is whether the project is exceeding or lagging its revenue forecasts: 407 ETR and the Warnow Tunnel offer respective examples of these situations. The second and more subtle element is constant, regardless of a project's revenue performance, and involves the benefit of reduced uncertainty. Since PPP risk is priced as cost contingencies relative to its magnitude, and this PPP risk decreases as uncertain aspects of the project become known, a renegotiated contract properly allots lower compensation for assuming reduced risk. The revenue-positive or -negative discoveries made on the basis of prior operational experience are, in essence, sunk costs (or benefits) which are factored into the renegotiated contract pricing as known elements. In either situation, the risk contingency to be included in that future contract is reduced, as indicated in the area under the curves in Figure 6-4. This diagram shows the sample case of a project underperforming its traffic-forecasts but still benefiting from reduced uncertainty through a smaller subsequent contingency.

Obviously this contingency reduction is not universal: there are still many unknowns remaining in a renegotiated PPP contract which merit appropriate risk allowances. But as shown in the above evaluation of the traffic-risk tables, the elements of project risk associated with tolling culture and facility-usage patterns do indeed decrease with operational experience, regardless of whether the project lags or exceeds its revenue forecasts. Those in the position of renegotiating or re-procuring PPP contracts should be aware of this distinction to take both these aspects into consideration.

As one illustration, the Warnow Tunnel developer's demand-risk contingency was clearly an insufficient cushion for actual usage, with traffic levels at half to a quarter of initial forecasts (7000 vehicles per day, compared to pre-opening daily estimates of 13,000 to 27,000+ vehicles). Although contract renegotiations lengthened the concession term by 67% (from 30 years to 50 years) to address the initial element of revenue performance, it is difficult to ascertain whether the state took into account the second aspect of renegotiation pricing—the mitigating influence of contingency reduction relative to the base case. This implicit benefit should have accrued to the state in this negotiation, based on the decrease in demand uncertainty in elements such as toll-acceptance culture and facility-usage patterns between the tunnel's 2003 opening and its 2006 renegotiation.

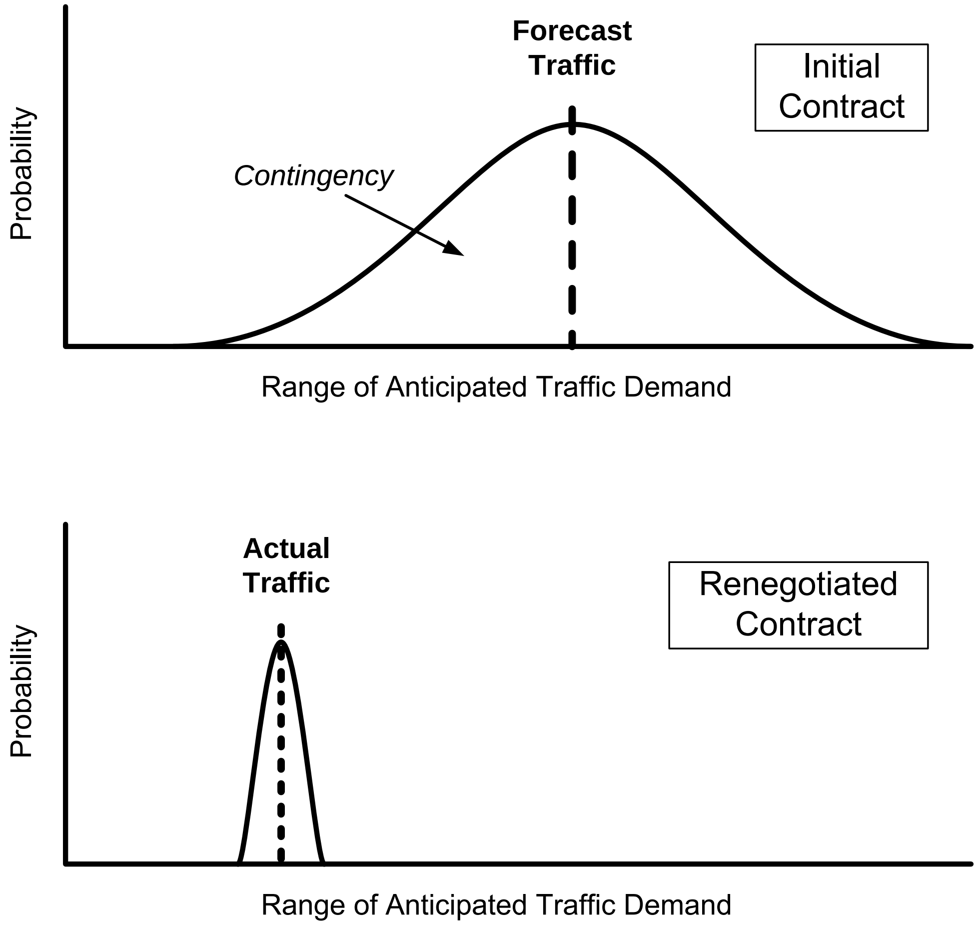

Figure 6-4: Contingency Reduction upon Renegotiation

6.3.2. Distinguishing Demand Risk and Project Risk

The above definition of the RISK variable sharpens the question of what exactly is meant in referring to a “risky PPP.” At least two interpretations are common, and their understanding impacts the treatment of upside benefit and the type of incentives which can effectively be incorporated in a PPP contract.

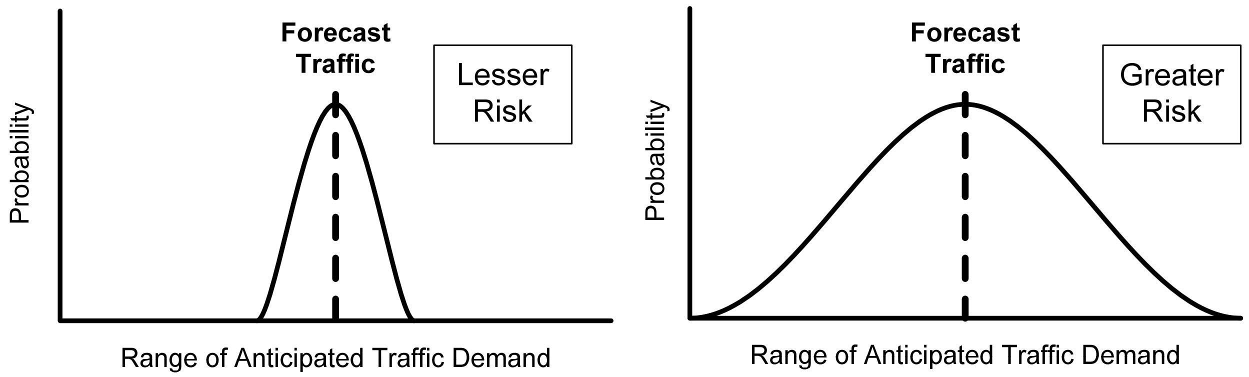

Figure 6-5: One Interpretation of Traffic Risk

(Demand Risk)

The first is reflected in the frequent maxim in PPP discussions that risk should correlate with reward; i.e., a project with a more significant downside should allow the private sector the opportunity for more generous returns, and vice versa. This understanding of the concept treats risk as the likelihood of an outcome and corresponds with the interpretation shown in Figure 6-5: the curve on the right has a greater downside possibility and thus is balanced with a greater potential upside benefit.

But another interpretation can also be at play when a “risky project” is discussed, as indicated in the Standard & Poor’s traffic-risk worksheet and Figure 6-6. This metric addresses more of a project’s overall economic risk than simply its demand risk. In fact, the term *risk* is almost a misnomer here, because the downside scenario is fairly certain: projects with a high S&P traffic-risk score (and which were designated high-risk in the analysis, or RISK = 1) were likely to have light traffic demand, a factor which influenced many other elements of the contract structure.

Hence, considering this interpretation as “risk” may indeed be appropriate on a larger project-level scale in which the near certainty of low traffic levels makes the entire project risky from a financing or viability standpoint. There is no practical level of upside reward or incentive which can effectively be offered in such cases to offset this economic risk; as indicated in the left-side curve of Figure 6-6, even the upside scenario (or right-hand tail) of this probability distribution still corresponds to a low amount of traffic overall.

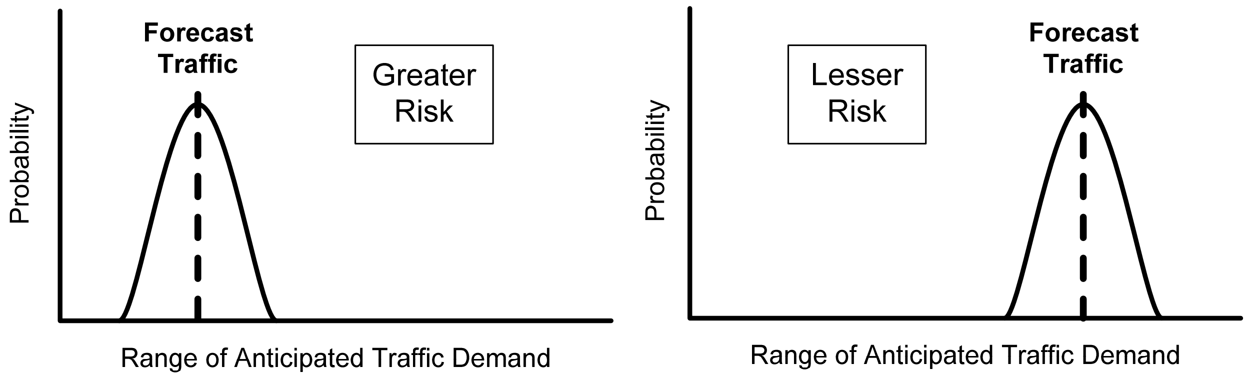

Figure 6-6: Another Interpretation of Traffic Risk

(Economic Risk)

6.3.3. Practical Application of Modified Traffic-Risk Worksheet

The Standard & Poor's traffic-risk index introduced in Bain (2009) formed the basis for calculating the RISK variable, as detailed previously. Bain observed higher scores on this scale indicated projects were potentially exposed to greater forecasting risk and uncertainty, and he further noted these scores "represented lender exposure to particular risks" and "highlighted issues which required further investigation or analysis."

While these uses of the risk index are valuable and appropriate, another application for the risk index emerges from the above analysis. Table 6-5 reiterates the toll-facility attributes evaluated in this study, and it becomes evident that these categories not only are demand-risk indicators, as originally intended, but also (when considered together) form a reasonable proxy for gauging overall traffic demand for a PPP facility. For instance, a highly-congested corridor will by definition have much stronger demand than one with limited or no congestion; similarly, the presence of fewer competing roads simply means more of the existing traffic will use the facility in question. Other attributes, such as the greenfield/brownfield distinction, are less quantitatively linked to traffic demand; but in the aggregate, the traffic risk score developed below is a useful "back of the envelope" calculation which can be performed at the earliest stages of a project to gain an understanding of whether a project is likely to be self-supporting on its own without outside subsidy or public-sector support.

Notably, the attributes in Table 6-5 are ones which can be evaluated based on existing physical, geographic, and demographic characteristics. Other elements of the unmodified Standard & Poor's index (Table 3-2) require traffic surveys, traffic and revenue studies, and even an established tolling plan—attributes which require fairly advanced development of a project. But the subset of factors summarized here can be evaluated even before development begins, furnishing a rough proxy for a road's feasibility as a self-supporting PPP.

<table>
<tr><th rowspan="2">Project Attribute</th><th colspan="10">Traffic Risk Index</th></tr>
<tr><th colspan="2">1</th><th colspan="2">2</th><th colspan="2">3</th><th colspan="2">4</th><th colspan="2">5</th></tr>
<tr><td>Tolling Culture</td><td colspan="5">Toll roads well established: data on actual use are available</td><td colspan="5">No toll roads in the country; uncertainty over toll acceptance</td></tr>
<tr><td rowspan="5">Toll Facility Details</td><td colspan="5">Estuarial crossings; radial corridors into urban areas</td><td colspan="5">Dense, urban networks; ring roads/ beltways around urban areas</td></tr>
<tr><td colspan="5">Extension/expansion of existing road</td><td colspan="5">Greenfield site</td></tr>
<tr><td colspan="5">Stand-alone (single) facility</td><td colspan="5">Reliance on other, proposed highway improvements</td></tr>
<tr><td colspan="5">Highly congested corridor</td><td colspan="5">Limited/no congestion</td></tr>
<tr><td colspan="5">Few competing roads</td><td colspan="5">Many alternative routes</td></tr>
<tr><td>Users</td><td colspan="5">High-income, time-sensitive market</td><td colspan="5">Average/low-income market</td></tr>
<tr><td>Traffic Growth</td><td colspan="5">Driven by/correlated with existing factors</td><td colspan="5">Reliance on future growth factors, new developments, etc.</td></tr>
</table>

Table 6-5: Excerpt from Risk Worksheet with Modified Traffic Risk Index

based on Bain (2009)

In summary, these closer considerations of the QCA data set and the nature of risks evaluated in the analysis shed additional light on how contract strategies interact with outcomes, and how the definition of traffic risk can affect negotiations and early-stage project evaluation.

Chapter 7 CONCLUSION

Through a review of international PPP contract strategies and the exploration of relevant public-policy principles, the central research question—"Given specific policy objectives for road pricing, how should public owners select PPP contract strategies which support these outcomes?" —was developed. The method of qualitative comparative analysis provided a flexible framework for identifying similarities among seemingly-disparate projects, and for applying these common elements for decision-making in structuring future procurements.

7.1. Summary of Contributions

This work presents six main contributions: the first three are primarily focused toward academia, while the last three provide new decision-making tools to aid practitioners.

1. Unifying and making accessible PPP-related contributions from academic literature across a broad span of disciplines, including construction, transportation, finance, economics, accounting, policy, and law. Over 450 papers are identified and categorized by topic (Appendix A), furnishing an extensive interdisciplinary catalog of the prior art for researchers in this field.

2. Distinguishing public objectives and public interest—topics which are frequently used interchangeably, complicating the core issues and making them more difficult to address. Yet considering public interest to represent the unvarying best practices for infrastructure procurements, while public objectives comprise goals which may legitimately vary among procurements, enables more effective consideration of the central issues in procurement structuring and policy.

3. Introducing qualitative comparative analysis to applied construction research. In this field, this work is among the first contributions to use the QCA method and is the first, to the author's knowledge, to apply the mvQCA approach. Given the frequent occurrence

of qualitative problems in construction research, the availability of such a tool with quantitative aspects can be of great value in strengthening rigor and replicability in future investigations.

4. Introducing the modified traffic-risk index as a simple-to-use proxy for PPP feasibility. This eight-attribute worksheet can be applied early in the development process to gauge the approximate overall economic risk of a proposed toll-road project.

5. Clarifying the relationship of PPP contract strategies to specific outcomes. The QCA patterns developed in this work yield insights into effective combinations of pricing, duration, and risk-management approaches for achieving desired contract objectives.

6. Developing a PPP case library for assessing projects under consideration. This framework for distilling projects into numeric configurations of contract strategies and outcomes furnishes a structured approach for comparing past and future procurements and developing general predictions about outcomes. The resulting case library of project characteristics may be compared to current and proposed PPPs throughout the world.

7.2. Limitations of Study

This study necessarily faces several limitations in its approach and application. Among the methodological cautions of the QCA approach is that its results, as crisp and tidy as they may appear, must not be over-generalized. The method summarizes and reports patterns from the available data set, whether or not this set is entirely representative of the broader population. Further, given the complexity of qualitative phenomena, the interpretation and application of QCA findings must be taken as guidelines, not as guaranteed recipes for project success.

An additional limitation, noted above, involves the possibility of geographic bias in this study's data set. On one hand, a wider assortment of PPPs could yield more comprehensive insights into the interaction among contract strategies and outcomes; but on the other, country-specific traits (such as US tax benefits for PPP contracts 50 years and longer) are obscured with a more diverse geographic population. These constraints must be borne in mind while interpreting the results.

7.3. Directions for Future Work

Two initiatives for further developing this work include (a) introducing new conditions into the QCA structure and (b) further populating the case library to assist in evaluating future procurements. Consideration of additional conditions, or contract strategies, would potentially 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.

In discussing comparative applications for the case library, contract outcomes which could be qualitatively considered less desirable were mentioned briefly—actual traffic demand far lower than anticipated levels, contract renegotiation (actual or requested), and/or widespread public backlash against the contract. The presence or absence of these situations could also be considered a QCA outcome in itself, enabling a subsequent study to analyze projects for patterns of factors contributing to these undesirable results.

