

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

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**Martha E. Gross, PhD, PE**

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# 30,000-Foot Overview

- Defining the question
  - Why do we use PPPs? To satisfy public objectives...but what are they?
  - What contractual elements in PPPs influence how we satisfy public objectives?
- Solving the question
  - Selection of research method
  - Execution and interpretation of analysis

# Acronym Control

- Public-private partnership (PPP) contracts for toll roads, bridges, tunnels, etc.
  - Extension of *design + build* concept
  - Usually *finance + design + build + maintain* (“greenfield project”)
  - Sometimes just *finance + maintain* (“brownfield project” or “operating lease”)

# Finance + Design + Build + Maintain

“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.”

– Adam Smith, *Wealth of Nations* (1776)

# Public-Policy Exploration

## Public Interest

(“What principles are valid for every procurement?”)

- Value for money
- Proper risk allocation
- Transparency
- Fair competition
- Clear selection criteria
- Use of proceeds

## Public Objectives

(“What are the goals for this specific procurement?”)

- General objectives
  - Safety/maintenance
  - Acceleration of delivery
- Pricing objectives
  - Specific toll rate
  - Congestion management
  - Max. revenue/min. subsidy

# PPP Contract Strategies: Pricing

- Pricing structure (construction literature)
  - Revenue-transfer mechanisms  
(direct toll, shadow toll, availability payment)
  
- Pricing rationale (economics literature)
  - Average cost pricing
  - Marginal social cost pricing
  - Revenue-maximizing pricing

# Other PPP Contract Strategies

- Length
  - Fixed-length concessions (~25 to 99 years)
  - Variable-length concessions
- Upside/downside provisions
  - Revenue sharing – if traffic levels and toll income are much better than anticipated
  - Risk sharing – if worse than anticipated
- (Effect of external risk environment)

# Development of Research Question

**Given specific policy objectives for road pricing, how should public owners select PPP contract strategies which support these outcomes?**

# Research Design

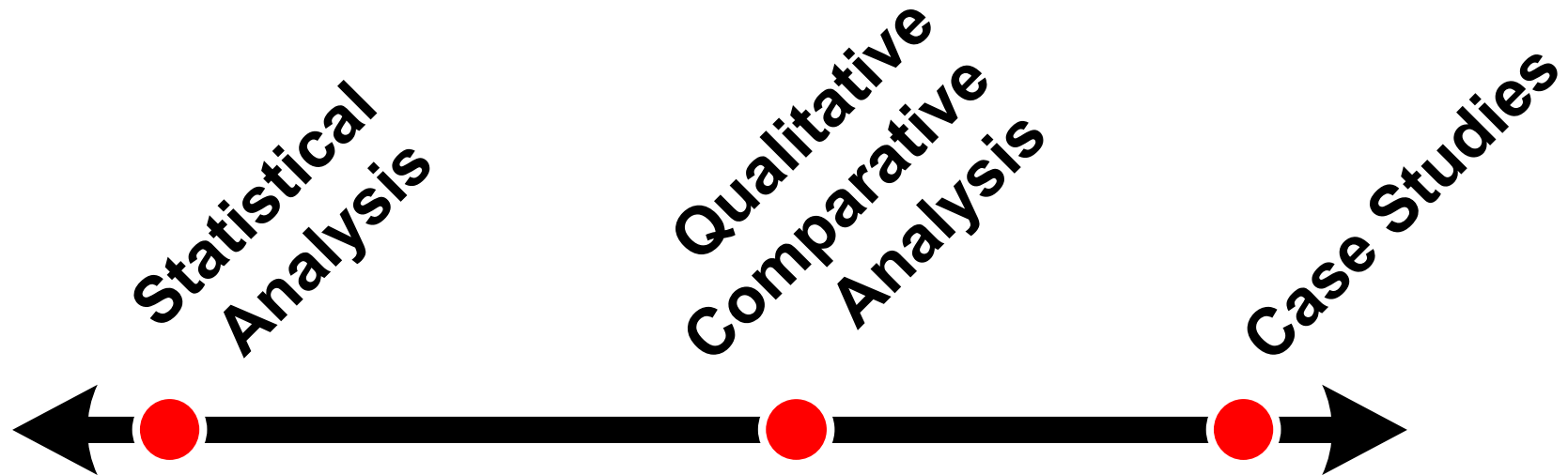
## ■ Quantitative methods

- Generally require large sample sizes...
- But PPPs' magnitude limits their frequency

## ■ Qualitative methods

- Permit smaller sample sizes...
- But require more in-depth information which (for PPPs) is often sensitive or proprietary

