UNDERSTANDING THE MANAGEMENT FACTORS THAT CONTRIBUTE TO SUCCESSFUL ELECRONIC TOLLING SYSTEMS

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EXECUTIVE SUMMARY

As states awaken to the realization that large, expensive surface transportation projects can no longer be undertaken given the constraints of current funding mechanisms, policy makers are beginning to rely more heavily on tolling as an alternate means of funding desperately needed infrastructure projects. Tolling technology has evolved considerably from the traditional cash collection that was prevalent fifty years ago to all electronic, high speed, open road tolling that allows vehicles to maintain highway speeds as they traverse tolling points. This relatively new technology has substantial benefits, but has inherent risks that left unaddressed could result in failure to collect toll revenues in a fair, efficient, effective manner.

For states moving toward tolling as a means of project funding, the ability of toll authorities to collect tolls accurately and efficiently is paramount. If toll authorities implementing electronic tolling fail to operate to their fullest potential, states risk not being able to fully satisfy the debt service requirements of bond holders that provide the capital needed to move forward with infrastructure construction. This endangers the ability of the state to finance future road and bridge projects.

As toll authorities implement all electronic tolling (AET) systems, they may look to other states for guidance where such technology has been successfully utilized in the past. However, this is an incomplete analysis. Different toll authorities experience unique circumstances and challenges that limit the ability to apply lessons learned by examining one authority to operations of another authority. This paper systematically examines nine tolling authorities over a ten year period using statistical analysis to identify factors under management control that are consistently associated with successful tolling.

The findings indicate that there are two important actions that managers can take to contribute to the success of electronic tolling. The first is to set the toll rate sufficiently high such that it is “worthwhile” for the authority to collect a toll. Toll rates that are too low, while potentially attractive to motorists, reduce the efficiency of the authority in collecting revenues. Secondly, large toll authorities should take steps to increase the number of vehicles that pay tolls through electronic means and minimize those that pay through cash or video invoicing. Small toll authorities should pool their operations with other authorities in order to make investments in electronic tolling cost effective.

While the analysis is subject to some limitations, it provides additional guidance and comfort to toll authority managers initiating new toll systems. When combined with case study analysis, managers should be able to use this paper to inform decisions about how to structure their tolling systems to ensure efficiency is optimized and the likelihood of collecting revenues sufficient to repay financial obligations is maximized.

BACKGROUND

There is a growing recognition of, and a sense of urgency to address, outdated and over-burdened bridge and roadway infrastructure in Kentucky[1]. Projects to rehabilitate and replace large bridges across the Ohio River between Kentucky and adjoining states are extremely expensive propositions. Kentucky's portion of the Louisville Bridges Project described below is approximately $1.3 billion; roughly the amount of revenue collected by the entire state Road Fund in a year. The U.S. Congress has not raised the federal gasoline tax for over two decades, placing the Federal Highway Trust Fund in dire fiscal condition and essentially eliminating the federal government as a potential source of funding for such projects[2]. Increasingly, states are looking to tolls as the only feasible source of revenue capable of supporting such large expenditures[3]. Of the $1.3 billion price tag mentioned for Kentucky with respect to the Louisville Bridges Project, $750 million was financed through the sale of bonds and loans secured by toll revenues to be collected.

The Louisville Bridges Project is the largest single public infrastructure project ever undertaken in Kentucky[4]. The project is a joint effort between the Commonwealth and the state of Indiana to improve mobility across the Ohio River in downtown Louisville and in the eastern part of Jefferson County, Kentucky. The map in Appendix A shows the major components of the Louisville Bridges Project.

The Louisville Bridges Project is divided into the East End Crossing and the Downtown Crossing[5]. The East End Crossing consists of a new bridge with associated approach work on both sides of the river approximately eight miles upstream from downtown Louisville that will complete the I-265 loop around the metro area. The East End Crossing is being financed, constructed, overseen, and will ultimately be maintained primarily by Indiana.

The Downtown Crossing consists of a major rehabilitation of the existing John F. Kennedy Bridge on I-65, the conversion of that bridge to southbound traffic only, the construction of a new bridge directly adjacent to the existing Kennedy Bridge to carry north bound traffic, and approach work on both sides of the river including significant safety improvements to the Kennedy Interchange just south of the bridges at the convergence of I-64, I-65, and I-71, known locally as Spaghetti Junction. The Downtown Crossing is being financed, constructed, overseen, and will ultimately be maintained primarily by Kentucky.