7.4. Implications for Policy and Practice

This work developed three practical tools to assist decision-makers in structuring PPP procurements. The first of these, the modified traffic-risk worksheet, distilled a lengthy list of project attributes into an eight-step evaluation which enables a rapid early-stage estimate of a toll-financed project's viability, even before financial and traffic studies have been performed. By quantifying characteristics of the Route 460 PPP in southeastern Virginia, this tool classified the procurement as one with high traffic risk which would encounter challenges in sustaining itself solely by toll revenues. The state's subsequent allotment of public funds to support the project furnished an independent corroboration of this quick analysis.

The second tool directly applied the analytical QCA results as guidance for selecting PPP contract strategies, based on desired pricing objectives. Through a study of 18 domestic and international PPP case studies, this research identified patterns of contract strategies which were consistently present for projects targeting three specific pricing objectives—a given toll rate, congestion management, or a minimum subsidy/maximum up-front payment. Application of this tool to Virginia's Midtown Tunnel, a current procurement aiming to deliver a broad scope of improvements for a $1.50 toll rate, illustrated several contract-structuring options based on QCA patterns from previous PPPs with the same objective.

Finally, case-library comparisons furnished a third decision-support tool for drawing parallels between proposed and established PPPs. Procurements with the same QCA configuration—a numerical pattern summarizing a project's contract strategies and pricing objectives—can be compared with each other to provide a quasi-forecast suggesting potential outcomes for a PPP still under development. Because the re-issued Route 460 procurement shared the same QCA configuration as another case study in the data set, a troubled tunnel concession in Germany, mitigation strategies appropriate to this contract were proposed for Route 460 as well. The recommended approach, taking decisive steps to narrow the gap between forecast project costs and revenues, was indeed followed in a subsequent addendum to the Route 460 solicitation.

7.5. Final Thoughts

The previous analysis and conclusions spring from the central idea that economic viability is the key determinant for the feasibility of PPP toll-road contracts. Thus, for instance, outcomes were selected which focused on pricing-related objectives, and the risk analysis characterized projects with greater traffic demand as those which were more likely to be self-supporting. This approach is indeed vital for infrastructure which is project-financed, or paid for entirely by the revenue stream which it produces.

Although the role of defining appropriate public-policy objectives for PPPs lies outside the scope of this work, as noted earlier, a few thoughts on the topic can nevertheless be offered. The PPP delivery method is intrinsically best suited for applications in which it enables infrastructure to be entirely self-supporting, converting user demand into a facility which directly satisfies that demand. Adam Smith's eloquent observations in 1776 are no less valid today:

> When high roads, bridges, canals, etc., are in this manner made and supported by the commerce which is carried on by means of them, they can be made only where that commerce requires them, and consequently where it is proper to make them.
>
> Their expenses too, their grandeur and magnificence, must be suited to what that commerce can afford to pay. They must be made consequently as it is proper to make them. A magnificent high road cannot be made through a desert country where there is little or no commerce...A great bridge cannot be thrown over a river at a place where nobody passes, or merely to embellish the view from the windows of a neighboring palace.

Highway development differs markedly from the development of social infrastructure—schools, hospitals, and prisons, for instance—whose funding is rarely linked to users' contributions and which thus relinquish the sensitivity of being influenced by users' choices. This responsiveness to consumers' decisions adds both challenge and elegance to the study of highway procurement.

Although infrastructure facilities can certainly be provided where traffic demand is not sufficient to support them, it is essential to recognize these projects will require external revenues and that the PPP delivery structure cannot make such projects financially self-sustaining. It is hoped this study can offer some small contribution toward evaluating when PPPs are best used, and in these cases, how they can be structured to achieve their desired outcomes most effectively.

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Appendix A: Survey of PPP Literature

The following compendium of PPP-related literature includes nearly 450 citations, primarily from archival sources in the fields of construction, finance, transportation, economics, public policy, accounting, and law.

To facilitate locating works of interest, these items are grouped by topic into nine categories, which are further divided into 69 sub-groups. Although some citations could reasonably be assigned to multiple categories among these sub-groups, in each case a single classification deemed most descriptive has been chosen.

1. General Concepts

Topic	References
Historical overview	(Bovaird 2004); (de Lemos et al. 2000); (Gomez-Ibañez et al. 1991); (Gramlich 1994); (Kwak et al. 2009); (Rienstra and Nijkamp 1997)
PPP terminology	(El-Diraby and Gill 2006); (Linder 1999); (Mazouz et al. 2008); (Wettenhall 2003)
Effectiveness of PPPs	(Garvin and Bosso 2008); (Hodge and Greve 2007); (Hodge and Greve 2009)
Success factors	(Abdel-Aziz 2007a); (Galilea and Medda 2009); (Jacobson and Choi 2008); (Jefferies 2006); (Li et al. 2005b); (Qiao et al. 2001); (Qiao et al. 2002); (Trafford and Proctor 2006); (Zhang 2005c); (Zhang 2005d)
Research trends and agenda	(Broadbent and Laughlin 1999); (Broadbent and Laughlin 2003b); (Ke et al. 2009); (Schäferhoff et al. 2009); (Sciulli 2007); (Wall and Connolly 2009)

2. Governance Issues

Topic	References
Relationship management	(Edelenbos and Klijn 2009); (Edkins and Smyth 2006a); (Grimsey and Lewis 2004); (Hall et al. 2000); (Leitch and Motion 2003); (Smyth and Edkins 2007); (Teicher et al. 2006); (Tranfield et al. 2005); (Yeo and Tiong 2000)
Stakeholder participation, roles, and competencies	(Asenova and Hood 2006); (Becker and Patterson 2005); (Bojović 2006); (El-Gohary et al. 2006); (Fischbacher and Beaumont 2003); (Joyner 2007); (Mustafa 1999); (Norton and Blanco 2009); (Raisbeck 2008); (Scharle 2002); (Wamuziri and Jiang 2008); (Zhang 2005a)
Partnership formation and institutionalization	(Chen et al. 2006b); (Clifton and Duffield 2006); (Demirag et al. 2009); (Koppenjan 2005); (Kumaraswamy et al. 2007); (Kumaraswamy and Anvuur 2008); (Weihe 2008)
Managerial roles/ decisions/skill sets	(Klijn et al. 2008); (Jones and Noble 2008); (Noble and Jones 2006); (Ricaurte et al. 2008)
Institutional roles/ challenges	(Fischer et al. 2006); (Klijn and Teisman 2003); (Kumaraswamy and Zhang 2001)
Public and private-sector perspectives	(Asenova et al. 2002); (Cheung et al. 2009); (Edkins and Smyth 2006b); (Li et al. 2005c); (Zhang 2006)
Public relations	(Michalski-Karl et al. 2009)

3. Procurement

Topic	References
Project selection and viability assessment	(Ashley et al. 1998); (Chen et al. 2001); (Laishram and Kalidindi 2009); (Ock and Han 2002); (Ock et al. 2005); (Ranasinghe 1999); (Ribeiro et al. 2003); (Roco 2005); (Salman et al. 2007); (Tsamboulas et al. 2000); (Wibowo 2005)
Bidding decision and costs	(Dudkin and Välilä 2006); (Ezulike et al. 1997); (Zitron 2006)
Competition	(Aragão et al. 2006); (Athias and Nuñez 2008); (Chong et al. 2006); (de Lemos et al. 2003b); (Tiong and Alum 1997a)
Negotiation and proposal selection	(Ababutain and Bullen 2003); (Ahadzi and Bowles 2004); (Ghere 2001b); (Liou and Huang 2008); (Ngee et al. 1997); (Noble 2006); (Tiong and Alum 1997b); (Tiong and Alum 1997c); (Zhang 2004); (Zhang 2005b)
Renegotiation	(de Brux 2010); (Guasch and Straub 2006); (Guasch et al. 2007); (Guasch et al. 2008); (Guasch and Straub 2009); (Ho 2006)
Facility lifecycle design	(Loizos et al. 2007); (McClure et al. 2008); (Swaffield and McDonald 2008)
Performance and service objectives	(Robinson and Scott 2009); (Yuan et al. 2009); (Yuan et al. 2010)
Innovation and quality	(Eaton et al. 2006); (Eger and Wilsker 2007); (Leiringer 2006); (Rangel and Galende 2010)

4. Contract Design

Topic	References
Contract structuring and framework	(Abdel-Aziz 2007b); (Abdel-Aziz and Russell 2001); (Cheng and Tiong 2005); (Cook 2008); (Martimort and Pouyet 2008); (Marty et al. 2005); (Ng and Wong 2006); (Ng and Wong 2007); (Pongsiri 2002); (Rausser and Stevens 2009); (Rodríguez 1999); (Ye and Tiong 2003b)
Contract design modeling	(Chen et al. 2003); (Chen et al. 2006a); (Chen and Subprasom 2007); (Chiou and Lan 2006); (Guo and Yang 2009); (McCowan and Mohamed 2007); (Ng et al. 2007a); (Ng et al. 2007b); (Shen et al. 2002); (Shen and Wu 2005); (Shen et al. 2007); (Subprasom et al. 2003); (Yang and Meng 2000); (Zhou et al. 2008)
Toll adjustment	(Athias and Saussier 2006); (Ye and Tiong 2003c)
Concession length	(d'Alpaos et al. 2006); (Vassallo 2004); (Ye and Tiong 2003a); (Zhang and AbouRizk 2006)
Variable-length concessions	(Albalate and Bel 2009); (de Rus and Romero 2004); (Engel et al. 1997); (Engel et al. 2001); (Engel et al. 2002); (Engel et al. 2006); (Nombela and de Rus 2004)
Tolls and congestion management	(DeCorla-Souza 2006a); (DeCorla-Souza 2006b)
Traffic risk mitigation strategies	(Singh and Kalidindi 2006); (Vassallo 2006); (Vassallo and Sánchez-Soliño 2006)
Revenue/risk sharing	(Charoenpornpattana and Minato 2007); (Takashima et al. 2010)

5. Risk Management

Topic	References
Risk identification and assessment	(Akintoye et al. 2003a); (Gallimore et al. 1997); (Grimsey and Lewis 2002b); (Iyer and Sagheer 2010); (Johnston and Gudergan 2007); (Songer et al. 1997); (Yang et al. 2010)
Risk modeling	(Chiara and Garvin 2008); (Kang et al. 2005); (Kang and Feng 2009); (Medda 2007); (Ng and Xie 2008); (Thomas et al. 2006); (Xu et al. 2010); (Zayed and Chang 2002)
Risk allocation	(Abdul-Malak et al. 2001); (Abednego and Ogunlana 2006); (Jin and Doloi 2008); (Li et al. 2005a); (Vega 1997)
Risk transfer	(Alonso-Conde et al. 2007); (Ball et al. 2003); (Eaton and O'Connor 2002a); (Hodge 2004a); (Hodge 2004b); (Lonsdale 2005)
Risk management	(Akintoye et al. 1998); (Asenova and Beck 2003a); (de Lemos et al. 2001); (Dey et al. 2002); (Dey and Ogunlana 2004); (Doloi and Jin 2007); (Froud 2003); (Hood and McGarvey 2002); (Nisar 2007a); (Özdoganm and Birgönül 2000); (Zou et al. 2008)
Financial risk	(Asenova and Beck 2003b); (Barney and White 2003); (Lam and Chow 1999); (Lu et al. 2000); (Wang et al. 2000a); (Wang et al. 2000b)
Political risk	(Smith and Gannon 2008); (Wang and Tiong 1999); (Wang and Tiong 2000)
Legal risk	(Xenidis and Angelides 2005)

6. Financial Elements

Topic	References
Capital structure	(Devapriya 2006); (Logan 2003); (Yun et al. 2009)
Project finance	(Akbiyikli et al. 2006); (Daube et al. 2008); (Schaufelberger and Wipadapisut 2003); (Tiong and Alum 1997d)
Debt structures and credit assessment	(Blanc-Brude and Strange 2007); (Cheng et al. 2007); (Leigland and Thomas 1999); (Vassallo and Sánchez-Soliño 2007)
Financial valuation and options	(Arboleda and Abraham 2006); (Bel and Foote 2009); (Garvin and Cheah 2004); (Huang and Chou 2006); (Huang and Pi 2009); (Kang et al. 2003); (Lara-Galera and Sánchez-Soliño 2010); (Liu and Cheah 2009); (Quiggin 2005); (Quiggin 2006); (Wibowo 2004); (Wooldridge et al. 2002)
Evaluation methods and discount rates	(Chiang et al. 2010); (Eschenbach and Cohen 2006); (Esty 1999); (Grout 2003); (Ke et al. 2008); (Tánczos and Kong 2001); (Wohl and Martin 1967); (Ye and Tiong 2000)

7. Economic Elements

Economic analysis of PPPs	(Athias 2007); (Ball et al. 2007); (de Bettignies and Ross 2004); (de Bettignies and Ross 2009); (Fourie and Burger 2000); (Grout 1997); (Hart 2003); (Sadka 2007); (Small 2010); (Thia and Ford 2009); (Trailer et al. 2004); (Välilä 2005)
Toll road economics	(Gronau 1999); (Levinson 2001); (Ponti 2005); (Ragazzi 2005); (Sharp et al. 1986)
Economic welfare modeling	(Subprasom and Chen 2007); (Tsai and Chu 2003); (Verhoef 2007); (Zhang and Ge 2004)
General road pricing	(Armelius 2005); (Chu and Tsai 2004); (de Palma et al. 2005); (Goldin 1968); (Goodwin 1989); (Harvey 2000); (Levinson 2005); (Newbery 1989); (Oh et al. 2007); (Williams et al. 2001); (Yang and Verhoef 2004); (Yang 2005)
Congestion pricing	(Arnott and Kraus 1998); (Bernstein and Muller 1993); (Glazer and Niskanen 2000); (McDonald 1986); (Thomson 1998); (Verhoef et al. 1995); (Verhoef and Small 2004); (Vickrey 1948); (Vickrey 1963); (Yang and Lam 1996)
Regulated (monopoly) concessions	(Demsetz 1968); (Evans and Guthrie 2005); (Fielding and Klein 1993); (Galetovic and Inostroza 2008); (Grout et al. 2004); (Harstad and Crew 1999); (Riordan and Sappington 1987); (Ubbels and Verhoef 2008)
Regulated (monopoly) pricing	(Arnott and Kraus 1993); (Dierker 1991); (Hartman et al. 1994); (López-de-Silanes 1997); (Oum and Tretheway 1988); (Sheehan 1991)

8. Public Sector Considerations

Topic	References
Public procurement principles	(de Lemos et al. 2003a); (Grimsey and Lewis 2007); (Grout and Stevens 2003); (McQuaid and Scherrer 2010); (Murphy 2008); (Siemiatycki 2010); (Vining and Boardman 2008b)
Public finance and budgeting	(Ball et al. 2002); (Ball and King 2006); (Fourie 2006); (Posner et al. 2009)
Public interest	(Ball et al. 2000); (Bloomfield 2006); (Buxbaum and Ortiz 2009); (Hood et al. 2006); (Mayer 2007); (Ortiz and Buxbaum 2008)
Value for money	(Akintoye et al. 2003b); (Colman 2000); (Eaton and O'Connor 2002b); (Grimsey and Lewis 2005); (Heald 2003); (Miyamoto et al. 2005); (Morallos and Amekudzi 2008); (Morallos et al. 2009); (Nisar 2007b); (Pitt et al. 2006)
Public sector comparator	(Coulson 2008); (Lamb and Merna 2004); (Quiggin 2004); (Russell and Nelms 2006)
Public accountability and transparency	(Broadbent and Laughlin 2003a); (Demirag et al. 2004); (Demirag and Khadaroo 2008); (Hodge 2006); (Watson 2003); (Watson 2004); (Watson 2006)
Accounting treatment	(Badawi 2003); (Broadbent and Laughlin 2002); (Grimsey and Lewis 2002a); (Heald and Geaughan 1997); (Hodges and Mellett 2002); (Hodges and Mellett 2004); (Hodges and Mellett 2005); (Khadaroo 2005); (Kirk and Wall 2001); (Maskin and Tirole 2008); (Rutherford 2003); (Walker 2003)
Policy and ethics	(Ghere 2001a); (Newberry and Pallot 2003); (Shaoul et al. 2007)
Probity and auditing	(English 2007); (Templeman and Paradise 2006)
Political aspects	(English and Skellern 2005); (Flinders 2005); (Kerr 1998)
Legal aspects	(Blackshield 2006); (Braun 2003); (Erhardt 2008); (Payne 1997)

9. National Applications and Case Studies

(generalized topics with national applications are listed in previous categories)