# Research Methods



## Quantitative Methods

- Variable-oriented
- Systematic analysis
- Large populations

## Qualitative Methods

- Case-oriented
- Contextual analysis
- Small to intermediate populations

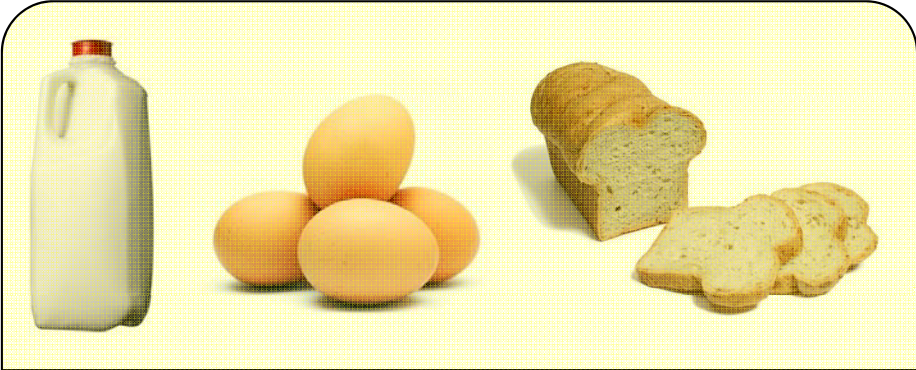

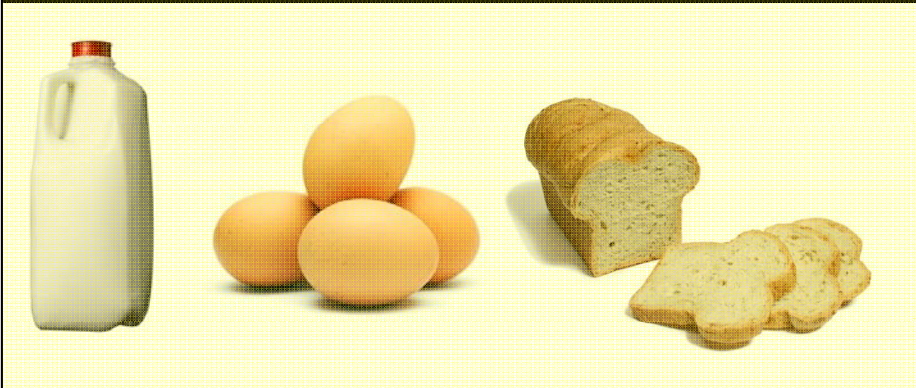

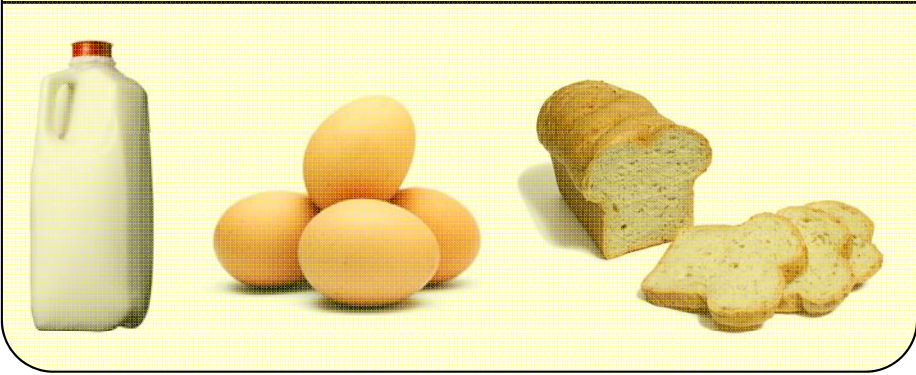

# Qualitative Comparative Analysis

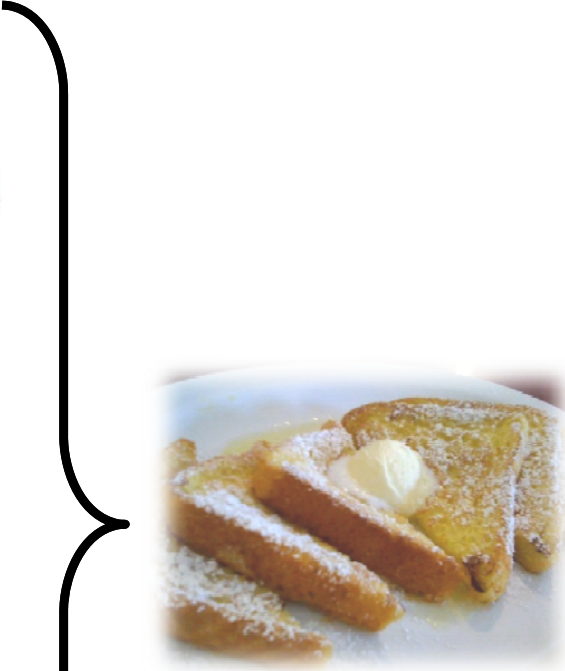
- Case-based approach with qualitative and quantitative aspects
- Recently developed (1987) for social-science inquiries
- Infrequently applied in construction research to date