In accordance with a Bi-State Development Agreement between Kentucky and Indiana, tolls will be imposed on all three new and rehabilitated bridges, and those toll revenues will be divided evenly between the states[6]. Indiana will use toll revenues to reimburse the Indiana Department of Transportation (INDOT) for appropriations used to make availability payments to a private partner. Shortfalls in the Indiana revenue share could result in INDOT being forced to subsidize payments to the private partner, reducing the amount of appropriations available for other transportation projects across the state.

Kentucky will use toll revenues to repay approximately $750 million in toll revenue bonds and toll-backed loans to the federal government. Shortfalls in the Kentucky revenue share could result in losses to bondholders or lenders, which would lower credit ratings and in turn negatively impact the ability to finance future toll projects. As such, both states have a strong financial incentive to ensure that tolls are collected in a fair and efficient manner.

The states have agreed to implement an AET system to collect revenues. In an AET environment, there is no option to pay cash at the tolling points. Motorists may either establish a prepaid electronic toll account, or be billed after they use the bridges. Those who choose to establish an electronic prepaid account are issued a transponder to affix to their windshield, which automatically charges their account the correct toll as they drive over a bridge. Those who choose not to establish a prepaid account are invoiced based on a video capture of their license plate. Transponder customers enjoy a lower toll rate when using the facilities.

The operational performance improvements that AET offers relative to cash toll collection are the primary motivator for considering AET. The introduction of AET significantly increases roadway capacity by decreasing average and peak wait times associated with toll payment[7]. This makes intuitive sense given the fact that AET takes place at highway speeds, as opposed to forcing vehicles to stop and pay a cash toll. The reduction in wait times results in significant environmental benefits by reducing air pollution. These environmental benefits were significant enough that the Federal Highway Administration required the states to engage in AET as a condition of constructing the Louisville Bridges Project[8].

Despite the advantages of AET, there is a significant risk associated with not having cash collection. Historically, cash based toll collection systems employed physical barriers such as gates to prevent motorists from using the facility until the correct toll was collected. With the introduction of an AET system, it is possible for some motorists to use the facility without paying the appropriate toll. This phenomenon, known in the toll industry as “leakage”, can erode toll collections if sufficient penalties and enforcement for non-payment are not in place.

Further complicating toll collection on the Louisville Bridges Project is the fact that most drivers in the Louisville area are not familiar with paying tolls. The last experience with tolling in the area ended with the removal of tolls from the George Rogers Clark Bridge on US 31, known locally as the Second Street Bridge, in 1946[9]. That means that drivers in the area have not been familiar with paying tolls for the past fifty years, and those experiences were cash tolling rather than AET.

Given the novelty of tolling to the area, the challenges associated with AET, and the importance of successful toll collection to future toll projects in Kentucky, it is imperative that officials managing the toll system have an understanding of the factors under their control that can influence the success of the tolling system.

LITERATURE REVIEW

The Louisville Bridges Project is the first electronic tolling project in Kentucky, but not the first in the nation. Rating agencies, state auditors, other toll authorities, the federal government, and non-partisan private research groups have all previously weighed in on the management factors associated with successful electronic tolling.

Fitch Ratings, Moody's Investors Service, and Standard and Poor's are the three most well recognized credit rating agencies in the United States. While each agency relies upon its own proprietary rules and internal credit counsel reviews in assigning final credit ratings, all three agencies periodically publish general rating criteria and methodology that can be useful in understanding what information the agencies will collect, and how they will attempt to analyze, understand and weigh each piece of information in making a ratings determination.

In discussing the management factors of toll roads, Fitch considers, "the experience of the management team, their record of revenue and cost management, facility maintenance, capital renewal, and their effectiveness relative to peers." [10] Moody's "normally meets with senior executives to assess business strategies, policies, and philosophies, and evaluates management performance relative to the performance of competitors." Moody's criteria further discusses the importance of financial controls directly under management influence, and the performance of certain liquidity measurements such as number of days of cash on hand[11]. Standard and Poor's assesses "management's overall ability to coordinate its activities with relevant planning boards and governmental bodies," and "evaluates management in the context of quality of planning involved in the budget-making process for operations, maintenance, and capital improvements." [12]

In the United States, both the Government Accountability Office (GAO) and the Congressional Budget Office (CBO) have produced research outlining management strategies associated with successful toll implementation. The GAO, recognizing the importance of overcoming public opposition, recommends building public support by overcoming the double-taxation argument, addressing regressivity, reinventing the government enterprise to function more like a business, and providing leadership by actively marketing the toll facility[13]. The CBO advises that users may be concerned about tolling information privacy in an AET scheme, and may resist paying tolls for existing infrastructure, though that resistance almost completely disappears when the tolls are supporting new or expanded capacity[14]. More recently, some commuters, including members of the United States Senate, have expressed concerns regarding tolls supporting corruption and graft, highlighting the need for transparency as a management tool that can contribute to AET success[14].

