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FINANCING INFRASTRUCTURE: FIXED PRICE VS. PRICE INDEX CONTRACTS

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ABSTRACT. This paper looks at a common type of price adjustment, price indexing, which provides contractors with compensation for increases in price volatile commodities. We address the effect of Firm Fixed Price (FFP) versus indexed price systems for a price volatile commodity. The impact of these two types of bid systems is analyzed through a combined qualitative and quantitative analysis. Results indicate that an indexed price system does not provide a reduction in costs compared to a Firm Fixed Price system. This study is important to state financial managers as they address the efficient use of resources invested in state infrastructure.

INTRODUCTION

State governments usually ask for bids among interested and qualified firms for long-term infrastructure construction. The lowest bidder is then chosen to fulfill the project requirements and is monitored by the state agency requesting the project until the completion of the infrastructure project. In the process of bidding, how to control the production costs and quality is the focal concern of the government. The contractor's concern is how to secure their profit. However, in this process, asymmetric information between the two parties, the government and the contractor, provides tension

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between the two groups. The asymmetric information involves the problems of moral hazard and adverse selection.[1] Moral hazard occurs when the contractor has information about the cost of production and the government is unable to acquire that cost information. Adverse selection arises when the government cannot observe the expected production level of the individual contractor. As a result, the government cannot differentiate inefficient contractors from efficient ones.

While designing the contract, the government must take into consideration the problems of moral hazard and adverse selection that are induced by the asymmetric information environment. In practice, three basic alternatives have been used to address the issue of information asymmetry, Firm Fixed Price contracts, Cost Plus Fixed Fee (CPFF) contracts, and Cost Plus Incentive Fee (CPIF) contracts (Thai, 2005). In this paper we look at price index models, a CPIF contract, and the FFP contract model to assess the financial implications of these two types of contracts in infrastructure provision. The price index model has not been a previous subject of inquiry although it is one of the most common models in infrastructure provision. We assess the implications through qualitative and quantitative techniques.

BACKGROUND

In practice, three basic alternatives have been used to address the issue of information asymmetry in long-term infrastructure contracting. These three types of long-term contracts are Firm Fixed Price contracts, Cost Plus Fixed Fee (CPFF) contracts, and Cost Plus Incentive Fee (CPIF) contracts In the FFP contract, the buyer (government) requests offers and the seller (contractor) responds to the request by offering the price for completing the project. With respect to information asymmetry, FFP contracts have no impact on moral hazard unless the government can assess the costs of inputs and resources required for the project. Without this knowledge, the assumption by government is that the contractor’s ex ante price is correct. This allows the contractor to acquire information rents from the government, extracting a higher price than it would have if the government had the same knowledge as the contractor. Empirical results indicate that the government usually overpays for the project under the fixed-price contracts if the government lacks the information of the inputs and resources for the projects. Simple projects with economical designs are usually procured with FFP contracts, since the cost of the complete ex ante design lowers the likelihood of the renegotiation changes ex post.

With CPFF contracts, the government pays the bid price plus a fixed fee which is negotiated at time of award (Thai, 2005). In this contract type, the contractor has no incentive to control the production cost. To reduce the negative incentive associated with the lack of control over production costs, the common practice is to replace the CPFF contract with the CPIF contract. The CPIF contract eliminates the desire of the contractor to drive up actual costs.

The CPIF contract is developed to increase the power of incentives of the CPFF contracts, reducing the overpayment problem of the FFP contracts. Under the CPIF contracts, the government pays the bid price plus a proportion of the cost overrun or minus a proportion of the cost saving. The cost overrun or saving is the difference between the targeted production cost and bid price. In this way, the government and the contractor share the risk of price volatility. The cost-share parameter is predetermined by the government and the contractor. According to the U.S General Accountability Office, the typical cost-share parameter is in the range of 15% to 25%. Usually, it is difficult for the government to calculate the targeted cost for the project. Instead of setting the target cost, the government's preference is the budget-based scheme that requires the contractor to provide the estimated target cost. By doing so, the government is able to get useful information for the budget planning process. The government provides the contractor with a menu of contracts based on the assessment of the basic parameters concerning cost minimization and cost-padding, computation of the incentive matrix and incentive profit. Reichelstein (1993) shows that the contractor's tendency is to choose a high profit target in return for a high cost-share parameter, under the premise that the cost of information is relatively favorable. The contractor is encouraged to control the cost simply because of the high cost-share rate, with the savings split by the government and the contractor. In this way, both parties are better off.