# Application of QCA

1. Identify *outcomes* of interest
  - (public-sector procurement objectives)
2. Select *conditions* posited to affect outcome
  - (contract strategies and risk environment)
3. Select cases (→ maximum diversity)
4. Construct/review data table
  - Convert qualitative data to quantitative form
  - Perform internal validity checks
5. Analyze data table to identify patterns

# QCA Example: Making French Toast

	Necessary but Insufficient	Not Necessary
Recipe #1		
Recipe #2		
Recipe #3		



(Courtesy of Henry Chan)

# Sample QCA Data Table: Outcomes

		Variables					Outcome
		Conditions					
		(A)	(B)	(C)	(D)	(E)	
		Pricing Approach	Concession Length	Upside Revenue Sharing	Downside Risk Sharing	Revenue-Transfer Mechanism	Objective Achieved?
Cases	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.						

**Configuration**

# How Outcomes Were Identified

- Selection based on review of literature and practice, calibrated by informal interviews with public-sector PPP officials
  - Originally-considered outcomes:
    - ~~Minimize state exposure to traffic risk~~
    - Minimize state subsidy
    - Maximize up-front revenue
    - Achieve specific toll rate
    - Manage congestion
- } *Combine*

# QCA Outcomes

## Public Interest

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  - Congestion management
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# Operationalization of Outcomes

<b>Public-Policy Objectives</b>	<b>Variable Name</b>	<b>Meaning</b>	<b>Value</b>
Achieve specific toll rate?	TOLLRATE	No	0
		Yes	1
Manage congestion?	FREEFLOW	No	0
		Yes	1
Maximize revenue/ minimize subsidy?	MINMAX	No	0
		Yes	1