The Reason Foundation did a fairly comprehensive analysis of the AET model for a paper comparing tolling costs to the cost of collecting motor fuel taxes[15]. The AET section was based primarily on three case analyses, but the general findings were instructional for toll managers. The findings indicated that acceptance by the public was a critical factor in system success. Public acceptance was increased through consistent messaging about the benefits of signing up for an electronic transponder as opposed to relying on video invoicing. This message needed to be reinforced through a differential toll rate. The paper also discussed the cost to collect tolls in the context of what toll was being charged; an indication that efficiency is directly related to toll rates. This paper provides the foundation for some of the hypotheses tested later.

Finally, let us turn our attention to what current and future practitioners of all electronic tolling have to say about successful management implementation. In 2003, the Auditor General of Illinois published an audit of the Illinois State Toll Highway Authority (ISTHA). The report listed 23 specific recommendations, some of which focused on the management of all electronic tolling. More importantly, the Auditor conducted a survey and undertook a comparative analysis of ISTHA performance against peer tolling across a wide range of metrics[16]. One recommendation was to improve enforcement against customers that chose not to pay through electronic means and were delinquent in making payments after using the roadway. This is an indication that ISHTA must have been struggling to address non-electronic customers.

When researchers investigated the implementation of AET by the Bay Area Transportation Authority, they found that what was needed was a differential toll rate that rewarded AET users over cash, that transponders needed to be more readily available to customers for purchase in convenient locations, and that a concerted two year marketing effort was needed to inform the public about AET. [17]

METHODOLOGY

The majority of existing literature addressing management of electronic tolling systems relies on case study analysis to identify and synthesize best practices. This can be a useful way to understand what has and has not worked well in other areas, and direct practitioners away from the pitfalls that were common among early adopters.

One way to strengthen the lessons learned from case study review is to perform a quantitative, statistical analysis of readily available tolling data. This type of analysis can supplement case study work, and can potentially uncover evidence of correlations between factors that might lead to toll system success, and the actual success itself. When correlation is present, and paired with a logical explanatory framework for why the data look the way they do, it is often possible to make very strong causal claims. For managers of the Louisville Bridges Project tolling system, it is beneficial to understand that managers in another state adopted policy "x" and that the state enjoys a successful tolling system. It is much more useful to have evidence that amongst multiple tolling agencies, those that adopted "x" were more successful than those that did not, all else being equal, *because they adopted* "x".

Using publicly available data from nine toll authorities in the United States, as discussed in the Data Description section, I construct a fixed effects linear regression model in an attempt to identify what factors make an electronic toll system successful. This model estimates the impacts that each control and explanatory variable has on the dependent variable, controlling for inherent differences between the authorities being studied.

Figure one gives a brief definition and explanation of each variable constructed from the data. Cost to collect, the dependent variable, is a broad measure of a toll authority's efficiency in collecting toll revenues. It represents the "success" of the tolling system in the sense that toll authorities that are more efficient in revenue collections are more commercially viable than those that are less efficient. To achieve a low value here (meaning to spend less per dollar of revenue to collect that dollar, or be "more efficient"), a toll authority must be collecting strong revenues and controlling costs.

The controls and explanatory variables are the factors that influence cost to collect, and by extension the success of the tolling system. Controls are variables beyond management's influence, but which are nonetheless likely related to cost to collect. Controls must be included in the regression to make any claims about the impact that explanatory variables have on the dependent variable. If controls are not accounted for, the model will have little explanatory power and any statistically significant results will be suspect because they could be the result of having omitted other important considerations.

A positive relationship is hypothesized for the number of toll system employees with respect to cost to collect. Generally, technology is seen as a lower cost substitute for labor and therefor one would expect to find that toll authorities that are heavily reliant on people to collect cash, invoice customers, review license plates, and other labor-intensive tasks would, on average, pay more in operating costs for each dollar of toll revenue they collect. For the same reasons, I expect that the percentage of transactions collected electronically would have a negative relationship with cost to collect. Authorities that can successfully drive customers away from cash or video invoicing and towards electronic payment through transponders will likely be more efficient, and expend less per dollar of revenue in terms of cost to collect.