Topic	References
UK (including PFI program analysis)	(Carrillo et al. 2008); (Clark and Root 1999); (Deakin 2002); (Debande 2002); (Dixon et al. 2005); (Glaister 1999); (Grubb 1998); (Hagan 1998); (Kirk and Wall 2002); (Pollock et al. 2007); (Sawyer 2005); (Shaoul et al. 2006); (Spackman 2002)
Northern Europe	(Collin 1998); (Greve 2003); (Reeves 2003); (Reeves 2005); (Tieva and Junnonen 2009)
Western Europe	(Burnham 2001); (Fayard and Bousquet 1998); (Fayard 2005); (Fernandes and Viegas 1999); (Koch and Buser 2006); (Lienhard 2006); (Sánchez-Soliño and Vassallo 2009); (Torres and Pina 2001); (Vassallo and Gallego 2005)
Eastern and Southern Europe	(Adamiak 2008); (Christakos and Kalfakakou 2007); (Cindea 2008); (Clement-Davies 2001); (Eaton et al. 2007); (Maslyukivska and Sohail 2007); (Roumboutsos and Anagnostopoulos 2008); (Tiede and Krispenz 2007)
Africa	(Binza 2008); (Ibrahim et al. 2006); (Rintala et al. 2008); (Serres 2000)
North America	(Algarni et al. 2007); (Battaglio and Khankarli 2008); (Cohn 2008); (Garvin 2010); (Mendoza et al. 1999); (Price 2001); (Vining et al. 2005); (Vining and Boardman 2008a)
Central and South America	(Alencar 2000); (Barral and Haas 2007); (Nicolini-Llosa 2002); (Paredes and Sánchez 2004); (Sirtaine et al. 2005)
Asia and Pacific (except China)	(Handley 1997); (Kumaraswamy and Morris 2002); (Mahalingam 2010); (Malini 1999); (Malone 2005); (Mubin and Ghaffar 2008); (Regan 2006); (Syuhaida and Aminah 2009); (Takim et al. 2008); (Takim et al. 2009); (Tam 1999); (Thomas et al. 2003); (Ward and Sussman 2006); (Wei and Chung 2002); (Yingsutthipun and Minato 1998)
China	(Adams et al. 2006); (Chan et al. 2005); (Chan et al. 2009); (Chan et al. 2010); (Chen and Doloi 2008); (Cheung and Chan 2009); (Chiang and Cheng 2009); (Hanley 1999); (Ke et al. 2010); (Liu and Yamamoto 2009); (Sachs et al. 2007); (Shen et al. 2006); (Zhang and Kumaraswamy 2001a); (Zhang and Kumaraswamy 2001b); (Zhang et al. 2002)
Developing and transition economies	(Dailami and Leipziger 1998); (Handley-Schachler and Gao 2003); (Jamali 2004); (Queiroz 2007); (Tanaka et al. 2005)

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Appendix B: Rubric for Assigning QCA Values

Source documentation

Contract documents, industry news reports, popular news reports (in order of priority)

Target elements within this literature

Permitted toll schedules (contract) and current toll levels (often published on project website)—compare to determine whether lower tolls than maximum allowable are being charged. Also see project planning documents (e.g., “Purpose and Need” chapter from EIS) to examine motivation for tolling and rationale for setting initial toll. See contract documentation to identify toll escalation rates.

How to code these elements

0 = average-cost pricing: tolls are set at a fixed pre-specified level intended to cover the cost of service provision. These may be set equivalent to rates for previous ferry service, for instance, and often escalate at a rate no higher than the consumer price index (CPI).

1 = marginal-social-cost pricing: tolling rationale is to control traffic congestion or other undesirable side-effect of excessive road usage. Tolls are usually variable and may produce more (or in rare cases, less) revenue than necessary to cover the cost of service provision.

2 = revenue-maximizing pricing: tolling rationale is to raise the greatest possible revenues. Tolls are often variable and are higher than marginal-social-cost pricing (toll rates for which traffic flow is optimized). These tolls often escalate at the rate of per-capita gross domestic product (GDP) or a fixed amount each year, regardless of economic indicators.

LENGTH

Condition

Source documentation

Contract documents, industry news reports, popular news reports (in order of priority)

Target elements within this literature

Contract section (or article excerpts) addressing concession length. For fixed-length concessions, consider base length, even if contract permits extensions under specified circumstances.

How to code these elements

0 = concession length not fixed at outset, even if bounded by minimum/maximum limits

1 = concession length (including any construction) up to 50 years

2 = concession length (including any construction) 50 years or greater

UPSIDE

Condition

Source documentation

Contract documents, industry news reports, popular news reports (in order of priority)

Target elements within this literature

Contract revenue-sharing provisions, often expressed in terms of permitted profits or rate-of-return. These provisions are sometimes outlined more concisely in industry-literature articles analyzing the contract.

How to code these elements

0 = concessionaire is not required to share revenues or shorten the concession when certain traffic levels/financial indicators are reached

1 = concessionaire is required to share revenues (including refinancing gains) or accept a shorter concession term when certain indicators are reached
(For variable-length concessions, UPSIDE = 1 only if contract also includes explicit revenue-sharing clauses in addition to varying-length provisions.)

DOWNSIDE

Condition

Source documentation

Contract documents, industry news reports, popular news reports (in order of priority)

Target elements within this literature

Examine any contract provisions discussing guarantees of revenue or traffic levels, or addressing steps to be taken if anticipated levels do not materialize. These provisions are sometimes outlined more concisely in industry news reports analyzing the contract.

How to code these elements

0 = concessionaire is <u>not</u> guaranteed a certain minimum amount of traffic, revenue, or rate-of-return; (i.e., compensation or contract length will <u>not</u> be increased if these thresholds are not met); or guarantees apply only to a limited set of circumstances and are unlikely to affect project

1 = concessionaire is guaranteed a certain minimum amount of traffic, revenue, or rate-of-return; compensation (toll rates and/or state subsidy) or contract length will be increased if these thresholds are not met

RISK

Condition

Source documentation

Contract documents, industry/popular news reports, maps, descriptions of local/regional setting (evaluate as many items as necessary to develop adequate picture of project risk climate)

Target elements within this literature

Topical areas indicated by specific attributes on supplemental worksheet

How to code these elements

Complete supplemental traffic-risk worksheet and calculate risk score, rounded to one decimal place.

0 = score is less than 2.25 (low traffic risk)

1 = score is greater than 2.25 (high traffic risk)

TOLLRATE

Outcome

Source documentation

Project planning documents (e.g., traffic-and-revenue studies), industry and/or popular news reports, academic reviews/case studies

Target elements within this literature

Look for statements in project-planning documents and news reports indicating whether the public sector specified an initial toll rate and/or rate cap, and if so, how this level was determined. Were the rates project-based (e.g., linked to traffic-and-revenue studies or project cost) or project-independent (e.g., aligned to previous levels of charging, popular sentiment, or other toll levels in the network)?

How to code these elements

0 = public sector does not specify an initial toll rate and/or rate cap; or, if toll levels are specified, the rate is based on project-related factors; or tolls are variable (by time of day or congestion level)

1 = public sector specifies an initial toll rate and/or rate cap based on project-independent factors

FREEFLOW

Outcome

Source documentation

Project planning documents (e.g., “Purpose and Need” chapter from EIS, traffic-and-revenue studies), current toll rates (often posted on project’s website), industry and/or popular news reports, academic reviews/case studies

Target elements within this literature

In project documents, consider existing traffic levels in the corridor, and whether the public sector identified congestion management (or “throughput maximization”) as a primary goal. In this case, the project name will often include the term “managed,” “express,” or “HOT” lanes. Also examine the toll rate sheet to determine whether tolls are fixed or variable, either by time-of-day or traffic levels.

How to code these elements

0 = fixed toll rates (not varying by time-of-day or traffic levels); or variable toll rates if MINMAX = 1

1 = variable toll rates, with congestion management stated as a major procurement objective for the public sector

Source documentation

Project planning documents (e.g., traffic-and-revenue studies, procurement documents), industry and/or popular news reports, academic reviews/case studies

Target elements within this literature

Examine the procurement documents for the evaluation criteria used in awarding the project: is the amount of up-front payment or subsidy a bid variable? Also consider news reports/analyses, which may indicate the public sector's goal is to collect the greatest up-front payment and/or to enable a contract which generates the maximum possible revenue for the concessionaire—for instance, to make a marginally self-sustaining project viable. Such a situation tends to arise when project costs are at or above the level of revenue forecasts (see traffic-and-revenue studies or industry reports).

Consider the contract's toll-setting mechanism: does the concessionaire have low or high flexibility in determining initial toll rates in order to deliver the most advantageous financial offer? Also consider the contract's mechanism for escalating tolls: is it based on a fixed indicator (such as CPI or GDP), or does the concessionaire have latitude to select from multiple annual indicators and/or apply a step function unrelated to these indices?

How to code these elements

0 = none of the conditions below (for MINMAX = 1) are met

1 = (a) subsidy minimization/revenue maximization is a stated procurement goal; or

(b) the level of payments to the state from the concessionaire (or the level of subsidies from the public sector) is among the evaluation criteria for the procurement; or

(c) the contract allows substantial latitude in the toll structure's "degrees of freedom," indicated by elements such as the following:
(i) the concessionaire specifies the initial and/or ongoing toll rates, or
(ii) toll escalation is based on the concessionaire's choice among multiple indicators (one of which is usually GDP), or by periodic increases which are much larger than typical GDP or CPI escalation

Project: **Scoring Worksheet**

Project Attribute	Traffic Risk Index					Toll Facility	
	1	2	3	4	5	Risk Score	Comments
Tolling Culture	Toll roads well established: data on actual use are available		No toll roads in the country, uncertainty over toll acceptance				
Toll Facility Details	Estuarial crossings; radial corridors into urban areas		Dense, urban networks; ring roads/beltways around urban areas				
	Extension/expansion of existing road		Greenfield site				
	Stand-alone (single) facility		Reliance on other, proposed highway improvements				
	Highly congested corridor		Limited/no congestion				
	Few competing roads		Many alternative routes				
Users	High-income, time-sensitive market		Average/low-income market				
Traffic Growth	Driven by/correlated with existing factors		Reliance on future growth factors, new developments, etc.				

Sum of Risk Scores:

Average Risk Score: (for average, divide sum by 8; round to one decimal place)

RISK variable = (0 if < 2.25; 1 if > 2.25)

Condition	Value
PRICING	
LENGTH	
UPSIDE	
DOWNSIDE	
RISK	

Outcome	Value
TOLLRATE	
FREEFLOW	
MINMAX	

Appendix C: Case Summaries

Route 460 Corridor Improvements (Virginia, USA) – first procurement

In 2003, Virginia's legislature called for a PPP to expand a 55-mile segment of US Route 460 between Suffolk and Petersburg. The new parallel highway would upgrade the road's capacity and safety standards and provide a hurricane evacuation route for the state's low-lying coastal regions, and the procurement was purposely structured as a PPP because no public funding was available. Although three concessionaire teams submitted conceptual proposals in 2006, they expressed concern that traffic demand would likely be insufficient to support the project, whose cost was estimated between $1 billion and $2 billion. To address this revenue risk, the 2009 draft comprehensive agreement outlined the first variable-length PPP in the US, stating tolls would be set at rates proposed by the concessionaire (Section 5 and Exhibit B-5). Still, the difficulty of funding the desired project scope solely through tolls indicated a revenue-maximizing pricing structure would be necessary for this highway to be built at all.

Although the concession's variable length covered most scenarios typically addressed by revenue sharing, the agreement nevertheless included such upside provisions (Exhibit E, Part C.1) in case toll income exceeded the project's targeted present value prior to the minimum 30-year concession term. There was no downside-risk sharing (Section 4.02(b)): if revenues did not reach the present-value target in 99 years, the concessionaire would receive no further compensation. Due to continued private-sector concerns about the project's economic viability, particularly with substantial diversion anticipated from the new tolled route to the parallel free route, no firms responded to the 2009 solicitation for detailed proposals. The procurement was terminated in 2010.

ID	PRICING	LENGTH	UPSIDE	DOWNSIDE	RISK	TOLLRATE	FREEFLOW	MINMAX
ROUTE460	2	0	1	0	3.4	0	0	1

References

Virginia Department of Transportation. (2006). Solicitation for Proposals, U.S. Route 460 Corridor Improvements Project through the Public-Private Transportation Act (issued February 15, 2006).

Virginia Department of Transportation. (2009). Request for Detailed Proposals, Part 3: Comprehensive Agreement, U.S. Route 460 Corridor Improvements Project, Addendum #1 (issued February 24, 2009).

Virginia General Assembly. (2003). Acts of Assembly, Chapter 953: "An Act to require the Virginia Department of Transportation to solicit proposals for improvements to U.S. Route 460 between Hampton Roads and the Richmond-Petersburg metropolitan area under the Public-Private Transportation Act of 1995."

I-595 Express Lanes (Florida, USA)

To relieve congestion along a busy 11-mile stretch of I-595, the Florida DOT (FDOT) planned a PPP for reversible HOT lanes in the highway's median, along with improvements to the existing corridor. Congestion pricing was envisioned on the new lanes to manage traffic flow, but FDOT recognized the desired improvements could not be fully covered by toll revenues. Hence funding for construction, operations, and maintenance was programmed into the state's long-range plan. The state retained toll-setting authority, as well as toll revenues, and the private developer was compensated through traffic-independent availability payments. FDOT issued a RFQ in October 2007, selected a concessionaire in October 2008, and finalized the contract in March 2009.

As the first availability-payment PPP in the US, this project has neither upside revenue sharing nor downside risk sharing: proposers declined the state's offer, in the draft concession agreement, to provide a per-car traffic payment in addition to the availability payment. The concession term extends 35 years from the date of the agreement.

ID	PRICING	LENGTH	UPSIDE	DOWNSIDE	RISK	TOLLRATE	FREEFLOW	MINMAX
I-595	1	1	0	0	1.3	0	1	0

References

Florida Department of Transportation. (2009). "Concession Agreement for I-595 Corridor Roadway Improvements Project" (executed March 3, 2009).

I-495 Capital Beltway HOT Lanes (Virginia, USA)

The I-495 concession extends 80 years from the date of the December 2007 comprehensive agreement, anticipating a five-year construction duration and a 75-year operating period. In order to include desired improvements to related highway facilities, the state plans to furnish $409 million of the project's estimated $1.4 billion overall cost. Congestion pricing will be implemented on the HOT lanes to maintain traffic at free-flow speeds.

The Virginia DOT agreed to cover certain elements of downside risk: "To assure that there is no disincentive for HOV and transit use of the HOT lanes, the Commonwealth will make payments to the Concessionaire if HOV use of the lanes exceeds projections under certain conditions." The state also shares in upside benefits resulting from refinancing gains, or if the concessionaire exceeds certain IRR targets (VDOT 2007a):

> The Commonwealth will also earn a permit fee (revenue sharing) of between 5 and 30 percent of earned annual gross revenue if projected HOT lane performance allows the private partners to achieve a rate of return on total invested funds in excess of agreed-to benchmarks. The permit fee will also be based on earned revenue from any positive project refinancing. Any permit fee or other revenues from the Project will be used for projects and programs that benefit the users of the HOT lanes.

(The last sentence is of interest from an economic perspective. Since it is essentially the individual drivers who have "paid too much" in the case of excess private-sector returns, the state ensures these road users realize the benefit of the shared revenues.)

The contract includes no non-compete provisions, but the concessionaire receives the right of first refusal to construct additional toll lanes if congestion exceeds the HOT lanes' capacity.

Original:

ID	PRICING	LENGTH	UPSIDE	DOWNSIDE	RISK	TOLLRATE	FREEFLOW	MINMAX
I-495	1	2	1	1	1.8	0	1	0

Re-coded:

ID	PRICING	LENGTH	UPSIDE	DOWNSIDE	RISK	TOLLRATE	FREEFLOW	MINMAX
I-495	1	2	1	0	1.8	0	1	0

References

Virginia Department of Transportation. (2007a). "Recommended Business Terms for the Capital Beltway High Occupancy Toll Lanes Comprehensive Agreement," Memo from Malcolm Kerley and Barbara Reese to David Ekern, September 5.

Virginia Department of Transportation. (2007b). "Amended and Restated Comprehensive Agreement Relating to the Route 495 HOT Lanes in Virginia Project" (executed December 19, 2007).

Chicago Skyway (Illinois, USA)

This eight-mile toll road and bridge linking southern Chicago to the Indiana border was opened in 1958. After years of light traffic, usage of the facility increased rapidly in the 1990's, and the city of Chicago took interest in leasing it to a private operator to provide a cash infusion for the city's budget difficulties. A competitive procurement eventually drew an offer of $1.83 billion from a consortium led by Australian investor Macquarie, and in 2005, the city finalized a 99-year operating-lease agreement structured with aggressive toll increases which enabled this sizeable up-front payment.