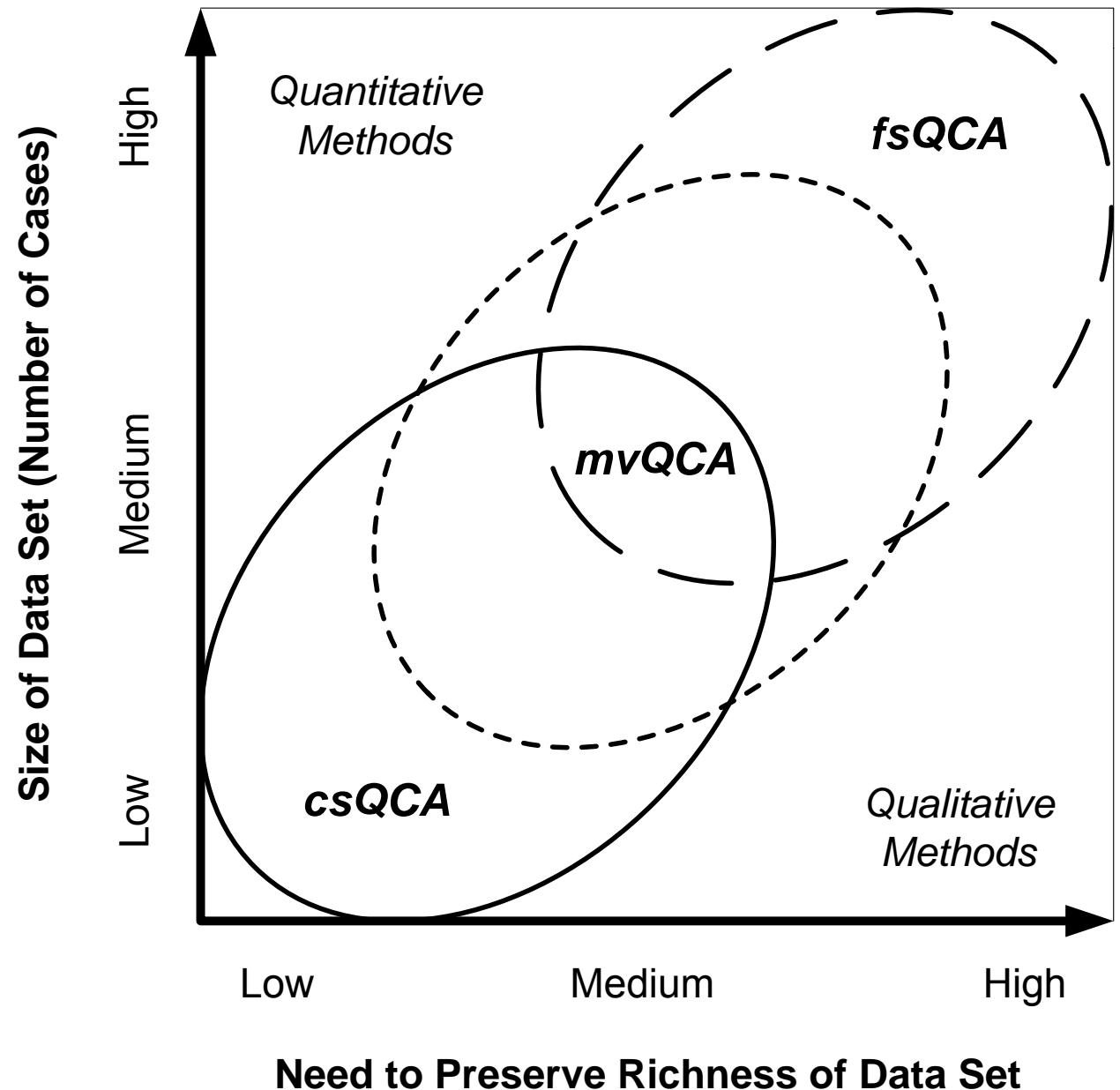
# Sample QCA Data Table: Conditions

		Variables					Outcome
		Conditions					
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	I-595 Improvements (Florida)	1	1	0	0	0	0
	Santiago Highway (Chile)	0	0	1	1	1	0
	etc.						

**Configuration**

# Conditions: QCA Variants

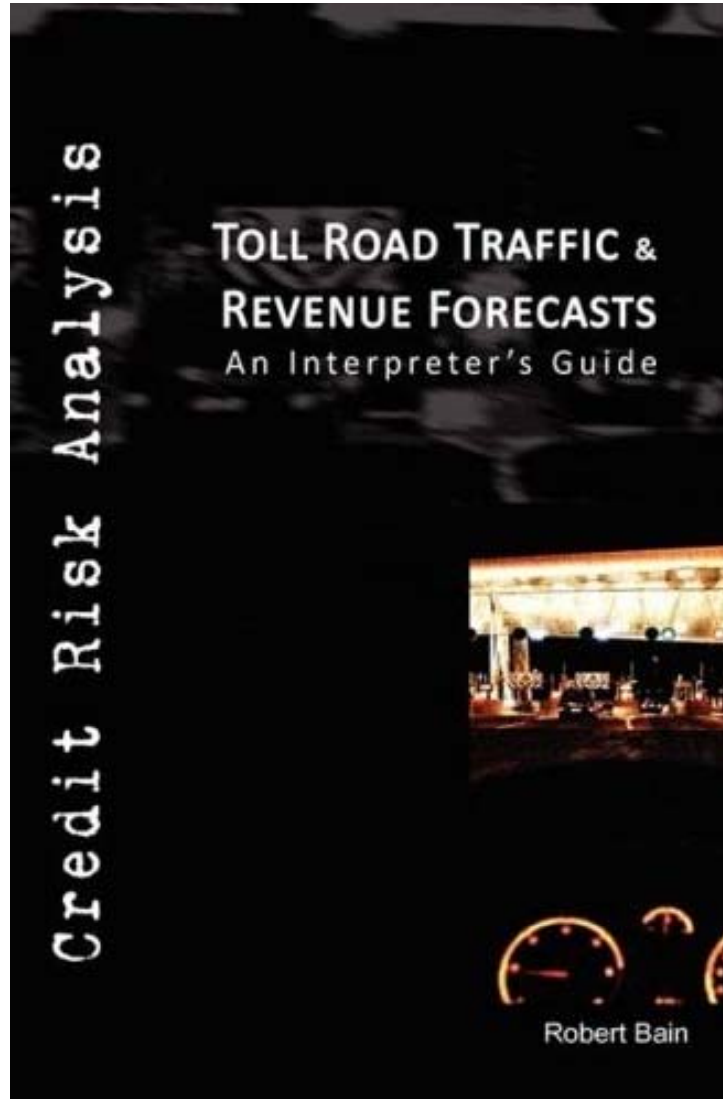
- Crisp-set  
(0 or 1)
- Multi-value  
(0, 1, 2, ...)
- Fuzzy-set  
(continuous)



# How Conditions Were Identified

- Originally-considered contract strategies:
    - Pricing approach
    - Concession length
    - ~~Revenue transfer mechanism~~
    - Upside revenue sharing
    - Downside risk sharing
    - Existence of parallel facilities
    - Level of congestion
    - User tolerance for tolls
- } *Combine into RISK element*

# Standard & Poor's Traffic Risk Index



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

Modified index combines and quantifies traffic-demand elements.