The final explanatory variable is revenue per transaction. This is a rough proxy for the average toll rate charged. Although this is influenced by factors outside of management control such as traffic mix and overall traffic level, the toll authority does have some flexibility to change toll rates and influence revenue per transaction. A negative relationship is hypothesized because authorities that are collecting more for each transaction should be able to cover their operating expenses more quickly than authorities that charge less per transaction.

In addition to explanatory variables, the model also contains four controls. Employee reporter is not expected to have any impact on cost to collect, but is included as a control to ensure that authorities that did not report their number of employees are not significantly different from those that did. This is discussed in further detail in the Data Description section.

Commercial vehicles are typically heavy adopters of transponder technology, so as the percentage of commercial traffic relative to overall traffic increases we would expect to see declines in cost to collect. Increases in commercial vehicle traffic as a percentage of overall traffic should increase the percentage of transactions that are collected electronically, which has already been hypothesized to have a negative relationship with cost to collect.

FIGURE 1
REGRESSION VARIABLES

Variable	Type	Definition	Hypothesized Impact on Cost To Collect
Authority	Control	Numeric value for each toll authority	Controls for unique authority characteristics through time
Cost to Collect	Dependent	Operating costs divided by toll revenue	Driven by changes in controls and explanatory variables
Employees	Explanatory	Number of non-maintenance employees	Increases cause cost to collect to increase (less efficient)
Revenue per Trans	Explanatory	Toll revenue divided by toll transactions	Increases cause cost to collect to decrease (more efficient)
Percent Electronic	Explanatory	Transactions collected electronically	Increases cause cost to collect to decrease (more efficient)
Percent Commercial	Control	Transactions from commercial vehicles	Increases cause cost to collect to decrease (more efficient)
Transactions	Control	Total number of tolled transactions	Increases cause cost to collect to decrease (more efficient)
Year	Control	Fiscal year reported by toll authority	Increases cause cost to collect to decrease (more efficient)
Employee Reporter	Control	Indicates if authority reported employees	None, included as a control for incomplete data

FIGURE 2
REGRESSION MODEL SETUP

$$Yit = \beta 1Xit + \alpha i + uit$$

Where[18]

αi (i=1….n) is the unknown intercept for each toll authority (n entity-specific intercepts).

Yit is the dependent variable where i = toll authority and t = time

Xit represents one explanatory variable or control

$\beta 1$ is the coefficient for the explanatory variable or control

$u$it is the error term

DATA DESCRIPTION

FIGURE 3
DESCRIPTIVE STATISTICS

VARIABLE	Unit of Measurement	Observation	Min	Max	Mean	S.Dev
Cost to Collect	Cents per dollar	85	20.7	63.9	36.3	12.9
Employee Number	Individual employees	59	85	2986	1044	845
Revenue per Transaction	Dollars per transaction	86	.471	5.30	2.33	.96
Percentage Electronic	Percentage	84	.000	.863	.504	.143
Percentage Commercial	Percentage	86	.005	.240	.113	.032
Toll Transactions	Millions per year	86	19.1	832	278	273

Data were collected from the Certified Annual Financial Reports (CAFR) of nine public toll authorities in the United States over the decade from 2003 to 2012[19]. The full list and map of tolling authorities is presented in Appendix B. These reports provide a source of financial and operational data that is relatively consistent across toll authorities. Certain portions of the CAFR must be compiled in accordance with generally accepted accounting principles and then audited in accordance with generally accepted auditing standards. The portions of the CAFR that are not audited are examined by auditors and management is questioned about the way in which the information was gathered and reported. This consistency and level of audit scrutiny provides comfort to investors and lenders that are typically the intended audience for CAFRs, but also makes them an excellent source of information for academic analysis.

While CAFRs are generally consistent, there is some flexibility in generally accepted accounting principles that allows entities to report slightly different variations of the same information. Some manual manipulation of source data was necessary to improve consistency amongst the tolling authorities, although even that was not sufficient to achieve complete consistency. As an example, some toll authorities include both depreciation of capital assets and maintenance of the roadway in their reported totals for operating expenses. While these are important pieces of information, they are not directly related to the cost of operating the tolling system. Depreciation is a function of prior capital expansion, and roadway maintenance expenses are a function of the desired level of roadway preservation. Changes in depreciation or roadway maintenance expense could be the result of a growing or contracting roadway system, or changes in the level of quality at which the roadway is being maintained. Since these expenses are unrelated, or perhaps weakly related, to the cost to operate the tolling system, they were extracted from total operating expenses for purposes of calculating cost to collect.