Macquarie felt comfortable with this substantial amount, noting the facility was well positioned for continued traffic and revenue growth. Average daily traffic levels in 2003 were around 48,000 vehicles, or 8000 vehicles per lane—about a third of the theoretical daily capacity of 23,000 vehicles per lane (Macquarie 2004). Further, the feasibility of diverting to competing facilities was limited, making drivers' demand more inelastic even with the increasing tolls.

ID	PRICING	LENGTH	UPSIDE	DOWNSIDE	RISK	TOLLRATE	FREEFLOW	MINMAX
SKYWAY	2	2	0	0	1.8	0	0	1

<u>References</u>

Macquarie (2004). Presentation, "Skyway financial close." <http://www.macquarie.com.au/au/mig/acrobat/mig_chicago_close.pdf> (October 30, 2009).

SR-91 Express Lanes (California, USA)

The State Route 91 project, one of four PPPs authorized by California's AB 680 legislation in 1989, comprised the 1995 addition of express lanes to the median of a congested ten-mile stretch of California's SR-91 freeway. Though there were no toll-rate restrictions for this facility with variable time-of-day pricing, any profits above 17% would be used to retire project debt (whose commercial interest rate was around 12%) or transferred to California's general highway fund. "The highway...was the first toll road in the United States to use variable congestion pricing. In addition, SR 91 was the world's first fully automated toll road, utilizing electronic transponders to collect tolls." (GAO, pp. 41-43)

Despite initial public resistance to tolling (GAO, p. 22), traffic demand was strong, with volume increasing from 7.3 million trips in 1999 to 9.5 million trips in 2002 due to growth in the region: "The project connects large residential areas in Riverside and San Bernardino counties, with major employment centers in Orange and Los Angeles counties. ...[O]ver the next 25 years Orange County is projected to add over a half million jobs, while Riverside County's population is projected to increase by one million people." (GAO, pp. 41, 43)

The concession extended 35 years, and the contract prohibited the state from expanding SR-91 or other facilities within 1.5 miles of the highway during this period. Construction of alternate routes was in fact unlikely, due to the mountains on either side of the route. (GAO, p. 43) Public pressure to improve SR-91's free lanes eventually led the state to buy the concession back from the developer in 2003.

ID	PRICING	LENGTH	UPSIDE	DOWNSIDE	RISK	TOLLRATE	FREEFLOW	MINMAX
SR91	1	1	1	0	1.4	0	1	0

References

Fielding, G.J., and Klein, D.B. (1993). "How to franchise highways." *J. Transp. Econ. Policy*, 27(2), 113-130.

US Government Accounting Office (GAO). (2004). "Highways and transit: private sector sponsorship of and investment in major projects has been limited." Report to Congressional Requesters, GAO-04-419, Washington, DC.

Price, W.T. (2001). "An odyssey of privatizing highways: the evolving case of SR 91." *Pub. Works Manage. Policy*, 5(4), 259-269.

Vining, A.R., Boardman, A.E., and Poschmann, F. (2005). "Public-private partnerships in the US and Canada: there are no free lunches." *J. Comp. Policy Analysis*, 7(3), 199-220.

SH-121 Managed Lanes (Texas, USA)

In 2007, the North Texas Tollway Authority (NTTA) granted TxDOT an up-front payment of $3.2 billion for a 50-year concession of 26 miles of State Highway 121, also known as the Sam Rayburn Tollway. At the time of the agreement, parts of SH-121 were already under construction through a separate TxDOT contract, and NTTA was responsible for integrating these with its construction of the remaining segments. The completed facility is to be 12 lanes wide, with three toll lanes and three frontage lanes (free lanes with traffic lights and lower speed limits) in each direction. Heavy population growth and increasing congestion in the Dallas-Fort Worth area are the main project drivers.

All-electronic time-of-day pricing will be used on the toll lanes, subject to per-mile base rate caps specified in Exhibit R, "Toll Regulations," of the Project Agreement. These maximum rates may be escalated every two years. According to Section 22(b)(ii) of the Agreement, tolls may be further increased if necessary to "preserve the financial condition of the NTTA System [or] comply with the provisions of any bonds, notes, trust agreements or other financial instruments or agreements secured by the revenues of the NTTA System."

Exhibit Q of the Agreement, "Table 1 – Band Floors and Ceilings" and "Table 2 – TxDOT Revenue Share Applicable Percentages," specifies traffic bands at which certain percentages of toll revenues will be shared with TxDOT.

ID	PRICING	LENGTH	UPSIDE	DOWNSIDE	RISK	TOLLRATE	FREEFLOW	MINMAX
SH121	1	2	1	1	1.4	1	1	0

References

Samuel, P. (2007). "$3.2b financial close on public-public toll concession for TX121," *TollRoadsNews*, November 30.

Texas Department of Transportation. (2007). "Project Agreement: SH 121 Toll Project" (executed October 18, 2007).

Warnow Tunnel (Germany) – first procurement

This immersed-tube tunnel, recognized as the country's first infrastructure PPP, was completed in 2003 and replaced a ferry across the Warnow River in Rostock, Germany. The contract, based on the country's 1994 "F Model" concessions law, was to have a 30-year term. Alternate routes included downtown city streets in Rostock, as well as a subsequently-constructed autobahn link.

In the early planning stages, proposers were furnished optimistic traffic forecasts ranging from 27,000 to 35,000 vehicles per day. These forecasts assumed traffic-calming measures would be installed in downtown Rostock and neglected the impact of traffic diversion to the nearby autobahn connection completed shortly after the tunnel's opening. The contract included no non-compete provisions.

During the design and planning process, the state requested various changes which raised the project cost considerably, and it was assumed this cost growth could be covered by higher tolls. Ultimately the government contributed 12% (about €26 million) of the project's €219 million cost, with the remainder drawn from sponsor equity and debt. Tolls were intended to cover the concessionaire's costs, with forecast revenues based on traffic projections, and were constant for each class of vehicle: passenger-car rates were initially set at €2.50 (summer) and €2.00 (winter), for instance.

A revised forecast later set the initial count at 13,000 vehicles. But traffic counts in the months after the facility's opening averaged less than 7000 vehicles per day, leading to substantial losses for the concessionaire.

ID	PRICING	LENGTH	UPSIDE	DOWNSIDE	RISK	TOLLRATE	FREEFLOW	MINMAX
WARNOW1	0	1	0	0	3.4	1	0	0

References

Beckers, T. (2005). "Die Realisierung von Projekten nach dem PPP-Ansatz bei Bundesfernstraßen," Dissertation, Technische Universität Berlin.

Boecker, A. (2004). "Private Straßenbetreiber über Auslastung enttäuscht," *Die Deutsche Bauindustrie,* September 14.

Boyce, A. (2006). "Rostock revisited." *Proc., European Transport Conference,* Strasbourg.

Gawel, E. (2005). "Private Finanzierung von Fernstraßen: Erfahrungen und Probleme," *Wirtschaftsdienst,* 85(3), 173-181.

Warnow Tunnel (Germany) – renegotiated contract

Following renegotiation, the Warnow Tunnel's concession length was increased in June 2006 from 30 to 50 years. After new tolls were implemented in spring 2008 and 2009 (Macquarie 2008, 2009), the result in 2008 was a 1.4% increase in traffic and a 6.5% increase in revenue, followed by 2009 growth of 1.9% and 7.3% in traffic and revenue, respectively.

Because traffic is still increasing along with revenue, toll rates are not yet at full revenue-maximizing levels. Yet the operator continues to negotiate with the state for periodic toll increases (Landtag 2009), a process which is complicated by the requirement of government approval for each adjustment. Hence the pricing outcomes are essentially a hybrid, balancing the concessionaire's efforts to maximize revenues to the extent possible with the state's goal to maintain toll rates which are societally acceptable.

As of April 2009, passenger-car rates were €2.90 (summer) and €2.30 (winter), with discounts for transponder users.

ID	PRICING	LENGTH	UPSIDE	DOWNSIDE	RISK	TOLLRATE	FREEFLOW	MINMAX
WARNOW2	2	2	0	0	2.6	1	0	1

References

Landtag Mecklenburg-Vorpommern. (2009). "Kleine Anfrage des Abgeordneten Birger Lüssow, Fraktion der NPD, Warnowquerung und Betreiber Macquarie Bank und Antwort der Landesregierung." Report no. 5/2501, May 14.

Macquarie (2008). "Warnow Tunnel." *Macquarie Infrastructure Group: Annual Report 2008*. <http://www.frostdesign.com.au/MIG_annual_report_2008/asset-html.html#Warnow> (April 5, 2010).

Macquarie (2009). "Warnow Tunnel." *Macquarie Infrastructure Group: Annual Report 2009.* <http://mig.republicast.com/ar2009/?page=20> (April 5, 2010).

MVregio News. (2006). "Rostock: Lehren aus dem Warnowtunnel ziehen," June 2. <http://www.mvregio.de/nachrichten_region/hro/11990.html> (April 5, 2010).

Herren Tunnel (Germany)

In 2005, a bored tunnel under the river Trave replaced an obsolete bascule bridge in Germany's northern coastal city of Lübeck. This "Herrentunnel" was the country's second PPP, and like the Warnow crossing, it was structured according to the "F Model," with a 30-year concession period. The German government provided a subsidy of €89 million, the estimated amount necessary for in-kind replacement of the bascule bridge, which totaled about half the project's €176 million cost.

Based on traffic volumes across the existing bridge, 40,000 to 45,000 vehicles per day were anticipated at the tunnel, and tolls were promised at 1 mark, or €0.51, accordingly. Inflation and additional tunnel-safety requirements increased this estimate; and when a new autobahn link was completed nearby, daily traffic on the existing bridge fell to 30,000 vehicles, prompting the tunnel's opening toll finally to be set at €0.90. New chokepoints formed at the city's untolled bridges across the Trave, and daily traffic through the tunnel averaged 22,000 vehicles, leading to a toll increase the following year to €1.10 and a traffic volume of 20,000 vehicles. (This revenue growth, in parallel with a decline in traffic, indicates tolls near or at the revenue-maximizing level.)

Initial:

ID	PRICING	LENGTH	UPSIDE	DOWNSIDE	RISK	TOLLRATE	FREEFLOW	MINMAX
HERREN	0	1	0	0	3.0	0	0	1

Re-coded:

ID	PRICING	LENGTH	UPSIDE	DOWNSIDE	RISK	TOLLRATE	FREEFLOW	MINMAX
HERREN	2	1	0	0	3.0	0	0	1

References

Beckers, T. (2005). "Die Realisierung von Projekten nach dem PPP-Ansatz bei Bundesfernstraßen," Dissertation, Technische Universität Berlin.

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Skye Bridge (UK)

The Skye Bridge opened in 1995, with capital costs of approximately £39 million, to replace a ferry whose waiting times reached 30 minutes during seasonal peak periods. The state contributed £6 million to cover the anticipated cost of approach roads, plus nearly £3 million additional to compensate the concessionaire for time and cost impacts of occasioned by the public sector. The project's financing was 98% debt and 2% equity.

According to Debande (2002), "The concession contract assigned to SBL [the concessionaire] the rights to charge tolls for traffic using the crossing, based on a fixed-price mechanism, that is, the tolls can be increased in relation to the RPI, with annual increases after the opening of the bridge. However, if toll revenue fell below a level corresponding to some 450,000 vehicles crossing a year (the 1990 traffic level), SBL could increase tolls up to 30 per cent more than the rate of inflation." This latter element provided downside risk protection.

The state also sought a specific toll rate, not exceeding the inflation-adjusted level of 1991 ferry charges. "SBL obtained in compensation a longer concession period. The period was defined by the promoter's worst case traffic projections inducing low volume risk. A semi-variable term for the operation of the bridge was included. The contract required SBL to cease collecting tolls when the pre-determined 'required net present value' or 27 years after opening the bridge was achieved, even if by this date the company had not achieved the target toll revenue." (Debande 2002)

As of 2002, traffic levels were such that the concession was expected to reach this pre-determined value of £23.64 million (at 1990 price levels, discounted at 6% plus inflation) between 2009 and 2013. Due to strong public opposition against the tolls, though, the state bought out the concession in late 2004 and abolished the tolls, paying the concessionaire a lump-sum termination fee of nearly £27 million.

ID	PRICING	LENGTH	UPSIDE	DOWNSIDE	RISK	TOLLRATE	FREEFLOW	MINMAX
SKYE	0	0	0	1	2.4	1	0	0

References

Debande, O. (2002). "Private financing of transport infrastructure: an assessment of the UK experience." *J. Transp. Econ. Policy*, 36(3), 355-387.

Highland Council. (2004). "Skye Bridge tolls: judicial review." Report by Head of Legal Services, June 24.

Moles, P., and Williams, G. (1995). "Privately funded infrastructure in the UK: participants' risk in the Skye Bridge project." *Transp. Policy*, 2(2), 129-134.

Scottish Parliament (2009). "Examples of public sector PPP/PFI contract buy outs." Advisory Paper, Finance Committee.

Second Tagus Crossing, or Vasco da Gama Bridge (Portugal)

With increasing congestion on the sole crossing of Lisbon's Tagus River, the April 25 Bridge, a joint concession for this structure and an additional not-yet-built bridge formed Portugal's first project-financed PPP in 1995. Construction of the new €645 million crossing, the Vasco da Gama Bridge, began in 1994, and the concessionaire took over operations of the existing span in 1996. The concession was to last 33 years (until March 2028), or until a cumulative traffic count of 2,250 million vehicles had been reached, whichever came first (de Lemos et al. 2004).

The government provided a schedule of toll rates for both bridges, with original tolls on the older structure to be gradually increased to €1.50, matching the eventual level of the new bridge. But public outcry forced the state to withdraw this plan, setting tolls at €0.75 and then €1.00 instead, and to provide the difference in revenues to the concessionaire out of state funds. Although traffic counts exceeded projected demand, the concession was renegotiated in 2000 with a fixed term expiring in March 2030, independent of traffic levels.

ID	PRICING	LENGTH	UPSIDE	DOWNSIDE	RISK	TOLLRATE	FREEFLOW	MINMAX
LISBON	0	0	0	0	1.6	1	0	0

References

de Lemos, T., Eaton, D., Betts, M., and de Almeida, L.T. (2004). "Risk management in the Lusoponte concession: a case study of the two bridges in Lisbon, Portugal." *Int. J. Proj. Manage.*, 22(1), 63-73.

Fernandes, C., and Viegas, J.M. (2005). "Portuguese experience in motorway concessions with real and shadow tolls." *Res. Transp. Econ.*, 15, 157-174.

Autopista M-12 or Eje Aeropuerto (Spain)

When Madrid expanded its Barajas Airport to include a distant new terminal, the M-12 road and tunnel were built to provide access to the new facility. This 9-km highway opened in June 2005 at a total investment cost of €427 million and was delivered as a 25-year concession with a final reversion fee. This amount, which was a bid variable, would be paid to the developer at the end of the PPP term in recognition that the short concession length may not permit recouping full capital and operations costs. Although reversion fees can be structured as variable amounts to compensate concessionaires for traffic uncertainty, in this case the constant demand for airport access was anticipated to minimize the project's traffic-demand risk, and the fee was constant (Vassallo and Maté 2002).

The initial toll was specified to increase annually by CPI (the 2010 level is €1.75), and average daily traffic in 2007 was 11,356 vehicles. After growing 16% from 2006 to 2007, these traffic levels fell 7% between 2007 and 2008, and the concessionaire submitted a request for contract rebalancing to the state in June 2008 (OHL 2008, 2009).

ID	PRICING	LENGTH	UPSIDE	DOWNSIDE	RISK	TOLLRATE	FREEFLOW	MINMAX
MADRID	0	1	0	0	2.1	1	0	0

> *Postscript: Subsequent review of original-language documents indicated initial traffic projections of 25,000 vehicles per day, forecast to increase to 50,000 once the new airport terminal opened in 2006. In addition to servicing the airport, the road was designed as a partial alternate outer beltway around Madrid, even though competing roads were untolled.*

References

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OHL. (2009). "Presentation: OHL Concesiones, April 23, 2009." <http://acm.ohlconcesiones.com/ACM_Upload/75MYZ692009.pdf> (April 5, 2010).

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Europa Press. (2005). "Abre al tráfico la autopista M-12." *El Mundo,* June 16.

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El Melón Tunnel (Chile)

The 23-year concession of the El Melón Tunnel, located on the Pan-American Highway 130 km north of Santiago, was in 1993 the first project in Chile's PPP program (Engel et al. 2003). The concession award was based on evaluation of seven variables, only two of which were weighted heavily enough to be influential in the outcome: toll rate structure and annual payment to the state. All four bidders requested the maximum allowable toll rates and concession length, with the award ultimately determined based on annual concession fee—bids for which ranged from $24,000 to $3.4 million among the four offerors (Paredes and Sánchez 2004).