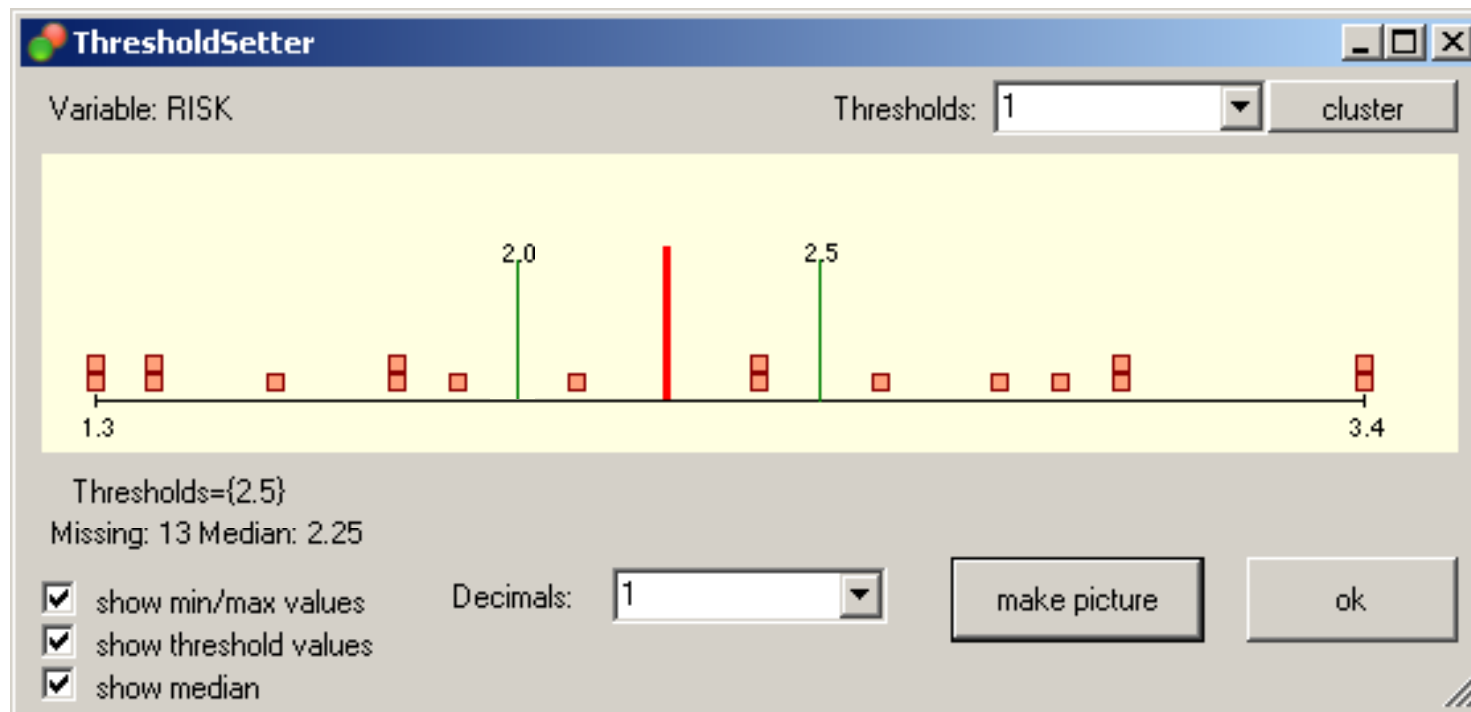
Sample case:  
Virginia  
Route 460

Average risk  
score = 3.4

<i>Project Attribute</i>	<b>Traffic Risk Index</b>					<b>Toll Facility</b>	
	1	2	3	4	5	Risk Score	Comments
<i>Tolling Culture</i>	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
<i>Toll Facility Details</i>	Estuarial crossings; radial corridors into urban areas		Dense, urban networks; ring roads/beltways around urban areas			1	Radial connector between Richmond and Hampton Roads metropolises
	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)
<i>Users</i>	High-income, time-sensitive market		Average/low-income market			4	Average-income users; significant commercial/ freight traffic component
<i>Traffic Growth</i>	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

# Converting Risk to QCA Variable

- RISK = 0 (low demand risk) or 1 (high risk)
  - Initial threshold between low and high: 2.25
  - Subsequent sensitivity analysis from 2.0 to 2.5



# Operationalization of Conditions

PPP Contract Strategies	Variable Name	Meaning	Value
Toll-rate approach	PRICING	Average cost pricing	0
		Marginal social-cost pricing	1
		Revenue-maximizing pricing	2
Concession length	LENGTH	Variable length	0
		Short concession (< 50 years)	1
		Long concession ( $\geq$ 50 years)	2
Upside revenue sharing	UPSIDE	Absent	0
		Present	1
Downside risk sharing	DOWNSIDE	Absent	0
		Present	1
Traffic demand-risk level	RISK	Low risk (Index = 1 to 2.2)	0
		High risk (Index = 2.3 to 5.0)	1