Three of the nine agencies did not report information on the number of employees. To ensure that the non-reporting agencies did not differ significantly from the agencies that did report, I included a control variable in the regression that indicates whether or not the agency reported information about employees. Those agencies that did report employees often did so in an aggregated fashion that included maintenance employees. As previously discussed, roadway maintenance is not directly related to the operation of the toll system itself; therefore those employees are best left out of the analysis.

Two of the nine toll authorities did not report information for the entire decade. One authority reported only nine years of data, and another reported only eight. Since the number of missing years was small relative to the total number of observations, no corrective action was taken.

Toll authorities, like all other governmental entities, report activity on the basis of a fiscal year. Some toll authorities in the study had a fiscal year that coincided with the calendar year, some reported on a fiscal year ending June 30th, while others reported on a fiscal year ending May 31st. While some authorities provided enough information before and after the decade being studied to make an approximate correction for this issue, not all authorities did, so the difference was ignored.

LIMITATIONS

Researchers would prefer that when their results are published that those results be accepted as absolute truths applicable to all other similar situations. These aspirations are captured in the terms "internal validity" and "external validity". Unfortunately, like other abstract constructs, regression models are only as powerful as the assumptions upon which they are built and the data that is being analyzed. When real life fails to behave in accordance with regression assumptions, and when the data available for analysis departs from the ideal, weaknesses are introduced into the analysis that limit internal and external validity.

Internal validity refers to a model's ability to capture what's happening with the dependent variable and offer the true and accurate explanation of why that is happening. If there are other plausible explanations for what is happening, or the researcher has failed to take into account the interplay between the variables in the model, then internal validity comes into question. Challenges to internal validity that cannot be addressed lead to the inability of the researcher to assert that the model correctly describes reality.

External validity refers to the ability of a model's predictions to be generalizable to other situations. Assuming that a model is internally valid, and is accurately explaining what is happening with the data, that does not necessarily mean that the results will be applicable in other situations that differ materially from the situation being examined. Challenges to external validity lead to the inability to use the results to draw conclusions about other situations.

The model under consideration has very few challenges to internal validity. The nature of panel regressions allows them to control for the unobserved characteristics of individual toll authorities that are consistent through time. This means we can be relatively confident that the impact the model assigns to each explanatory variable is in fact due to changes in that variable, and not some other unobserved characteristic. The only remaining challenge to internal validity would be exclusion from the model of variables that are important in determining cost to collect.

One tradeoff to gain the internal validity of a panel regression model is that it loses some external validity. We are inherently assuming that there is something unique and unobservable about each individual toll authority. Controlling for that uniqueness strengthens our explanatory power, but places a limitation on how far the results can be applied to other agencies. A further challenge to external validity is the fact that all of the data collected for the analysis come from older, well-established toll authorities. These agencies are convenient for data collection purposes because they report the most financial and operational data, but if they differ in any significant way from other toll authorities, then the results of the analysis may not be applicable to other agencies.

While limitations on external validity are unfortunate, they do not necessarily negate the results. Recall that the primary reason for engaging in this model was to lend statistical credence to some of the lessons learned more informally through case analysis. To the extent that the results confirm the knowledge from case studies, there is a strong argument that external validity should not be a critical concern. Also, challenges to external validity present an opportunity for follow-up research. Researchers wishing to continue this line of inquiry might consider reanalyzing this model with data from younger toll authorities when available.

RESULTS AND INTERPRETATION

FIGURE 4
REGRESSION MODEL RESULTS

VARIABLE	ESTIMATED IMPACT	STANDARD ERROR	SIGNIFIGANCE
Employee Number	-.0000152	.0001141	
Revenue per Transaction	-.3573838	.0480593	***
Percentage Electronic	.5949798	.2113711	***
Percentage Commercial	.213582	1.536083	
Toll Transactions	1.017547	.5576331	**
Employee Reporter	.0389781	.1624331	
Year	.0116462	.0066718	**
Electronic X Transactions	-.9554784	.4109635	***

**Significant at 90% confidence
***Significant at 95% confidence

Recall that the dependent variable is cost to collect. Note that cost to collect was transformed to a logarithmic scale for this analysis. This scaling better reflects the way in which cost to collect is impacted by movements in the explanatory variables and controls. However, it means that we are examining *percentage* changes in cost to collect, and not linear changes. For example, if a movement in an explanatory variable causes cost to collect to increase by "five" that does not mean that the toll authority is spending an additional five cents to collect one dollar of revenue; it means that the authority's cost to collect is expected to increase by *5%*. If we are considering an agency with a cost to collect of 15 cents per dollar and the model predicts a movement in the explanatory variable will cause cost to collect to increase by "five", we mean that cost to collect will increase to (15*1.05)=15.75 cents per dollar, not 20 cents per dollar.