The emphasis on a high annual concession payment drove tolls to the maximum permissible cap. The state guaranteed minimum traffic levels, though for the sum of vehicles using the tunnel and the winding single-lane El Melón hill road. Diversion to this free route was substantial, and the concessionaire unsuccessfully pressed for renegotiation. "The government has refused to change toll prices and transfers beyond the contract stipulations on the grounds that conditions have not changed, that a bidder in a concession must accept the demand risk, and that renegotiation is costly and hampers its reputation" (Basañes et al. 1998). The concessionaire subsequently lowered tolls in an effort to attract traffic from the free road (Gómez-Lobo and Hinojosa 2000).

To share any upside benefits, the contract stipulated profits must be split equally with the state once the concessionaire's rate of return exceeds 15%.

ID	PRICING	LENGTH	UPSIDE	DOWNSIDE	RISK	TOLLRATE	FREEFLOW	MINMAX
ELMELON	2	1	1	0	2.8	0	0	1

References

Basañes, C.F., Saavedra, E., and Soto, R. (1998). "Post-privatization renegotiation and disputes in Chile." Working paper no. 116, Infrastructure and Financial Market, Washington, DC.

Engel, E., Fischer, R., and Galetovic, A. (2003). "Privatizing highways in Latin America: is it possible to fix what went wrong?" Discussion paper no. 866, Economic Growth Center, Yale University.

Gómez-Lobo, A., and Hinojosa, S. (2000). "Broad roads in a thin country: infrastructure concessions in Chile." Policy research working paper no. 2279, World Bank.

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Paredes, R. D., and Sánchez, J. M. (2004). "Government concession contracts in Chile: the role of competition in the bidding process." *Econ. Devel., Cult. Change*, 53(1), 215-234.

Santiago-Valparaíso-Viña del Mar Toll Road, or Route 68 (Chile)

This 141-km collection of new and existing highways, connecting major cities in central Chile, was the first PPP in the Americas to use the least present value of revenue (LPVR) concession structure. Its 1998 contract also incorporated a minimum income guarantee to cover downside risk (Vassallo 2006), along with a minimum concession term of 12 years. The maximum term was 25 years, though "based on official cost and traffic estimates, the concession is expected to last approximately 17 years." (Gómez-Lobo and Hinojosa 2000) Because most toll highways in Chile have no free alternatives (Vassallo 2006, p. 366), traffic demand risk is reduced.

A comparison of this contract's specified toll caps (Chile 2008) with the highway's actual toll rates indicates the concessionaire is charging the highest permitted toll for almost all vehicle classes, seeking revenue-maximizing income within the rate-cap constraints. This approach is consistent with an LPVR structure, since the private sector logically seeks to reduce uncertainty about future receipts, thus preferring higher tolls in order to accelerate income and end the concession sooner.

ID	PRICING	LENGTH	UPSIDE	DOWNSIDE	RISK	TOLLRATE	FREEFLOW	MINMAX
SANTIAGO	2	0	0	1	1.3	1	0	0

References

Birebent, P. (2003). "Case study: Rutas del Pacifico SA." *Project Finance International*, March 2003.

Chile Ministry of Public Works. (2008). "Señala tarifas máximas en la obra pública fiscal denominada 'Concesión Internacional Interconexión Vial Santiago-Valparaíso-Viña del Mar'," Santiago, December 29.

Engel, E., Fischer, R., and Galetovic, A. (2003). "Privatizing highways in Latin America: is it possible to fix what went wrong?" Discussion paper no. 866, Economic Growth Center, Yale University.

Gómez-Lobo, A., and Hinojosa, S. (2000). "Broad roads in a thin country: infrastructure concessions in Chile." Research paper 2279, World Bank Institute, Washington, DC.

Vassallo, J. M. (2006). "Traffic risk mitigation in highway concession projects: the experience of Chile." *J. Transp. Econ. Policy*, 40(3), 359-381.

407 ETR (Ontario, Canada) – first procurement

Strong population and commercial growth around Toronto in the early 1990's led to interest in finally constructing the long-planned Highway 407 to ease the area's heavy traffic congestion and air pollution. Since the Ontario government was weak financially due to a recent recession, it planned to contract for the facility as a PPP toll road, which would also serve as a job-creation opportunity (Miller 2002).

Without traffic or revenue guarantees, though, the cost of the originally-envisioned private-sector debt was at least 0.75% greater than that of public-sector borrowing (Vining et al. 2005). As a result, the province assumed full responsibility for the facility's C$1.5 billion financing, and the 407 Express Toll Route (ETR) was procured in 1994 as a 30-year design-build-operate contract. During the 18 months which Ontario held the highway following completion, it retained toll-setting authority and revenues, along with the project's revenue risk.

The pricing was variable by time of day (Samuel 1996) to control congestion.

ID	PRICING	LENGTH	UPSIDE	DOWNSIDE	RISK	TOLLRATE	FREEFLOW	MINMAX
407ETR1	1	1	0	0	2.9	0	1	0

References

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Samuel, P. (1996). "407-ETR marketing," *TollRoadsNews*, October 29.

Vining, A. R., Boardman, A. E., and Poschmann, F. (2005). "Public-private partnerships in the US and Canada: there are no free lunches." *J. Comp. Policy Analysis*, 7(3), 199-220.

407 ETR (Ontario, Canada) – second procurement

To retire the 407 ETR's construction debt and divest many of the public sector's retained risks, Ontario subsequently leased the highway to a private operator in May 1999 in exchange for an up-front payment of C$3.1 billion. As an additional condition of the 99-year operating lease, the concessionaire was required to provide some $900 million of capital improvements, adding 39 km to the facility's existing 69 km.

According to Mendoza et al. (1999), "The decision on the concession's term generated perhaps the most debate. The objective was to offer a term long enough *to extract the highest possible value from the road* [italics added—indicating the state's goal of achieving maximum revenue] but not beyond that for which no additional value could be generated. Terms from 35 to 999 years were considered. Eventually, bidders were asked to submit indicative prices based on three concession terms. A ninety-nine-year term was ultimately chosen for several reasons. First, the province believed it had a mandate to genuinely privatize Highway 407, not merely lease it. Second, the privatization team believed that a very long concession term offered ownership and financing benefits that would generate a significantly higher winning bid than a shorter term, but that no real value would be achieved beyond ninety-nine years. Finally, potential legal issues in Canada regarding leases longer than ninety-nine years were avoided."

The goal was for the road to accommodate a full capacity of 9000 vehicles/hour at peak periods. If traffic levels were less than capacity, the concessionaire was permitted to charge passenger vehicles a toll of 10¢ per km, increasing annually at a rate linked to inflation. If traffic exceeded peak-hour capacity, the concessionaire could raise tolls as necessary to bring the flow back to 9000 vehicles/hour (Miller 2002). There was no rate-of-return restriction (Mendoza et al. 1999). In 2004, the concessionaire asserted it was losing money on the contract and raised the initial base-toll levels, despite initial opposition and unsuccessful lawsuits from the government.

Initial:

ID	PRICING	LENGTH	UPSIDE	DOWNSIDE	RISK	TOLLRATE	FREEFLOW	MINMAX
407ETR2	2	2	0	0	1.9	0	1	1

Re-coded:

ID	PRICING	LENGTH	UPSIDE	DOWNSIDE	RISK	TOLLRATE	FREEFLOW	MINMAX
407ETR2	2	2	0	0	1.9	0	0	1

References

Mendoza, E., Gold. M., Carter, P., and Parmar, J. (1999). "The sale of Highway 407 express toll route: a case study." *J. Proj. Finance*, 5(3), 5-14.

Miller, J.B. (2002). "Highway 407 ETR (Part 2)." *Case studies in infrastructure delivery,* Kluwer Academic Publishers, Norwell, Mass., 149-62.

Vining, A. R., Boardman, A. E., and Poschmann, F. (2005). "Public-private partnerships in the US and Canada: there are no free lunches." *J. Comp. Policy Analysis*, 7(3), 199-220.

Confederation Bridge (Prince Edward Island, Canada)

When Prince Edward Island became a Canadian province in 1873, it was constitutionally established that the Canadian government would provide ferry access in perpetuity from the mainland to the island. Interest in a fixed link gradually increased due to complications from icy winter conditions in the channel as well as increasing ferry-service costs. Proposals were solicited in 1987, a developer was selected in 1992, and the eight-mile bridge was opened to traffic in 1997 at a construction cost of over $1 billion.

The procurement was structured as a 35-year concession, with the compensation in the form of annual $41.9 million payments (in 1992 Canadian dollars), which represented the government's approximate subsidy of the subsequently-discontinued ferry services. In addition, the operator collected all toll revenues, with tolls initially set at a level equivalent to the previous ferry rates, with annual increases linked to inflation. (As of 2010, car tolls were C$42.50 for a round trip, or approximately US$42.25). The state also provided the concessionaire a minimum revenue guarantee of C$13.9 million annually (Vining et al. 2005).

ID	PRICING	LENGTH	UPSIDE	DOWNSIDE	RISK	TOLLRATE	FREEFLOW	MINMAX
CONFED	0	1	0	1	2.4	1	0	0

References

Miller, J.B. (2002). "Confederation Bridge over the Northumberland Strait." *Case studies in infrastructure delivery,* Kluwer Academic Publishers, Norwell, Mass., 99-114.

Vining, A.R., Boardman, A.E., and Poschmann, F. (2005). "Public-private partnerships in the US and Canada: there are no free lunches." *J. Comp. Policy Analysis*, 7(3), 199-220.

Cross City Tunnel (New South Wales, Australia)

The Cross-City Tunnel under Sydney's central business district was envisioned as a shortcut saving motorists 15-20 minutes per peak-hour trip. Although initial analyses indicated a weak cost-benefit relationship for the project (Phibbs 2008), the state nevertheless proposed advancing it as a 30-year PPP concession.

Because the government insisted the tunnel be built at no cost to the public sector, numerous changes during the planning stage were offset through higher initial tolls and a more aggressive toll-escalation structure. The state paid for $75 million of extra work, for instance, by increasing the annual toll escalation from direct CPI to the greater of 4% or CPI, which would be decreased gradually to CPI escalation in the later years of the concession (Phibbs 2008). The change with the most significant impact, though, was an increase in the tunnel's length from the originally-envisioned 1.2 km to a final length of 2.1 km. As a result of these scope changes, the base toll (which was originally estimated at $2.50 in 1998) rose to $3.56 when the $800 million tunnel opened in 2005. Part of this rate covered the winning concessionaire's $100 million up-front payment to the state. The two unsuccessful proposers, who had calculated much lower traffic forecasts, requested government subsidies for the project instead.

Traffic forecasts prepared by the concessionaire and the state's advisor were highly optimistic: initial projections anticipated 70,000 vehicles per day, but the facility's opening produced barely 20,000 daily users. Even a brief toll-free period raised daily traffic demand only to 50,000 trips. Although the city had planned traffic-calming measures for above-ground streets in anticipation of reduced surface traffic, the tunnel's light usage resulted in continued heavy demand for these roadways. Significant public opposition arose to this closure and reconfiguring of downtown streets, which drivers viewed as an attempt to force them to use the tunnel by making free roads impractical.

Although the concessionaire hoped traffic would grow closer to forecast levels after an initial ramp-up period, these anticipated volumes never materialized. The project went into receivership in 2006, less than two years after its opening, and was sold to an investor group in 2007.
It became Australia's first road PPP to fail financially.

ID	PRICING	LENGTH	UPSIDE	DOWNSIDE	RISK	TOLLRATE	FREEFLOW	MINMAX
CROSCITY	2	1	0	0	3.0	0	0	1

References

New South Wales Government. (2008). "Cross City Tunnel: summary of contracts." Report, Roads and Traffic Authority, June 30.

Phibbs, P. (2008). "Driving alone: Sydney's Cross City Tunnel." *Built Environment*, 33(3), 364-374.

Appendix D: Risk Worksheets

Project: Route 460 (Virginia, USA) – first procurement Risk Worksheet

Project Attribute	Traffic Risk Index					Toll Facility	
	1	2	3	4	5	Risk Score	Comments
Tolling Culture	Toll roads well established: data on actual use are available				No toll roads in the country, uncertainty over toll acceptance	4	Few tollroads in region; prospect of toll facilities unpopular with majority of drivers
Toll Facility Details	Estuarial crossings; radial corridors into urban areas				Dense, urban networks; ring roads/beltways around urban areas	1	Radial connector between Richmond and Hampton Roads metropolitan areas
	Extension/expansion of existing road				Greenfield site	3	Parallel route to existing road
	Stand-alone (single) facility				Reliance on other, proposed highway improvements	1	Contract to include all necessary connections to existing routes
	Highly congested corridor				Limited/no congestion	5	Existing parallel facility occasionally congested, e.g. at stoplights
	Few competing roads				Many alternative routes	5	Free existing parallel route (460); free interstate alternative (I-64)
Users	High-income, time-sensitive market				Average/low-income market	4	Average-income users; significant commercial/ freight traffic component
Traffic Growth	Driven by/correlated with existing factors				Reliance on future growth factors, new developments, etc.	4	Facility relies on future growth of Hampton Roads port/freight traffic

Sum of Risk Scores: 27

Average Risk Score: 3.4 ➔ High Risk

Project: I-595 Express Lanes (Florida, USA)

Project Attribute	Traffic Risk Index					Toll Facility	
	1	2	3	4	5	Risk Score	Comments
Tolling Culture	Toll roads well established: data on actual use are available			No toll roads in the country, uncertainty over toll acceptance		1	Local users/residents accustomed to paying tolls on nearby Florida Turnpike
Toll Facility Details	Estuarial crossings; radial corridors into urban areas			Dense, urban networks; ring roads/beltways around urban areas		1	Radial corridor into Ft. Lauderdale area
	Extension/expansion of existing road			Greenfield site		1	Addition of express lanes to existing corridor
	Stand-alone (single) facility			Reliance on other, proposed highway improvements		2	Eastward extension to I-95 to be completed later as future/separate project
	Highly congested corridor			Limited/no congestion		1	Existing I-595 corridor highly congested
	Few competing roads			Many alternative routes		1	City-street alternatives are significantly slower; free parallel lanes are heavily congested in peak hours
Users	High-income, time-sensitive market			Average/low-income market		2	Many users are urban business commuters
Traffic Growth	Driven by/correlated with existing factors			Reliance on future growth factors, new developments, etc.		1	Strong traffic flow/demand already exists

Sum of Risk Scores: 10

Average Risk Score: 1.3 ➔ Low Risk

Project: I-495 Capital Beltway HOT Lanes (Virginia, USA) Risk Worksheet

Project Attribute	Traffic Risk Index					Toll Facility	
	1	2	3	4	5	Risk Score	Comments
Tolling Culture	Toll roads well established: data on actual use are available			No toll roads in the country, uncertainty over toll acceptance		2	Multiple tollroads already in region (e.g. Dulles Tollroad and Greenway), though no previous HOT lanes
Toll Facility Details	Estuarial crossings; radial corridors into urban areas			Dense, urban networks; ring roads/beltways around urban areas		5	Beltway around Washington, DC
	Extension/expansion of existing road			Greenfield site		1	Addition of toll lanes to existing corridor
	Stand-alone (single) facility			Reliance on other, proposed highway improvements		2	System partially linked to proposed I-95/395 HOT lanes project
	Highly congested corridor			Limited/no congestion		1	High congestion
	Few competing roads			Many alternative routes		1	Few practical alternatives (free lanes on I-495 are prohibitively congested at peak hours)
Users	High-income, time-sensitive market			Average/low-income market		1	High-income users
Traffic Growth	Driven by/correlated with existing factors			Reliance on future growth factors, new developments, etc.		1	Strong traffic demand already exists