# Case Selection Criteria

- PPPs with direct tolls
  - Subsequent re-procurements considered as separate cases
  - Greenfield and brownfield
- Highway/bridge/tunnel projects
- Geographic variety
  - Enables greater diversity of configurations
- Sufficient documentation available

# Case Locations (18 Total)



# PPPs in Germany

- National PPP enabling legislation (1994):  
“Fernstrassenbauprivatfinanzierungsgesetz”
  - 12 syllables, 40 letters
  - In practice: the “F Model”

(Fern / strassen / bau / privat / finanzierungs / gesetz)

(High / ways / construction / private / financing / law)

# Construct Data Table

- For each case:
  - Develop one-page project summary, highlighting developments related to contract strategies and outcomes
  - Assign numerical values for each condition and outcome, based on QCA rubric
- Result: QCA data table
- Check internal validity of data and coding

# Initial Data Table

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	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	0	1	0	0	1	0	0	1
(etc.)								

# Internal Validity Checking

- Ensure outcome diversity
- Avoid counterintuitive configurations
  - Causal conditions absent but outcomes present
- Ensure cross-condition diversity
  - Condition pairs do not appear in “lock step”
- Ensure sufficient variation for each condition
  - “A variable must vary”
- Avoid contradictory configurations
  - Identical conditions with different outcomes
- Conduct inter-rater reliability test

# Contradictory Configurations

ID	PRICING	LENGTH	UPSIDE	DOWNSIDE	RISK	TOLLRATE	FREEFLOW	MINMAX
I-495	1	2	1	1	0	0	1	0
SKYWAY	2	2	0	0	0	0	0	1
SH121	1	2	1	1	0	1	1	0
WARNOW1	0	1	0	0	1	1	0	0
HERREN	0	1	0	0	1	0	0	1
407ETR2	2	2	0	0	0	0	1	1

# Inter-Rater Reliability Test

- Ensure qualitative-to-quantitative data conversion is robust and replicable
- Evaluate/refine initial QCA rubric
  - Eight cases (in three sets) selected for re-coding by independent reviewers
  - Reviewers used same project documentation
  - Rubric was iteratively clarified before review of subsequent case set
- Converging scores → stronger validity

# Analysis: TOSMANA

The screenshot shows the (MV)QCA software interface. A dialog box is open in the foreground, displaying the logical expression:  $PRICING\{0\} + DOWNSIDE\{1\} + LENGTH\{2\}RISK\{1\}$ . The background window has the following settings:

- Not used: FREEFLOW, REVMAX
- Case Descriptor: ID
- Outcome: TOLLRATE
- Conditions: PRICING, LENGTH, UPSIDE, DOWNSIDE, RISK
- Selection Mode: Show all
- just result button
- Include for reduction: Outcome 0 (radio), Outcome 1 (radio), Contradictions (radio), Missing Outcome (radio), Remainders (radio)
- Exclude: Outcome 0 (radio), Outcome 1 (radio), Contradictions (radio), Missing Outcome (radio), Remainders (radio)
- Use upper-case/lower-case notation:
- Include variable information in Output:
- Close Reports on Exit:
- Compute Simplifying Assumptions:
- Output Mode: HTML (in IE)
- Buttons: close, Visualize, Truth Table, show implicants, go

# Results: TOLLRATE variable

- TOLLRATE = 1 (specific toll level is attained) when...

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

# Results: FREEFLOW variable

- FREEFLOW = 1 (maximum throughput or congestion management is enabled) when...