The model contains three explanatory variables, and four controls. Addressing the controls first, none of the control variables were significant at a 95% level of confidence, which is the conventional level of significance for social science work; the interpretation of the results changes if you assign a lower level of significance. This means that there is insufficient evidence available to claim that there is any relationship between the value for the four control variables and the value for an authority's cost to collect. Whether or not an authority reports the number of employees, the year during the study, the total number of transactions, and the percentage of commercial vehicle traffic all have no impact on reducing or increasing the cost to collect. Somewhat unexpectedly, the control variable for number of toll transactions is nearly statistically significant in the positive direction. This will be addressed momentarily.

Moving to the three explanatory variables, two are found to be significant. There is no evidence to make any claims at a 95% level of confidence that toll authorities with fewer employees are any more or less efficient in terms of cost to collect than their counterparts. There is, however, sufficient evidence to claim with 95% confidence that higher toll revenues per transaction are associated with lower costs to collect.

Surprisingly, the evidence indicates that there is a statistically significant positive relationship between the percentage of transactions collected through electronic means and the cost to collect. This result contradicts the hypothesized relationship, and is frustratingly counterintuitive. This means that as a toll authority increases the number of its customers using electronic tolling, doing so actually *increases* the cost to collect and correspondingly decreases efficiency. This odd result is a function of some of the underlying assumptions that are being made with linear regression. By regressing the total number of toll transactions and the percentage of electronic transactions on cost to collect individually, the assumption is that each of those variables reacts in a linear fashion with cost to collect. That is to say, that increasing the number of transactions or the percentage of electronic transactions impacts the cost to collect in a linear fashion, increasing or decreasing the cost to collect by the same percentage regardless of all else.

To use linear regression on variables which may not always impact the dependent variable in a linear way, we must use an interaction term. The last variable listed is a continuous interaction term between toll transactions and the percentage of transactions collected electronically. The interpretation of this result is the most interesting finding. What it says is that increasing the percentage of electronically collected tolls does, in fact, reduce cost to collect; but only for toll authorities that process roughly 500,000,000 toll transactions per year or more. For smaller volume toll authorities, increases in the percentage of electronically collected tolls increases cost to collect.

CONCLUSIONS

Managers of electronic toll systems must be careful to understand what influence they have over the efficiency of the system. Existing literature indicates that strong financial oversight of a tolling system is important. Since tolling is a customer driven business, toll managers must also take steps to ensure the public understands the benefits of the system and uses it in the most efficient way.

The analysis indicates that managers can be more efficient in terms of reducing cost to collect by setting toll rates sufficiently high, and by focusing efforts to increase electronic usage of the system when transaction volumes are high. Managers of smaller tolling systems can increase their efficiency by increasing electronic collection only when they "team" with other small agencies to achieve sufficiently high volumes.

This analysis uses efficiency of revenue collections as a proxy for toll system success. To the extent that toll managers may have goals that are constrained by other factors, they may choose a policy or set of policies that does not maximize revenue collection efficiency. This is acceptable, but it is important for managers to recognize when they are doing so, and understand the sacrifices in efficiency that may result from the pursuit of a competing goal.

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APPENDIX A
LOUISVILLE BRIDGES PROJECT

APPENDIX B
TOLL AUTHORITIES EXAMINED

APPENDIX C
RESEARCHER COMPILED DATASET

Authority	Cost to Collect	% Electronic	Rev per Trans	Employee	Report Emp	Year	Transactions	%Commercial
Oklahoma Turnpike	.289635	.688223	1.50368	498	Yes	2012	155.2840	.086532
Oklahoma Turnpike	.299867	.686357	1.51060	507	Yes	2011	150.6840	.085981
Oklahoma Turnpike	.237039	.662910	1.48080	510	Yes	2010	154.2880	.084102
Oklahoma Turnpike	.260594	.646114	1.36307	512	Yes	2009	150.2180	.082959
Oklahoma Turnpike	.280976	.642634	1.34349	509	Yes	2008	146.0100	.093610
Oklahoma Turnpike	.254836	.628483	1.39017	505	Yes	2007	141.4930	.096457
Oklahoma Turnpike	.240664	..616596	1.44011	495	Yes	2006	135.0820	.098074
Oklahoma Turnpike	.235944	.601602	1.45855	529	Yes	2005	131.0850	.098562
Oklahoma Turnpike	.207178	.593212	1.49336	518	Yes	2004	124.4800	.098843
Oklahoma Turnpike	.211819	.574886	1.51515	0	No	2003	118.3660	.098474
New Jersey Turnpike	.289308	.772139	2.35406	0	No	2012	592.0314	.056528
New Jersey Turnpike	.452408	.	1.54629	0	No	2011	613.6494	..056117
New Jersey Turnpike	.438940	.724824	153336	0	No	2010	620.9671	.055000
New Jersey Turnpike	.431805	.714677	1.50267	0	No	2009	633.8183	.053279
New Jersey Turnpike	.545049	.696850	1.14309	0	No	2008	653.2624	.055969
New Jersey Turnpike	.532344	.673129	1.11197	0	No	2007	670.8106	.056187
New Jersey Turnpike	.500346	.662500	1.08231	0	No	2006	681.2100	.055254
New Jersey Turnpike	.501011	.635000	.945753	0	No	2005	752.6646	.052072
New Jersey Turnpike	.	.	.	.	.	2004		.
New Jersey Turnpike	.	.	.	.	.	2003		.