Sum of Risk Scores: 14

Average Risk Score: 1.8 ➔ Low Risk

Project: Chicago Skyway (Illinois, USA) Risk Worksheet

<table>
<tr><th rowspan="2">Project Attribute</th><th colspan="10">Traffic Risk Index</th><th colspan="2">Toll Facility</th></tr>
<tr><th colspan="2">1</th><th colspan="2">2</th><th colspan="2">3</th><th colspan="2">4</th><th colspan="2">5</th><th>Risk Score</th><th>Comments</th></tr>
<tr><td>Tolling Culture</td><td colspan="5">Toll roads well established: data on actual use are available</td><td colspan="5">No toll roads in the country, uncertainty over toll acceptance</td><td>1</td><td>Existing facility with long toll history</td></tr>
<tr><td rowspan="5">Toll Facility Details</td><td colspan="5">Estuarial crossings; radial corridors into urban areas</td><td colspan="5">Dense, urban networks; ring roads/beltways around urban areas</td><td>2</td><td>Radial corridor/river crossing in dense urban area</td></tr>
<tr><td colspan="5">Extension/expansion of existing road</td><td colspan="5">Greenfield site</td><td>1</td><td>Operating lease of existing facility</td></tr>
<tr><td colspan="5">Stand-alone (single) facility</td><td colspan="5">Reliance on other, proposed highway improvements</td><td>1</td><td>Established stand-alone facility</td></tr>
<tr><td colspan="5">Highly congested corridor</td><td colspan="5">Limited/no congestion</td><td>3</td><td>Strong traffic demand exists, though facility has unused capacity remaining</td></tr>
<tr><td colspan="5">Few competing roads</td><td colspan="5">Many alternative routes</td><td>3</td><td>Recent completion of improvements to local interstates now offers increased competition</td></tr>
<tr><td>Users</td><td colspan="5">High-income, time-sensitive market</td><td colspan="5">Average/low-income market</td><td>2</td><td>Primarily urban commuters</td></tr>
<tr><td>Traffic Growth</td><td colspan="5">Driven by/correlated with existing factors</td><td colspan="5">Reliance on future growth factors, new developments, etc.</td><td>1</td><td>Strong current traffic and recent traffic growth</td></tr>
</table>

Sum of Risk Scores: 14

Average Risk Score: 1.8 ➔ Low Risk

Project: SR-91 Express Lanes (California, USA) Risk Worksheet

Project Attribute	**Traffic Risk Index**					**Toll Facility**	
	1	2	3	4	5	Risk Score	Comments
Tolling Culture	Toll roads well established: data on actual use are available			No toll roads in the country, uncertainty over toll acceptance		3	Several other tollroads exist in Orange County, though public opposition existed to adding another toll route
Toll Facility Details	Estuarial crossings; radial corridors into urban areas			Dense, urban networks; ring roads/beltways around urban areas		1	Radial connection between large residential zones and major employment centers
	Extension/expansion of existing road			Greenfield site		1	Addition of express lanes in median of existing road
	Stand-alone (single) facility			Reliance on other, proposed highway improvements		1	Express lanes effective as stand-alone project
	Highly congested corridor			Limited/no congestion		1	Existing SR-91 lanes were highly congested
	Few competing roads			Many alternative routes		1	Contract included non-compete clause; mountains adjoining roadway also prohibited expansion
Users	High-income, time-sensitive market			Average/low-income market		2	Urban/suburban commuters
Traffic Growth	Driven by/correlated with existing factors			Reliance on future growth factors, new developments, etc.		1	Project addressed existing congestion, forecast to become more severe

Sum of Risk Scores: 11

Average Risk Score: 1.4 ➔ Low Risk

Project: SH-121 Managed Lanes (Texas, USA) Risk Worksheet

Project Attribute	**Traffic Risk Index**					**Toll Facility**	
	1	2	3	4	5	Risk Score	Comments
Tolling Culture	Toll roads well established: data on actual use are available				No toll roads in the country, uncertainty over toll acceptance	1	North Texas Tollway Authority operates several other toll facilities in region
Toll Facility Details	Estuarial crossings; radial corridors into urban areas				Dense, urban networks; ring roads/beltways around urban areas	3	Partially radial, partially circumferential corridor into Dallas/Ft. Worth urban area
	Extension/expansion of existing road				Greenfield site	1	Partial upgrade of existing road to freeway standards
	Stand-alone (single) facility				Reliance on other, proposed highway improvements	1	Facility connects other major thoroughfares
	Highly congested corridor				Limited/no congestion	1	Significant congestion already exists
	Few competing roads				Many alternative routes	1	Few practical alternatives
Users	High-income, time-sensitive market				Average/low-income market	2	Urban/suburban commuters including Dallas/Ft. Worth airport traffic
Traffic Growth	Driven by/correlated with existing factors				Reliance on future growth factors, new developments, etc.	1	Recent strong population growth in region is forecast to continue

Sum of Risk Scores: 11

Average Risk Score: 1.4 ➔ Low Risk

Project: Warnow Tunnel (Germany) – first procurement Risk Worksheet

Project Attribute	Traffic Risk Index					Toll Facility	
	1	2	3	4	5	Risk Score	Comments
Tolling Culture	Toll roads well established: data on actual use are available			No toll roads in the country, uncertainty over toll acceptance		5	Facility was Germany's first modern-day toll road
Toll Facility Details	Estuarial crossings; radial corridors into urban areas			Dense, urban networks; ring roads/beltways around urban areas		3	Crossing of Warnow River, but part of ring road around city of Rostock
	Extension/expansion of existing road			Greenfield site		3	No previous fixed crossing, but relevant demand data were available from ferry service at same location
	Stand-alone (single) facility			Reliance on other, proposed highway improvements		1	Stand-alone facility
	Highly congested corridor			Limited/no congestion		3	Tunnel allowed bypassing congestion in city center
	Few competing roads			Many alternative routes		5	Anticipated traffic-calming measures on free alternate routes were not installed
Users	High-income, time-sensitive market			Average/low-income market		4	Many users did not place high value on time savings
Traffic Growth	Driven by/correlated with existing factors			Reliance on future growth factors, new developments, etc.		3	Commercial traffic forecasts rely on future port growth; regional population is expected to decline

Sum of Risk Scores: 27

Average Risk Score: 3.4 ➔ High Risk

Project: Warnow Tunnel (Germany) – renegotiated contract Risk Worksheet

Project Attribute	**Traffic Risk Index**					**Toll Facility**	
	1	2	3	4	5	Risk Score	Comments
Tolling Culture	Toll roads well established: data on actual use are available			No toll roads in the country, uncertainty over toll acceptance		1	Actual data on facility's toll acceptance were available from 2003-06 operations
Toll Facility Details	Estuarial crossings; radial corridors into urban areas			Dense, urban networks; ring roads/beltways around urban areas		3	Crossing of Warnow River, but part of ring road around city of Rostock
	Extension/expansion of existing road			Greenfield site		1	Actual usage levels (low) were known from traffic data since 2003 opening
	Stand-alone (single) facility			Reliance on other, proposed highway improvements		1	Stand-alone facility
	Highly congested corridor			Limited/no congestion		3	Tunnel allowed bypassing congestion in city center
	Few competing roads			Many alternative routes		5	Anticipated traffic-calming measures on free alternate routes were not installed
Users	High-income, time-sensitive market			Average/low-income market		4	Many users did not place high value on time savings
Traffic Growth	Driven by/correlated with existing factors			Reliance on future growth factors, new developments, etc.		3	Commercial traffic forecasts rely on future port growth; regional population is expected to decline

Sum of Risk Scores: 21

Average Risk Score: 2.6 ➔ High Risk

Project: Herren Tunnel (Germany)

<table>
<tr><th rowspan="2">Project Attribute</th><th colspan="10">Traffic Risk Index</th><th colspan="2">Toll Facility</th></tr>
<tr><th colspan="2">1</th><th colspan="2">2</th><th colspan="2">3</th><th colspan="2">4</th><th colspan="2">5</th><th>Risk Score</th><th>Comments</th></tr>
<tr><td><i>Tolling Culture</i></td><td colspan="5">Toll roads well established: data on actual use are available</td><td colspan="5">No toll roads in the country, uncertainty over toll acceptance</td><td>4</td><td>Tolls for passenger vehicles relatively uncommon in Germany</td></tr>
<tr><td rowspan="5"><i>Toll Facility Details</i></td><td colspan="5">Estuarial crossings; radial corridors into urban areas</td><td colspan="5">Dense, urban networks; ring roads/beltways around urban areas</td><td>1</td><td>Crossing of Trave River; radial route into city of Lübeck</td></tr>
<tr><td colspan="5">Extension/expansion of existing road</td><td colspan="5">Greenfield site</td><td>1</td><td>Replacement of existing bascule bridge</td></tr>
<tr><td colspan="5">Stand-alone (single) facility</td><td colspan="5">Reliance on other, proposed highway improvements</td><td>1</td><td>Stand-alone facility</td></tr>
<tr><td colspan="5">Highly congested corridor</td><td colspan="5">Limited/no congestion</td><td>5</td><td>Traffic on existing bridge was ~30,000 vehicles per day → little congestion for four-lane tunnel</td></tr>
<tr><td colspan="5">Few competing roads</td><td colspan="5">Many alternative routes</td><td>5</td><td>Other free river crossings exist; nearby autobahn link was also completed shortly before tunnel opening</td></tr>
<tr><td><i>Users</i></td><td colspan="5">High-income, time-sensitive market</td><td colspan="5">Average/low-income market</td><td>4</td><td>Many drivers prefer to avoid toll by spending 10 minutes extra on autobahn alternate</td></tr>
<tr><td><i>Traffic Growth</i></td><td colspan="5">Driven by/correlated with existing factors</td><td colspan="5">Reliance on future growth factors, new developments, etc.</td><td>3</td><td>Little indication of growth consideration in developing tolling scheme</td></tr>
</table>

Sum of Risk Scores: 24

Average Risk Score: 3.0 → High Risk

Project: Skye Bridge (UK)

Project Attribute	Traffic Risk Index					Toll Facility	
	1	2	3	4	5	Risk Score	Comments
Tolling Culture	Toll roads well established: data on actual use are available				No toll roads in the country, uncertainty over toll acceptance	4	Relatively few direct-toll facilities in country, though bridge tolls were set equal to previous ferry charges
Toll Facility Details	Estuarial crossings; radial corridors into urban areas				Dense, urban networks; ring roads/beltways around urban areas	1	Crossing of Loch Alsh between Scottish mainland and Isle of Skye
	Extension/expansion of existing road				Greenfield site	3	No previous fixed crossing, but relevant demand data were available from ferry service at same location
	Stand-alone (single) facility				Reliance on other, proposed highway improvements	1	Stand-alone facility
	Highly congested corridor				Limited/no congestion	3	Before bridge construction, some congestion at ferry terminals during summer peak-travel months
	Few competing roads				Many alternative routes	1	Facility is sole fixed-link access to Isle of Skye
Users	High-income, time-sensitive market				Average/low-income market	3	Combination of locals and (summer) tourists
Traffic Growth	Driven by/correlated with existing factors				Reliance on future growth factors, new developments, etc.	3	Little indication of growth consideration in developing tolling scheme

Sum of Risk Scores: 19

Average Risk Score: 2.4 ➔ High Risk

Project: Second Tagus Crossing/Vasco da Gama Bridge (Portugal) Risk Worksheet

Project Attribute	**Traffic Risk Index**					**Toll Facility**	
	1	2	3	4	5	Risk Score	Comments
Tolling Culture	Toll roads well established: data on actual use are available				No toll roads in the country, uncertainty over toll acceptance	1	Neighboring "25 April Bridge" already tolled
Toll Facility Details	Estuarial crossings; radial corridors into urban areas				Dense, urban networks; ring roads/beltways around urban areas	1	Crossing of Tagus River in Lisbon
	Extension/expansion of existing road				Greenfield site	3	Though at a greenfield site, facility connects points with known demand
	Stand-alone (single) facility				Reliance on other, proposed highway improvements	1	Stand-alone facility
	Highly congested corridor				Limited/no congestion	1	Severe congestion on neighboring bridge; feasibility planning for third crossing already underway
	Few competing roads				Many alternative routes	2	Other than also-tolled "25 April Bridge," next fixed crossing is 40km upriver; ferry service also exists
Users	High-income, time-sensitive market				Average/low-income market	2	Urban/suburban commuters
Traffic Growth	Driven by/correlated with existing factors				Reliance on future growth factors, new developments, etc.	2	Usage has grown faster than anticipated, though continued growth depends in part on land development

Sum of Risk Scores: 13

Average Risk Score: 1.6 ➔ Low Risk

Project: Autopista M-12 / Eje Aeropuerto (Spain)

<table>
<tr><th rowspan="2"><i>Project Attribute</i></th><th colspan="10">Traffic Risk Index</th><th colspan="2">Toll Facility</th></tr>
<tr><th colspan="2">1</th><th colspan="2">2</th><th colspan="2">3</th><th colspan="2">4</th><th colspan="2">5</th><th>Risk Score</th><th>Comments</th></tr>
<tr><td><i>Tolling Culture</i></td><td colspan="5">Toll roads well established: data on actual use are available</td><td colspan="5">No toll roads in the country, uncertainty over toll acceptance</td><td>1</td><td>Extensive tollroad network established in Spain</td></tr>
<tr><td rowspan="5"><i>Toll Facility Details</i></td><td colspan="5">Estuarial crossings; radial corridors into urban areas</td><td colspan="5">Dense, urban networks; ring roads/beltways around urban areas</td><td>2</td><td>Generally radial route in suburban Madrid; provides access to large new airport terminal</td></tr>
<tr><td colspan="5">Extension/expansion of existing road</td><td colspan="5">Greenfield site</td><td>5</td><td>New route</td></tr>
<tr><td colspan="5">Stand-alone (single) facility</td><td colspan="5">Reliance on other, proposed highway improvements</td><td>1</td><td>Stand-alone facility</td></tr>
<tr><td colspan="5">Highly congested corridor</td><td colspan="5">Limited/no congestion</td><td>5</td><td>Facility goal is not to relieve congestion but to provide airport access</td></tr>
<tr><td colspan="5">Few competing roads</td><td colspan="5">Many alternative routes</td><td>1</td><td>No other road access to new airport terminal</td></tr>
<tr><td><i>Users</i></td><td colspan="5">High-income, time-sensitive market</td><td colspan="5">Average/low-income market</td><td>1</td><td>Users are airport travelers</td></tr>
<tr><td><i>Traffic Growth</i></td><td colspan="5">Driven by/correlated with existing factors</td><td colspan="5">Reliance on future growth factors, new developments, etc.</td><td>1</td><td>Airport terminal already open</td></tr>
</table>

Sum of Risk Scores: 17

Average Risk Score: 2.1 ➔ Low Risk

Project: El Melón Tunnel (Chile)

<table>
<tr><th rowspan="2"><i>Project Attribute</i></th><th colspan="10">Traffic Risk Index</th><th colspan="2">Toll Facility</th></tr>
<tr><th colspan="2">1</th><th colspan="2">2</th><th colspan="2">3</th><th colspan="2">4</th><th colspan="2">5</th><th>Risk Score</th><th>Comments</th></tr>
<tr><td><i>Tolling Culture</i></td><td colspan="5">Toll roads well established: data on actual use are available</td><td colspan="5">No toll roads in the country, uncertainty over toll acceptance</td><td>1</td><td>Tolls have become widely accepted in country since first tollroad in 1963</td></tr>
<tr><td rowspan="5"><i>Toll Facility Details</i></td><td colspan="5">Estuarial crossings; radial corridors into urban areas</td><td colspan="5">Dense, urban networks; ring roads/beltways around urban areas</td><td>1</td><td>Tunnel through mountain pass</td></tr>
<tr><td colspan="5">Extension/expansion of existing road</td><td colspan="5">Greenfield site</td><td>1</td><td>Parallel construction to existing route</td></tr>
<tr><td colspan="5">Stand-alone (single) facility</td><td colspan="5">Reliance on other, proposed highway improvements</td><td>1</td><td>Stand-alone facility</td></tr>
<tr><td colspan="5">Highly congested corridor</td><td colspan="5">Limited/no congestion</td><td>5</td><td>Facility's primary goals are to shorten travel time and improve safety</td></tr>
<tr><td colspan="5">Few competing roads</td><td colspan="5">Many alternative routes</td><td>5</td><td>Free parallel route over top of mountain</td></tr>
<tr><td><i>Users</i></td><td colspan="5">High-income, time-sensitive market</td><td colspan="5">Average/low-income market</td><td>5</td><td>Many users willing to take significantly longer and less safe mountaintop road to avoid high tunnel tolls</td></tr>
<tr><td><i>Traffic Growth</i></td><td colspan="5">Driven by/correlated with existing factors</td><td colspan="5">Reliance on future growth factors, new developments, etc.</td><td>3</td><td>Little indication of growth consideration in developing tolling scheme</td></tr>
</table>