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

# Results: MINMAX variable

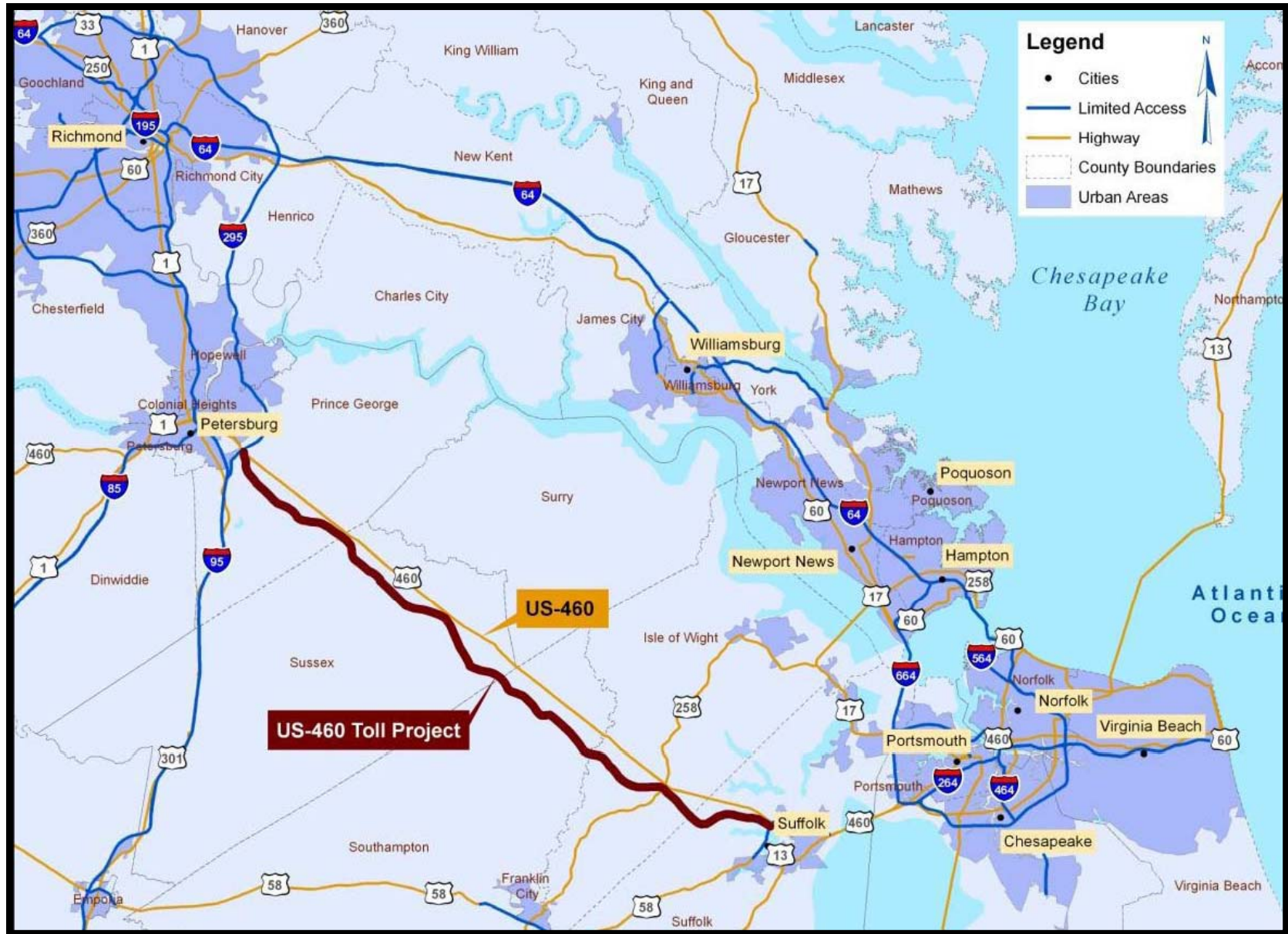
- MINMAX = 1 (maximum revenue or minimum subsidy is enabled) when...

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

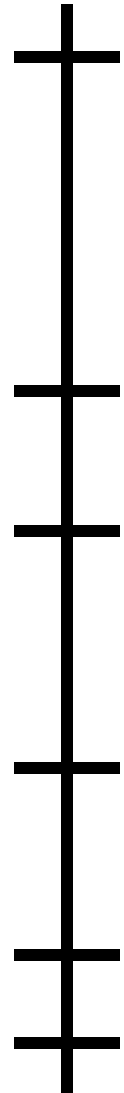
# Implications for Policy and Practice

- Support for decision-makers
  - Tool #1: QCA analytical guidance
  - Tool #2: Risk-worksheet score
  - In development: QCA “case library”
- Illustration of tools’ application to current PPP procurement