In the construction and testing of the procurement model, Cox et al. (1996) conclude that as predicted in economic theory, there is a fundamental trade-off between the maximization of allocative efficiency and the minimization of the budgetary procurement expense. The lower expense by the CPIF contract can offset the cost of inefficiency caused by the moral hazard and adverse selection problems. These findings have suggested to policymakers the need to reduce the use of fixed-price contracts, moving to the more favorable cost share contract. Furthermore, research indicates that the CPFF contract is not proper for multiple bidders and incentive based contracts minimize the procurement cost (McAfee & McMillian, 1986).

Prior scholarship indicates that the fixed bid contracts may be inefficient, while cost share contracts may reduce inefficiencies caused by moral hazard and adverse selection. A modification of the cost share contract is the price adjustment method, known as price index contracts. The basic rationale of adopting a price index in the long-term contract is that the real value of the currency is unstable; the future payment should be tied to the future current units.

The economic reason for price indexing is that the indexing of an input may lead to a reduction in long-term costs. To examine this premise, this study looks at one of the most commonly indexed items in road construction, liquid asphalt cement. This input into the production of road asphalt is an extremely price volatile petroleum product. To approach the cost savings potential of price indexing liquid asphalt cement, the remainder of this paper looks at six southern region states in which a state that uses a fixed price system is bordered by five states using a monthly price index for the price of liquid asphalt cement.

Price Indexing and Liquid Asphalt Cement

In the case of government contracting for infrastructure construction, the price of some input resources, like liquid asphalt cement, is volatile leading some state governments to adopt the price index model to address this issue. In the years under study, the state of Georgia is using the fixed-price contract model for road asphalt construction while all five bordering states have adopted the asphalt price index to adjust for the volatility of this input's price. Given that the price index model is similar to the cost-share contract and

Georgia uses a fixed price model, the opportunity to evaluate these two models is presented.

This study adds to this comparison by providing the first assessment between fixed-price and index-price contracts. With the emergence of the price index contracts, the question of the impact of the price index model and its financial benefits to state government are of critical importance in assessing the true costs of infrastructure provision.

QUALITATIVE ANALYSIS

To begin the analysis, we establish the definition of a long-term contract for state contracts to indicate a contract life in excess of one-year or the contract meets a minimum tonnage consideration and exceeds one-year in span. A qualitative review of the current price indexes shows that all five price index states use a very similar procedure to adjust the price of liquid asphalt cement. As shown in Table 1, differences arise among the timing of the adjustment with two states using the 1st of the month, one state using the 3rd day of the month, another state uses the 15th day of the month, and the final state does not indicate the timing of the adjustment. All the price index states use an average F.O.B.[2] terminal selling price for major providers of asphalt products, with one state dropping both the low and high prices prior to computing the average selling price. Four of the five price index states require a market change of at least 5% of the initial bid price for liquid asphalt cement before an adjustment is made.

The standards and specifications of the liquid asphalt cement price index provide little differentiation among the price index states. To understand the use of the price index instrument, each state was interviewed and surveyed. Initial contact was made with the DOT Commissioner's office. Each Commissioner's office provided the contact individual who was interviewed regarding the liquid asphalt price index. The interviews and survey, which included open-ended and multiple choice questions, asked the border states' representatives to respond to questions focused on their index processes, the lessons they have learned from their years with the price index, and the costs and benefits associated with the price index. The results indicate that four of the five states are satisfied

TABLE 1
Comparison Chart of Pricing Indexes for the Border States of Georgia

	Alabama	Florida	North Carolina	South Carolina	Tennessee
Timing of index(S)	Index established monthly (no date listed)	Index established on the 15th day of each month	Index implemented on the 3rd day of each month	Index established on the 1st day of each month	Index established on the 1st day of each month
Change required for adjustment	No minimum percent change required	Increase or decrease of more than 5%	Increase or decrease of more than 5%	Increase or decrease of more than 5%	Increase or decrease of more than 5%
Location of price index	Standard Specifications Manual	Standard Specifications Manual	Standard Specifications Manual	Special provision to the Standard Specifications Manual	Special Provision 109B to the Standard Specifications Manual
After completion dates pass	Price adjustment for a decrease in asphalt price	No provision	No date specifications listed	At unit cost price or at adjusted unit price whichever is lower	At unit cost price or at adjusted unit price whichever is lower
How index is determined	Average F.O.B. terminal selling price for major suppliers	Average F.O.B. terminal selling price for suppliers	Average F.O.B. terminal selling price for suppliers for omitting highest and lowest terminal price	Average F.O.B. terminal selling price for suppliers to contractor	Average F.O.B. terminal selling price for suppliers to contractor
Other requirements to qualify for price adjustment	None	Time must exceed 365 calendar days or use more than 5,000 tons of asphalt concrete	None	None	None
Price adjustment calculations provided	No	Yes	Yes	No	Yes
How Index(S) published	Online by month and year	Online by month and year	Online by month, year and by supplier terminal	Online by month, year and with conversion table from +/- 5-45%	Not published online

with their price index process: however some states have concerns focused on the financial savings associated with the price index, the true costs of administering the index, and the effect of the index on the supply of liquid asphalt cement. These issues of the effect of the price index system may arise from the fact that none of the states using the price index in this study have performed a cost-benefit analysis to assess the financial value of the price index system.