Sum of Risk Scores: 22

Average Risk Score: 2.8 ➔ High Risk

Project: Santiago-Valparaíso-Viña del Mar Toll Road (Chile) Risk Worksheet

<table>
<tr><th rowspan="2">Project Attribute</th><th colspan="10">Traffic Risk Index</th><th colspan="2">Toll Facility</th></tr>
<tr><th colspan="2">1</th><th colspan="2">2</th><th colspan="2">3</th><th colspan="2">4</th><th colspan="2">5</th><th>Risk Score</th><th>Comments</th></tr>
<tr><td>Tolling Culture</td><td colspan="5">Toll roads well established: data on actual use are available</td><td colspan="5">No toll roads in the country, uncertainty over toll acceptance</td><td>1</td><td>Tolls have become widely accepted in country since first tollroad in 1963</td></tr>
<tr><td rowspan="5">Toll Facility Details</td><td colspan="5">Estuarial crossings; radial corridors into urban areas</td><td colspan="5">Dense, urban networks; ring roads/beltways around urban areas</td><td>1</td><td>Major artery between Santiago and the coast</td></tr>
<tr><td colspan="5">Extension/expansion of existing road</td><td colspan="5">Greenfield site</td><td>1</td><td>Project comprised major improvements/extensions to existing facilities, along with three new tunnels</td></tr>
<tr><td colspan="5">Stand-alone (single) facility</td><td colspan="5">Reliance on other, proposed highway improvements</td><td>1</td><td>Stand-alone facility</td></tr>
<tr><td colspan="5">Highly congested corridor</td><td colspan="5">Limited/no congestion</td><td>1</td><td>Further expansions to accommodate traffic growth are already anticipated</td></tr>
<tr><td colspan="5">Few competing roads</td><td colspan="5">Many alternative routes</td><td>1</td><td>No practical alternatives</td></tr>
<tr><td>Users</td><td colspan="5">High-income, time-sensitive market</td><td colspan="5">Average/low-income market</td><td>3</td><td>Urban and suburban travelers</td></tr>
<tr><td>Traffic Growth</td><td colspan="5">Driven by/correlated with existing factors</td><td colspan="5">Reliance on future growth factors, new developments, etc.</td><td>1</td><td>Expected strong growth is already materializing</td></tr>
</table>

Sum of Risk Scores: 10

Average Risk Score: 1.3 ➔ Low Risk

Project: 407 Express Toll Route (Canada) – first procurement Risk Worksheet

<table>
<tr><th rowspan="2">Project Attribute</th><th colspan="10">Traffic Risk Index</th><th colspan="2">Toll Facility</th></tr>
<tr><th colspan="2">1</th><th colspan="2">2</th><th colspan="2">3</th><th colspan="2">4</th><th colspan="2">5</th><th>Risk Score</th><th>Comments</th></tr>
<tr><td>Tolling Culture</td><td colspan="5">Toll roads well established: data on actual use are available</td><td colspan="5">No toll roads in the country, uncertainty over toll acceptance</td><td>5</td><td>Facility was Ontario’s first toll highway</td></tr>
<tr><td rowspan="5">Toll Facility Details</td><td colspan="5">Estuarial crossings; radial corridors into urban areas</td><td colspan="5">Dense, urban networks; ring roads/beltways around urban areas</td><td>5</td><td>Primarily circumferential beltway segment around Toronto</td></tr>
<tr><td colspan="5">Extension/expansion of existing road</td><td colspan="5">Greenfield site</td><td>4</td><td>Majority of facility was a new alignment</td></tr>
<tr><td colspan="5">Stand-alone (single) facility</td><td colspan="5">Reliance on other, proposed highway improvements</td><td>3</td><td>Future highway extensions anticipated at eastern and western termini</td></tr>
<tr><td colspan="5">Highly congested corridor</td><td colspan="5">Limited/no congestion</td><td>1</td><td>Parallel Highway 401 (“inner-loop beltway”) was highly congested</td></tr>
<tr><td colspan="5">Few competing roads</td><td colspan="5">Many alternative routes</td><td>2</td><td>Parallel Highway 401 posed relatively little competition due to high congestion</td></tr>
<tr><td>Users</td><td colspan="5">High-income, time-sensitive market</td><td colspan="5">Average/low-income market</td><td>2</td><td>Urban/suburban commuters</td></tr>
<tr><td>Traffic Growth</td><td colspan="5">Driven by/correlated with existing factors</td><td colspan="5">Reliance on future growth factors, new developments, etc.</td><td>1</td><td>Demand expectations based on existing growth patterns</td></tr>
</table>

Sum of Risk Scores: 23

Average Risk Score: 2.9 ➔ High Risk

Project: 407 Express Toll Route (Canada) – second procurement Risk Worksheet

<table>
<tr><th rowspan="2">Project Attribute</th><th colspan="10">Traffic Risk Index</th><th colspan="2">Toll Facility</th></tr>
<tr><th colspan="2">1</th><th colspan="2">2</th><th colspan="2">3</th><th colspan="2">4</th><th colspan="2">5</th><th>Risk Score</th><th>Comments</th></tr>
<tr><td>Tolling Culture</td><td colspan="5">Toll roads well established: data on actual use are available</td><td colspan="5">No toll roads in the country, uncertainty over toll acceptance</td><td>1</td><td>Actual usage data available for operating lease</td></tr>
<tr><td rowspan="5">Toll Facility Details</td><td colspan="5">Estuarial crossings; radial corridors into urban areas</td><td colspan="5">Dense, urban networks; ring roads/beltways around urban areas</td><td>4</td><td>Partially radial, partially circumferential beltway segment around Toronto</td></tr>
<tr><td colspan="5">Extension/expansion of existing road</td><td colspan="5">Greenfield site</td><td>1</td><td>For operating lease, facility had several years of known traffic-demand history</td></tr>
<tr><td colspan="5">Stand-alone (single) facility</td><td colspan="5">Reliance on other, proposed highway improvements</td><td>2</td><td>Second extension anticipated at eastern terminus</td></tr>
<tr><td colspan="5">Highly congested corridor</td><td colspan="5">Limited/no congestion</td><td>1</td><td>Strong demand for route (300,000 trips/day in 2008)</td></tr>
<tr><td colspan="5">Few competing roads</td><td colspan="5">Many alternative routes</td><td>3</td><td>Partially parallel Highways 401 and 403 pose relatively little competition due to congestion and location</td></tr>
<tr><td>Users</td><td colspan="5">High-income, time-sensitive market</td><td colspan="5">Average/low-income market</td><td>2</td><td>Urban/suburban commuters</td></tr>
<tr><td>Traffic Growth</td><td colspan="5">Driven by/correlated with existing factors</td><td colspan="5">Reliance on future growth factors, new developments, etc.</td><td>1</td><td>Demand expectations based on existing growth patterns</td></tr>
</table>

Sum of Risk Scores: 15

Average Risk Score: 1.9 ➔ Low Risk

Project: Confederation Bridge (Canada) Risk Worksheet

<table>
<tr><th rowspan="2">Project Attribute</th><th colspan="10">Traffic Risk Index</th><th colspan="2">Toll Facility</th></tr>
<tr><th colspan="2">1</th><th colspan="2">2</th><th colspan="2">3</th><th colspan="2">4</th><th colspan="2">5</th><th>Risk Score</th><th>Comments</th></tr>
<tr><td>Tolling Culture</td><td colspan="5">Toll roads well established: data on actual use are available</td><td colspan="5">No toll roads in the country, uncertainty over toll acceptance</td><td>2</td><td>Toll charges were direct replacement for ferry fees, so users were accustomed to paying for crossing</td></tr>
<tr><td rowspan="5">Toll Facility Details</td><td colspan="5">Estuarial crossings; radial corridors into urban areas</td><td colspan="5">Dense, urban networks; ring roads/beltways around urban areas</td><td>1</td><td>Bridge is sole fixed crossing of Northumberland Strait</td></tr>
<tr><td colspan="5">Extension/expansion of existing road</td><td colspan="5">Greenfield site</td><td>3</td><td>No previous fixed crossing, but relevant demand data were available from ferry service at same location</td></tr>
<tr><td colspan="5">Stand-alone (single) facility</td><td colspan="5">Reliance on other, proposed highway improvements</td><td>1</td><td>Stand-alone facility</td></tr>
<tr><td colspan="5">Highly congested corridor</td><td colspan="5">Limited/no congestion</td><td>5</td><td>Minimal congestion, though tourist traffic increases in summer months</td></tr>
<tr><td colspan="5">Few competing roads</td><td colspan="5">Many alternative routes</td><td>1</td><td>Ferry service provides alternate access to Prince Edward Island, but trip takes 5-6 times longer</td></tr>
<tr><td>Users</td><td colspan="5">High-income, time-sensitive market</td><td colspan="5">Average/low-income market</td><td>5</td><td>Per-capita income on Prince Edward Island is among lowest in Canada</td></tr>
<tr><td>Traffic Growth</td><td colspan="5">Driven by/correlated with existing factors</td><td colspan="5">Reliance on future growth factors, new developments, etc.</td><td>1</td><td>Demand expectations based on existing growth patterns</td></tr>
</table>

Sum of Risk Scores: 19

Average Risk Score: 2.4 ➔ High Risk

Project: Cross City Tunnel (New South Wales, Australia) Risk Worksheet

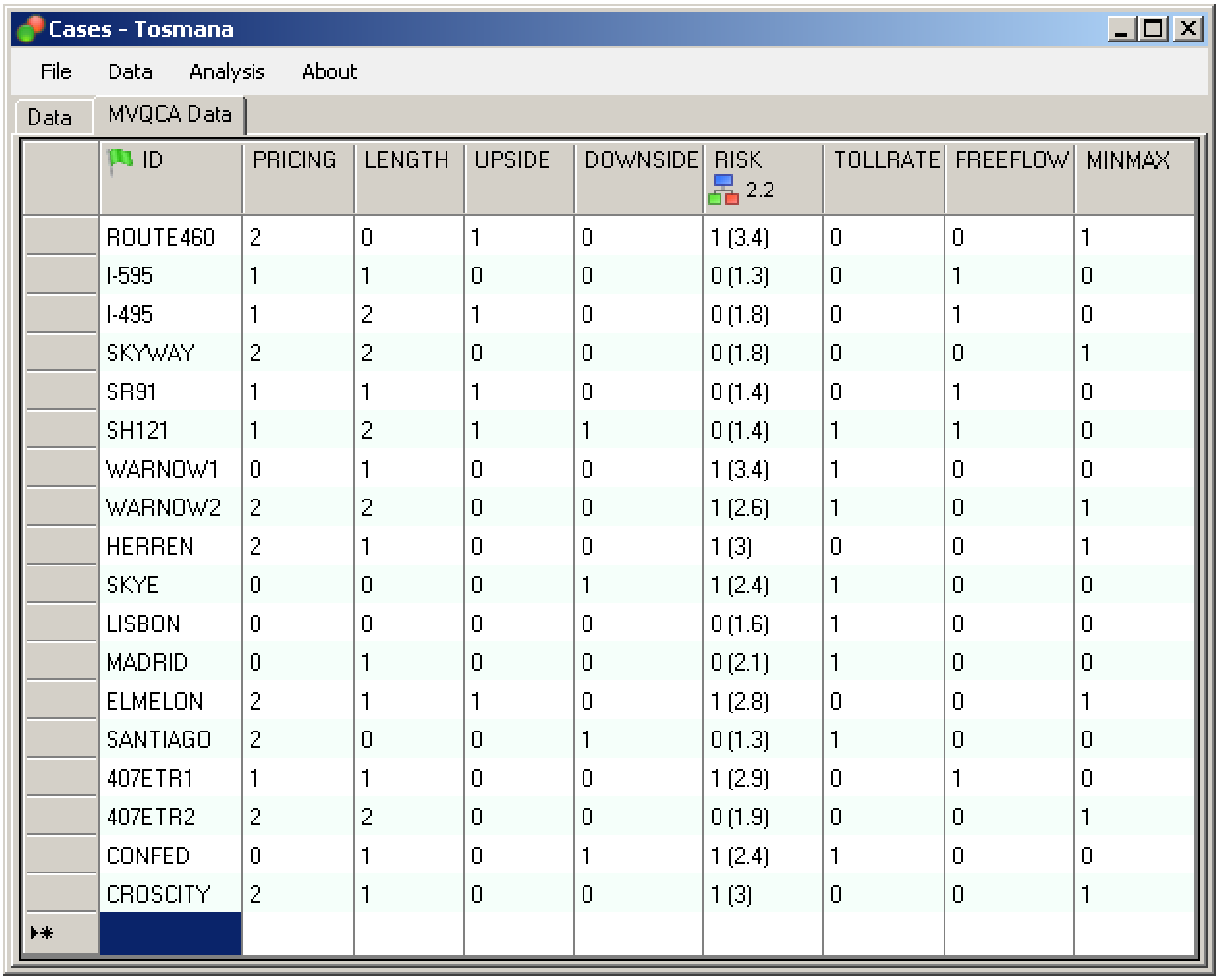
<table>
<tr><th rowspan="2"><i>Project Attribute</i></th><th colspan="10">Traffic Risk Index</th><th colspan="2">Toll Facility</th></tr>
<tr><th colspan="2">1</th><th colspan="2">2</th><th colspan="2">3</th><th colspan="2">4</th><th colspan="2">5</th><th>Risk Score</th><th>Comments</th></tr>
<tr><td><i>Tolling Culture</i></td><td colspan="5">Toll roads well established: data on actual use are available</td><td colspan="5">No toll roads in the country, uncertainty over toll acceptance</td><td>1</td><td>Neighboring Sydney Harbor Bridge and Tunnel are both pre-existing toll facilities</td></tr>
<tr><td rowspan="5"><i>Toll Facility Details</i></td><td colspan="5">Estuarial crossings; radial corridors into urban areas</td><td colspan="5">Dense, urban networks; ring roads/beltways around urban areas</td><td>5</td><td>Tunnel provided direct route under Sydney’s central business district</td></tr>
<tr><td colspan="5">Extension/expansion of existing road</td><td colspan="5">Greenfield site</td><td>2</td><td>Existing surface roads approximated tunnel route</td></tr>
<tr><td colspan="5">Stand-alone (single) facility</td><td colspan="5">Reliance on other, proposed highway improvements</td><td>1</td><td>Stand-alone facility</td></tr>
<tr><td colspan="5">Highly congested corridor</td><td colspan="5">Limited/no congestion</td><td>3</td><td>Some congestion on downtown surface roads</td></tr>
<tr><td colspan="5">Few competing roads</td><td colspan="5">Many alternative routes</td><td>5</td><td>Surface roads offered alternative to tunnel, due to elimination of promised traffic-calming measures</td></tr>
<tr><td><i>Users</i></td><td colspan="5">High-income, time-sensitive market</td><td colspan="5">Average/low-income market</td><td>3</td><td>Many drivers preferred to spend additional time on surface roads rather than pay tunnel toll</td></tr>
<tr><td><i>Traffic Growth</i></td><td colspan="5">Driven by/correlated with existing factors</td><td colspan="5">Reliance on future growth factors, new developments, etc.</td><td>4</td><td>Affluent suburbs at eastern end of tunnel were already developed to capacity and unlikely to grow further</td></tr>
</table>