APPENDIX C
RESEARCHER COMPILED DATASET

Authority	Cost to Collect	% Electronic	Rev per Trans	Employee	Report Emp	Year	Transactions	%Commercial
Illinois State Highway	.248311	.863000	1.14757	1206	Yes	2012	803.7800	.114584
Illinois State Highway	.339684	.840000	.783684	1153	Yes	2011	832.8280	.107625
Illinois State Highway	.351441	.830000	.806227	1241	Yes	2010	817.0820	.105601
Illinois State Highway	.395504	.820000	..763605	1331	Yes	2009	775.3530	.103844
Illinois State Highway	.368017	.810000	.750302	1371	Yes	2008	777.8820	.114884
Illinois State Highway	.322454	.800000	.725737	1354	Yes	2007	788.2920	.117009
Illinois State Highway	.304021	.790000	.742679	1317	Yes	2006	764.1250	.112010
Illinois State Highway	.288451	.740000	.743731	1354	Yes	2005	780.4460	..108999
Illinois State Highway	.415432	.474000	.475720	0	No	2004	823.1450	.132449
Illinois State Highway	.394507	.	.470874	0	No	2003	801.6030	.134850
Florida Turnpike Sys	.285316	.791258	.916500	2251	Yes	2012	664.2790	.051727
Florida Turnpike Sys	.300060	.756103	.919158	2328	Yes	2011	652.8570	.050939
Florida Turnpike Sys	.292651	.710031	.921409	2589	Yes	2010	639.4260	.049435
Florida Turnpike Sys	.322767	..682749	.936067	2625	Yes	2009	630.8610	.051295
Florida Turnpike Sys	.298766	.654884	.952423	2986	Yes	2008	667.3200	.054777
Florida Turnpike Sys	.277064	.618984	.961560	2930	Yes	2007	690.4850	.056873
Florida Turnpike Sys	.256024	.554470	.956874	2924	Yes	2006	661.3680	.064185
Florida Turnpike Sys	.279628	.524132	.948755	2798	Yes	2005	617.9300	.055074
Florida Turnpike Sys	.	.447373	.887879	2841	Yes	2004	587.0430	.052226
Florida Turnpike Sys	.	.360005	.846173	2909	Yes	2003	532.3510	.048320

APPENDIX C
RESEARCHER COMPILED DATASET

Authority	Cost to Collect	% Electronic	Rev per Trans	Employee	Report Emp	Year	Transactions	%Commercial
Pennsylvania Turnpike	.496295	.641100	4.12931	1392	Yes	2012	189.0870	.127597
Pennsylvania Turnpike	.486505	.600600	3.91291	1382	Yes	2011	189.0420	.125961
Pennsylvania Turnpike	.545418	.566100	3.71961	1384	Yes	2010	186.5320	.122944
Pennsylvania Turnpike	.638989	.534000	3.30579	1568	Yes	2009	186.2200	.126635
Pennsylvania Turnpike	.622713	.524000	3.15971	1494	Yes	2008	189.5510	.134291
Pennsylvania Turnpike	.624079	.464200	3.19616	1493	Yes	2007	185.4230	.136531
Pennsylvania Turnpike	.616030	.419100	3.16640	1485	Yes	2006	185.9010	.136153
Pennsylvania Turnpike	.496564	.368300	2.89324	1518	Yes	2005	188.4250	.133257
Pennsylvania Turnpike	.580787	.312300	2.17395	1583	Yes	2004	188.0190	.129811
Pennsylvania Turnpike	.	.	.	0	No	2003	.	.
Ohio Turnpike Comm	.296014	.462000	5.13888	973	Yes	2012	49.8040	.208537
Ohio Turnpike Comm	.316512	.422000	4.76026	0	No	2011	49.2460	.207530
Ohio Turnpike Comm	.332575	.372000	4.82008	0	No	2010	48.8560	.203783
Ohio Turnpike Comm	.409899	.320000	3.94677	0	No	2009	48.2020	.201734
Ohio Turnpike Comm	.402212	0	3.81061	0	No	2008	50.0120	.219467
Ohio Turnpike Comm	.366477	0	3.89060	0	No	2007	51.5270	.221107
Ohio Turnpike Comm	.385327	0	3.61009	0	No	2006	51.7840	.222366
Ohio Turnpike Comm	.386036	0	3.55851	0	No	2005	51.1490	.215058
Ohio Turnpike Comm	.348432	0	3.83674	1338	Yes	2004	50.1600	.195295
Ohio Turnpike Comm	.371271	0	3.78485	0	No	2003	48.2820	.188186