# Route 460 Improvements



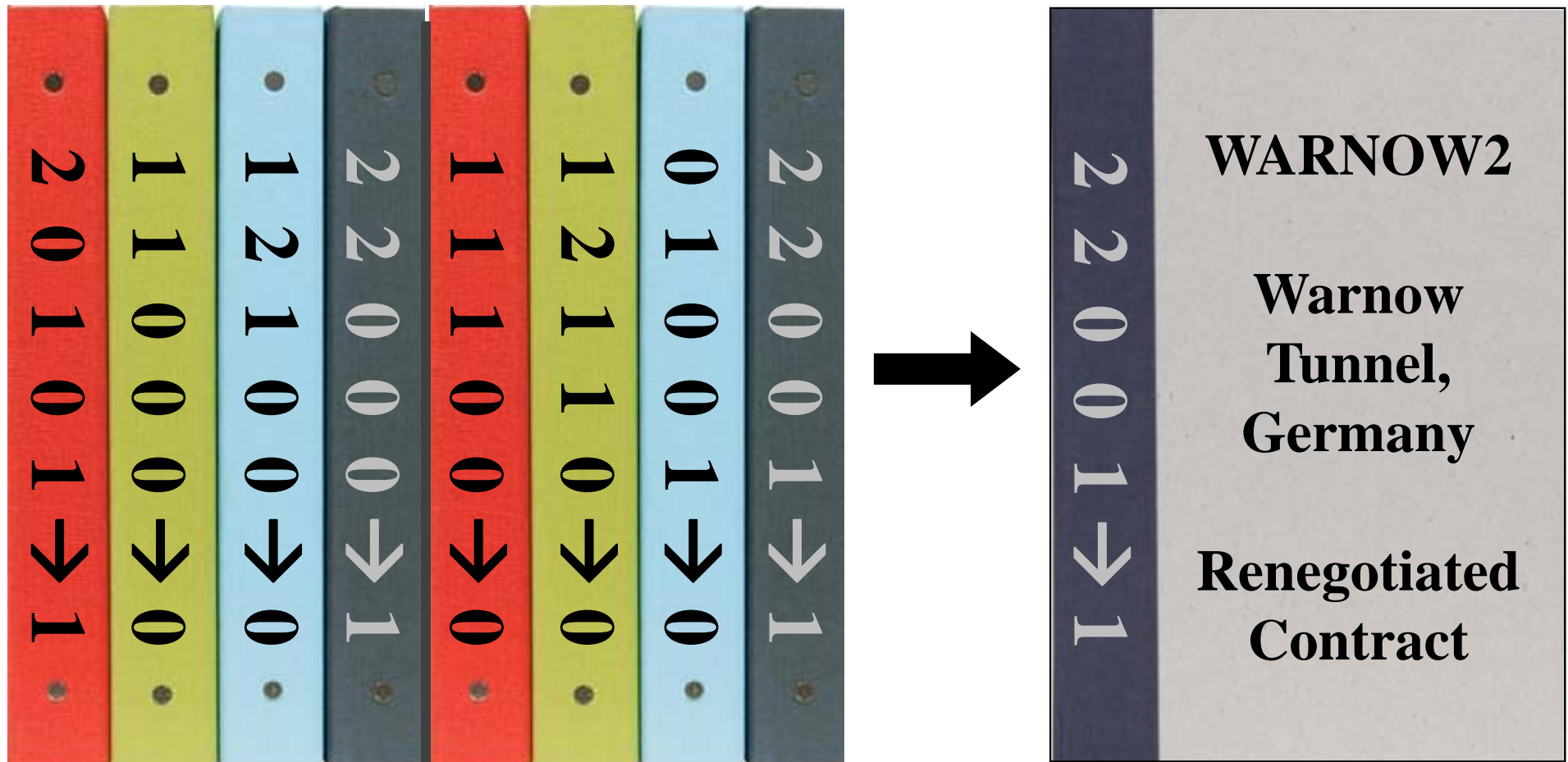
# Procurement Timeline

- 
- 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

# Tool #2: Risk Worksheet Score

- Traffic-risk score is linked to demographic/geographical characteristics of project and is largely independent of procurement structure
  - First procurement: risk score = 3.4
  - Second procurement: risk score = 3.5
  - → RISK = 1 (high risk) in both cases
- Consistent with actual developments: limited interest from private sector

# In Development: Comparison with QCA "Case Library"



# Comparing Configurations

ID	PRICING	LENGTH	UPSIDE	DOWNSIDE	RISK	MINMAX
460 #1	2	0	1	0	3.4 → 1	1
460 #2	2	2	0	0	3.5 → 1	1
WARNOW2	2	2	0	0	1	1

- Warnow Tunnel: revenue was simply too low relative to substantial project cost
- New Route 460 solicitation (July 2010):
  - Decreases cost (e.g., state assumes risks)
  - Increases revenue (state will provide subsidy)

# Conclusion

- Central research question:
  - “Given specific policy objectives for road pricing, how should public owners select PPP contract strategies which support these outcomes?”
- QCA model developed to address question
- Directions for future work
  - Extending QCA model to incorporate additional conditions (contract strategies)
  - Further populating “case library” to assist in evaluating future procurements

# Limitations of Research

- Caution: avoid over-generalization of results
- Results are guidelines, not a recipe
- Possibility of geographic bias

# Questions?

## For Further Information

- Gross, Martha E. (2010) *Aligning Public-Private Partnership Contracts with Public Objectives for Transportation Infrastructure*. PhD dissertation, Virginia Tech.
- Full text available here:  
[http://scholar.lib.vt.edu/theses/available/etd-08242010-173605/unrestricted/Gross ME D 2010.pdf](http://scholar.lib.vt.edu/theses/available/etd-08242010-173605/unrestricted/Gross_ME_D_2010.pdf)