Sum of Risk Scores: 24

Average Risk Score: 3.0 ➔ High Risk

Appendix E: Software Output

Tosmana Source Data

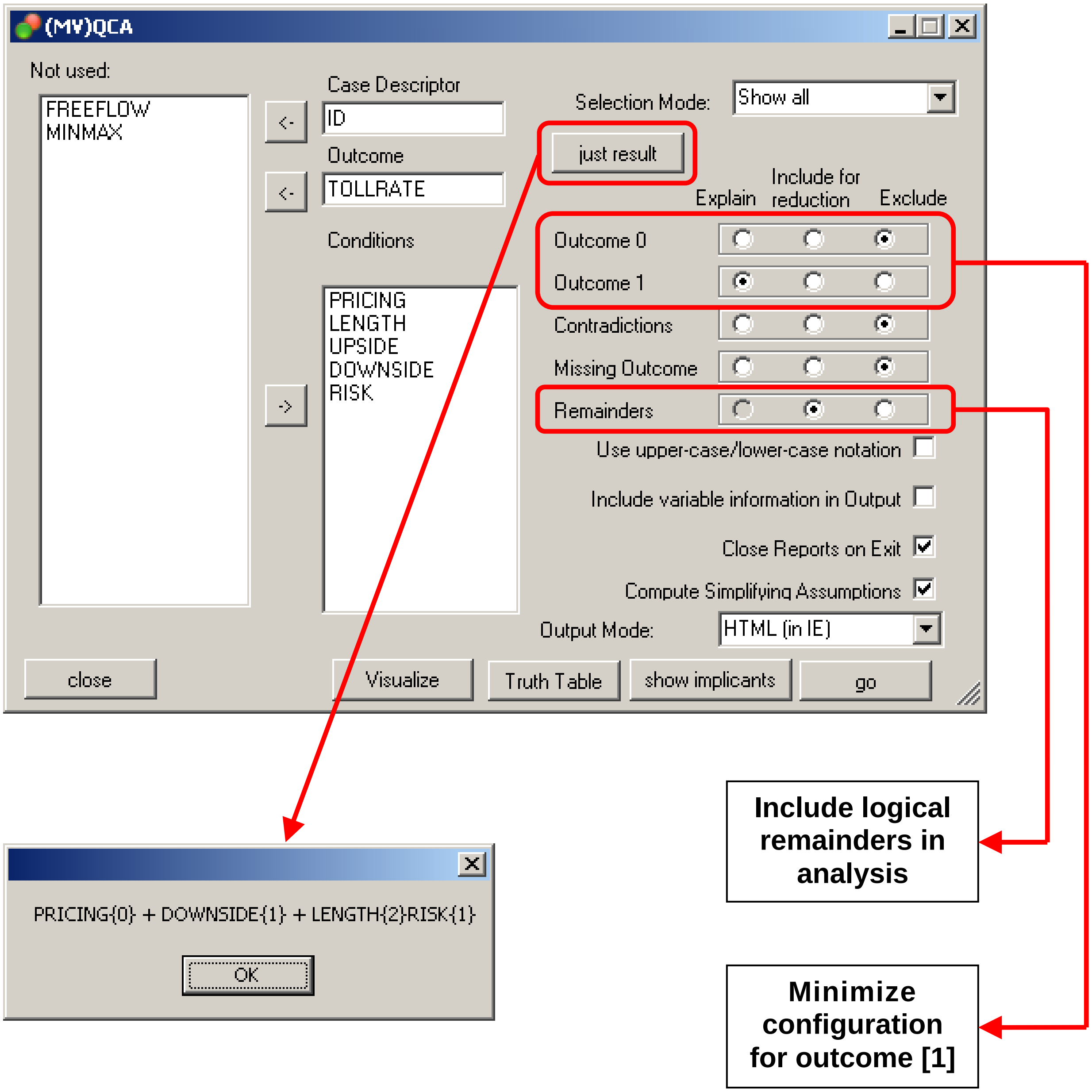


ID	PRICING	LENGTH	UPSIDE	DOWNSIDE	RISK 2.2	TOLLRATE	FREEFLOW	MINMAX
ROUTE460	2	0	1	0	1 (3.4)	0	0	1
I-595	1	1	0	0	0 (1.3)	0	1	0
I-495	1	2	1	0	0 (1.8)	0	1	0
SKYWAY	2	2	0	0	0 (1.8)	0	0	1
SR91	1	1	1	0	0 (1.4)	0	1	0
SH121	1	2	1	1	0 (1.4)	1	1	0
WARNOW1	0	1	0	0	1 (3.4)	1	0	0
WARNOW2	2	2	0	0	1 (2.6)	1	0	1
HERREN	2	1	0	0	1 (3)	0	0	1
SKYE	0	0	0	1	1 (2.4)	1	0	0
LISBON	0	0	0	0	0 (1.6)	1	0	0
MADRID	0	1	0	0	0 (2.1)	1	0	0
ELMELON	2	1	1	0	1 (2.8)	0	0	1
SANTIAGO	2	0	0	1	0 (1.3)	1	0	0
407ETR1	1	1	0	0	1 (2.9)	0	1	0
407ETR2	2	2	0	0	0 (1.9)	0	0	1
CONFED	0	1	0	1	1 (2.4)	1	0	0
CROSCITY	2	1	0	0	1 (3)	0	0	1

Tosmana Analysis Options

Sample menu for outcome TOLLRATE = 1

See following analysis 1B “TOLLRATE (with remainders)” for results of these selections.



Not used:
FREEFLOW
MINMAX

Case Descriptor: ID

Outcome: TOLLRATE

Conditions:
PRICING
LENGTH
UPSIDE
DOWNSIDE
RISK

Selection Mode: Show all

	Explain	Include for reduction	Exclude
Outcome 0	○	○	●
Outcome 1	●	○	○
Contradictions	○	○	●
Missing Outcome	○	○	●
Remainders	○	●	○

Use upper-case/lower-case notation ☐

Include variable information in Output ☐

Close Reports on Exit ☑

Compute Simplifying Assumptions ☑

Output Mode: HTML (in IE)

```
PRICING{0} + DOWNSIDE{1} + LENGTH{2}RISK{1}
```

Include logical remainders in analysis

Minimize configuration for outcome [1]

1A. TOLLRATE (without remainders)

Algorithm: MultiValue TopDown

File: Z:\MEG\Research Pieces\07 Pre-Defense\Cases.tosmana

Settings:
Minimizing Value 1
including:

Data:

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

Results: (all)

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}
(WARNOW1+CONFED)	(WARNOW1+MADRID)	(SH121)	(WARNOW2)	(SKYE)	(LISBON)	(SANTIAGO)

Created with Tosmana Version 1.3

1B. TOLLRATE (with remainders)

Algorithm: Graph-based Agent

File: Z:\MEG\Research Pieces\07 Pre-Defense\Cases.tosmana

Settings:

Minimizing Value 1
including: R

Data:

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

Results: (all)

PRICING{0} +	DOWNSIDE{1} +	LENGTH{2}RISK{1}
(WARNOW1+SKYE+LISBON +MADRID+CONFED)	(SH121+SKYE+SANTIAGO+CONFED)	(WARNOW2)

Simplifying Assumptions PRICING{0}LENGTH{0}UPSIDE{0}DOWNSIDE{0}RISK{1} +
PRICING{0}LENGTH{0}UPSIDE{0}DOWNSIDE{1}RISK{0} +
PRICING{0}LENGTH{0}UPSIDE{1}DOWNSIDE{0}RISK{0} +
PRICING{0}LENGTH{0}UPSIDE{1}DOWNSIDE{0}RISK{1} +
PRICING{0}LENGTH{0}UPSIDE{1}DOWNSIDE{1}RISK{0} +
PRICING{0}LENGTH{0}UPSIDE{1}DOWNSIDE{1}RISK{1} +
PRICING{0}LENGTH{1}UPSIDE{0}DOWNSIDE{1}RISK{0} +
PRICING{0}LENGTH{1}UPSIDE{1}DOWNSIDE{0}RISK{0} +
PRICING{0}LENGTH{1}UPSIDE{1}DOWNSIDE{0}RISK{1} +
PRICING{0}LENGTH{1}UPSIDE{1}DOWNSIDE{1}RISK{0} +
PRICING{0}LENGTH{1}UPSIDE{1}DOWNSIDE{1}RISK{1} +

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PRICING{0}LENGTH{2}UPSIDE{0}DOWNSIDE{0}RISK{0} +
PRICING{0}LENGTH{2}UPSIDE{0}DOWNSIDE{0}RISK{1} +
PRICING{0}LENGTH{2}UPSIDE{0}DOWNSIDE{1}RISK{0} +
PRICING{0}LENGTH{2}UPSIDE{0}DOWNSIDE{1}RISK{1} +
PRICING{0}LENGTH{2}UPSIDE{1}DOWNSIDE{0}RISK{0} +
PRICING{0}LENGTH{2}UPSIDE{1}DOWNSIDE{0}RISK{1} +
PRICING{0}LENGTH{2}UPSIDE{1}DOWNSIDE{1}RISK{0} +
PRICING{0}LENGTH{2}UPSIDE{1}DOWNSIDE{1}RISK{1} +
PRICING{1}LENGTH{0}UPSIDE{0}DOWNSIDE{1}RISK{0} +
PRICING{1}LENGTH{0}UPSIDE{0}DOWNSIDE{1}RISK{1} +
PRICING{1}LENGTH{0}UPSIDE{1}DOWNSIDE{1}RISK{0} +
PRICING{1}LENGTH{0}UPSIDE{1}DOWNSIDE{1}RISK{1} +
PRICING{1}LENGTH{1}UPSIDE{0}DOWNSIDE{1}RISK{0} +
PRICING{1}LENGTH{1}UPSIDE{0}DOWNSIDE{1}RISK{1} +
PRICING{1}LENGTH{1}UPSIDE{1}DOWNSIDE{1}RISK{0} +
PRICING{1}LENGTH{1}UPSIDE{1}DOWNSIDE{1}RISK{1} +
PRICING{1}LENGTH{2}UPSIDE{0}DOWNSIDE{0}RISK{1} +
PRICING{1}LENGTH{2}UPSIDE{0}DOWNSIDE{1}RISK{0} +
PRICING{1}LENGTH{2}UPSIDE{0}DOWNSIDE{1}RISK{1} +
PRICING{1}LENGTH{2}UPSIDE{1}DOWNSIDE{0}RISK{1} +
PRICING{1}LENGTH{2}UPSIDE{1}DOWNSIDE{1}RISK{1} +
PRICING{2}LENGTH{0}UPSIDE{0}DOWNSIDE{1}RISK{1} +
PRICING{2}LENGTH{0}UPSIDE{1}DOWNSIDE{1}RISK{0} +
PRICING{2}LENGTH{0}UPSIDE{1}DOWNSIDE{1}RISK{1} +
PRICING{2}LENGTH{1}UPSIDE{0}DOWNSIDE{1}RISK{0} +
PRICING{2}LENGTH{1}UPSIDE{0}DOWNSIDE{1}RISK{1} +
PRICING{2}LENGTH{1}UPSIDE{1}DOWNSIDE{1}RISK{0} +
PRICING{2}LENGTH{1}UPSIDE{1}DOWNSIDE{1}RISK{1} +
PRICING{2}LENGTH{2}UPSIDE{0}DOWNSIDE{1}RISK{0} +
PRICING{2}LENGTH{2}UPSIDE{0}DOWNSIDE{1}RISK{1} +
PRICING{2}LENGTH{2}UPSIDE{1}DOWNSIDE{0}RISK{1} +
PRICING{2}LENGTH{2}UPSIDE{1}DOWNSIDE{1}RISK{0} +
PRICING{2}LENGTH{2}UPSIDE{1}DOWNSIDE{1}RISK{1}

Number of Simplifying Assumptions: 44
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Created with Tosmana Version 1.3

2A. FREEFLOW (without remainders)

Algorithm: MultiValue TopDown

File: Z:\MEG\Research Pieces\07 Pre-Defense\Cases.tosmana

Settings:
Minimizing Value 1
including:

Data:

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

Results: (all)

PRICING{1} * LENGTH{1} * DOWNSIDE{0} * RISK{0} +	PRICING{1} * LENGTH{1} * UPSIDE{0} * DOWNSIDE{0} +	PRICING{1} * LENGTH{2} * UPSIDE{1} * RISK{0}
(I-595+SR91)	(I-595+407ETR1)	(I-495+SH121)

Created with Tosmana Version 1.3

2B. FREEFLOW (with remainders)

Algorithm: Graph-based Agent

File: Z:\MEG\Research Pieces\07 Pre-Defense\Cases.tosmana

Settings:

Minimizing Value 1
including: R

Data:

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

Results: (all)

PRICING{1}
(I-595+I-495+SR91+SH121+407ETR1)

Simplifying Assumptions PRICING{1}LENGTH{0}UPSIDE{0}DOWNSIDE{0}RISK{0} +
PRICING{1}LENGTH{0}UPSIDE{0}DOWNSIDE{0}RISK{1} +
PRICING{1}LENGTH{0}UPSIDE{0}DOWNSIDE{1}RISK{0} +
PRICING{1}LENGTH{0}UPSIDE{0}DOWNSIDE{1}RISK{1} +
PRICING{1}LENGTH{0}UPSIDE{1}DOWNSIDE{0}RISK{0} +
PRICING{1}LENGTH{0}UPSIDE{1}DOWNSIDE{0}RISK{1} +
PRICING{1}LENGTH{0}UPSIDE{1}DOWNSIDE{1}RISK{0} +
PRICING{1}LENGTH{0}UPSIDE{1}DOWNSIDE{1}RISK{1} +
PRICING{1}LENGTH{1}UPSIDE{0}DOWNSIDE{1}RISK{0} +
PRICING{1}LENGTH{1}UPSIDE{0}DOWNSIDE{1}RISK{1} +
PRICING{1}LENGTH{1}UPSIDE{1}DOWNSIDE{0}RISK{1} +
PRICING{1}LENGTH{1}UPSIDE{1}DOWNSIDE{1}RISK{0} +

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PRICING{1}LENGTH{1}UPSIDE{1}DOWNSIDE{1}RISK{1} +
PRICING{1}LENGTH{2}UPSIDE{0}DOWNSIDE{0}RISK{0} +
PRICING{1}LENGTH{2}UPSIDE{0}DOWNSIDE{0}RISK{1} +
PRICING{1}LENGTH{2}UPSIDE{0}DOWNSIDE{1}RISK{0} +
PRICING{1}LENGTH{2}UPSIDE{0}DOWNSIDE{1}RISK{1} +
PRICING{1}LENGTH{2}UPSIDE{1}DOWNSIDE{0}RISK{1} +
PRICING{1}LENGTH{2}UPSIDE{1}DOWNSIDE{1}RISK{1}

Number of Simplifying Assumptions: 19
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Created with Tosmana Version 1.3

3A. MINMAX (without remainders)

Algorithm: MultiValue TopDown

File: Z:\MEG\Research Pieces\07 Pre-Defense\Cases.tosmana

Settings:
Minimizing Value 1
including:

Data:

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

Results: (all)

PRICING{2} * LENGTH{2} * UPSIDE{0} * DOWNSIDE{0} +	PRICING{2} * LENGTH{1} * DOWNSIDE{0} * RISK{1} +	PRICING{2} * LENGTH{0} * UPSIDE{1} * DOWNSIDE{0} * RISK{1}
(SKYWAY,407ETR2+WARNOW2)	(HERREN,CROSCITY+ELMELON)	(ROUTE460)

Created with Tosmana Version 1.3

3B. MINMAX (with remainders)

Algorithm: Graph-based Agent

File: Z:\MEG\Research Pieces\07 Pre-Defense\Cases.tosmana

Settings:

Minimizing Value 1
including: R

Data:

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

Results: (all)

PRICING{2}DOWNSIDE{0}
(ROUTE460+SKYWAY,407ETR2+WARNOW2+HERREN,CROSCITY+ELMELON)

Simplifying Assumptions PRICING{2}LENGTH{0}UPSIDE{0}DOWNSIDE{0}RISK{0} +
PRICING{2}LENGTH{0}UPSIDE{0}DOWNSIDE{0}RISK{1} +
PRICING{2}LENGTH{0}UPSIDE{1}DOWNSIDE{0}RISK{0} +
PRICING{2}LENGTH{1}UPSIDE{0}DOWNSIDE{0}RISK{0} +
PRICING{2}LENGTH{1}UPSIDE{1}DOWNSIDE{0}RISK{0} +
PRICING{2}LENGTH{2}UPSIDE{1}DOWNSIDE{0}RISK{0} +
PRICING{2}LENGTH{2}UPSIDE{1}DOWNSIDE{0}RISK{1}

Number of Simplifying Assumptions: 7

Created with Tosmana Version 1.3

3C. MINMAX (with remainders and manual selection)

Algorithm: Graph-based Agent / File: Z:\MEG\Research Pieces\07 Pre-Defense\Cases.tosmana

Settings:

Minimizing Value 1
including: R

Data:

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

Results: (individual selection - not minimized by Tosmana)

PRICING{2}LENGTH{1,2}+	PRICING{2}RISK{1}
(SKYWAY,407ETR2+WARNOW2+HERREN,CROSCITY +ELMELON)	(ROUTE460+WARNOW2+HERREN,CROSCITY+ ELMELON)

Simplifying Assumptions:

PRICING{2}LENGTH{0}UPSIDE{0}DOWNSIDE{0}RISK{1} +
PRICING{2}LENGTH{0}UPSIDE{0}DOWNSIDE{1}RISK{1} +
PRICING{2}LENGTH{0}UPSIDE{1}DOWNSIDE{1}RISK{1} +
PRICING{2}LENGTH{1}UPSIDE{0}DOWNSIDE{0}RISK{0} +
PRICING{2}LENGTH{1}UPSIDE{0}DOWNSIDE{1}RISK{0} +
PRICING{2}LENGTH{1}UPSIDE{0}DOWNSIDE{1}RISK{1} +
PRICING{2}LENGTH{1}UPSIDE{1}DOWNSIDE{0}RISK{0} +
PRICING{2}LENGTH{1}UPSIDE{1}DOWNSIDE{1}RISK{0} +
PRICING{2}LENGTH{1}UPSIDE{1}DOWNSIDE{1}RISK{1} +
PRICING{2}LENGTH{2}UPSIDE{0}DOWNSIDE{1}RISK{1} +
PRICING{2}LENGTH{2}UPSIDE{1}DOWNSIDE{0}RISK{1} +
PRICING{2}LENGTH{2}UPSIDE{1}DOWNSIDE{1}RISK{1}

Created with
Tosmana Version 1.3

Number of Simplifying Assumptions: 12