APPENDIX C
RESEARCHER COMPILED DATASET

Authority	Cost to Collect	% Electronic	Rev per Trans	Employee	Report Emp	Year	Transactions	%Commercial
Kansas Turnpike Auth	.359514	..495028	2.48337	0	No	2012	35.2619	.117074
Kansas Turnpike Auth	.355062	.485953	2.55216	0	No	2011	33.0557	.124803
Kansas Turnpike Auth	.354757	.472027	2.53914	0	No	2010	33.3130	.120061
Kansas Turnpike Auth	.371350	.432610	2.40839	0	No	2009	32.9992	.120052
Kansas Turnpike Auth	.393740	.424618	2.41623	0	No	2008	32.4610	.132081
Kansas Turnpike Auth	.329740	.407337	2.35831	0	No	2007	33.1575	.134759
Kansas Turnpike Auth	.382963	.392329	2.31243	0	No	2006	32.7559	.136106
Kansas Turnpike Auth	.380168	.380435	2.28637	0	No	2005	32.2005	.133802
Kansas Turnpike Auth	.370580	.362446	2.21753	0	No	2004	32.3199	.130066
Kansas Turnpike Auth	.380463	.	.	0	No	2003	.	.
Golden Gate Bridge	.260675	.681877	5.29505	90	Yes	2012	19.4170	.005408
Golden Gate Bridge	.277703	.672815	5.28013	99	Yes	2011	19.0840	.005188
Golden Gate Bridge	.266941	.642913	5.21218	101	Yes	2010	19.2950	.005235
Golden Gate Bridge	.295621	.627242	5.09394	101	Yes	2009	19.0660	.005402
Golden Gate Bridge	.321743	.600875	4.34510	101	Yes	2008	19.6580	.006511
Golden Gate Bridge	..300977	.533050	4.30423	101	Yes	2007	19.7580	.007136
Golden Gate Bridge	.325970	.517277	4.35113	87	Yes	2006	19.4770	.007085
Golden Gate Bridge	.310071	.507758	4.34110	85	Yes	2005	19.3990	.007268
Golden Gate Bridge	..315660	.493158	4.34259	99	Yes	2004	19.4400	.006996
Golden Gate Bridge	.319237	.411961	4.08806	98	Yes	2003	19.4290	.007103

APPENDIX C
RESEARCHER COMPILED DATASET

Authority	Cost to Collect	% Electronic	Rev per Trans	Employee	Report Emp	Year	Transactions	%Commercial
West Virginia Parkway	.294099	.326900	2.39297	244	Yes	2012	35.0640	.214322
West Virginia Parkway	.286018	.301600	2.37786	244	Yes	2011	34.4680	.212603
West Virginia Parkway	.291883	.290000	2.32372	240	Yes	2010	34.3720	.213226
West Virginia Parkway	.416228	.262500	1.58710	234	Yes	2009	33.6090	.211193
West Virginia Parkway	.403585	.263000	1.64279	247	Yes	2008	34.4310	.232872
West Virginia Parkway	.381020	.252200	1.65124	247	Yes	2007	35.2250	.234634
West Virginia Parkway	.360406	.239400	1.75823	247	Yes	2006	35.1820	.239810
West Virginia Parkway	.381248	..208200	1.63904	252	Yes	2005	35.3860	.234782
West Virginia Parkway	.369666	.193800	1.60559	249	Yes	2004	35.4100	.222141
West Virginia Parkway	.367387	.186000	1.59103	264	Yes	2003	34.4160	.221031