QUANTITATIVE ANALYSIS

To analyze the effects of the price index system, a review of the indexed prices of liquid asphalt cement in the price index states and the quoted prices by suppliers to Georgia was compared.[3] A numerical comparison of the price index states and Georgia was established. Table 2 provides the descriptive statistics for the monthly time period. Using Table 2, Georgia Department of Transportation (GDOT) has the lowest statewide average and median price for liquid asphalt cement as reported for the time period. Although the descriptive statistics offered in Table 2 indicate that Georgia was quoted the lowest average and median price for the time period, a statistical analysis of the data, as provided by means testing, indicates that no statistically significant differences are found between the price index states and Georgia.

TABLE 2

Descriptive Statistics for Non-Polymer Liquid Asphalt Cement Monthly in English Tons: November 2001- December 2003 (In $)

	Alabama	Florida	Georgia	North Carolina	South Carolina	Tennessee
Mean	173.57	170.15	164.59	173.60	169.82	173.59
Median	172.49	171.71	166.78	176.18	174.03	178.27
Standard Dev.	14.97	18.03	19.85	22.61	24.26	18.29

Source: Data obtained is the price index by month from each border state's Department of Transportation and the quoted monthly price for Georgia's Department of Transportation.

As shown in Table 3, the average price of liquid asphalt cement for the time period is similar among Georgia and its border states. However, as shown in Table 3, the volatility in the price of liquid asphalt cement in Georgia, as measured by the standard deviation, is higher than the states of Alabama, Florida, and Tennessee but lower than the states of North Carolina and South Carolina.

TABLE 3
t-Test of the Monthly Means for Non-Polymer Liquid Asphalt Cement (November 2001 – December 2003)

	|t| Statistic*	p-value
Georgia Compared to Alabama	1.84	0.072
Georgia Compared to Florida	1.06	0.296
Georgia Compared to North Carolina	1.53	0.133
Georgia Compared to South Carolina	0.85	0.399
Georgia Compared to Tennessee	1.70	0.095

Note: * Hypothesis tested is that there is no difference between the means.

Hot Mix Asphalt

Although no difference is found between the border state's index price and the quoted price of liquid asphalt cement in Georgia, this lack of a difference may indicate that no financial differences exist between the two types of contract systems or may be due to a lack of a true cost for Georgia liquid asphalt cement since Georgia does not require liquid asphalt cement as a separate pay item. The price of liquid asphalt cement is included in the total costs of hot mix asphalt (HMA) in Georgia. Although the price of liquid asphalt cement appears similar in the statistical analysis of its quoted price, we further analyze the price of liquid asphalt cement as represented in the total price of HMA. The HMA analyses[5] include a price evaluation of Superpave 12.5 mm and all Superpave for the states of Georgia and South Carolina. The groups are defined as follows[6]: All Superpave includes all non-polymer surface, binder, and base courses of Superpave; and Superpave 12.5mm includes only non-polymer mix types of the 12.5mm. Data for the comparison is complete for the time period January 2001 through December 2003.

The comparison of the two states was established to assess possible differences in the price of asphalt cement due to the two different contractor bidding systems. Recall that Georgia is a fixed price system for liquid asphalt cement while South Carolina uses a price index system for liquid asphalt cement. South Carolina's price index system is very similar to all the border states of Georgia. This similarity provides the opportunity to statistically compare a price index state to a fixed price state.

The analyses compare Georgia to South Carolina based on monthly matching independent samples.[7] Thus, data that is missing in either state are dropped from the analysis. This limitation reduces the statistical analyses to 25 single months of comparison. These months include six months in 2001, nine months in 2002, and ten months in 2003.

The data in the Table 4 shows quantity, costs, and the weighted average cost for the analyses. As shown in the table, Georgia reported using about 12 times as much Superpave 12.5 mm HMA and about 24 times as much total Superpave as South Carolina during the 2001 – 2003 time period. Although tonnage is much higher in Georgia, each project is bid independently; therefore, aggregated volume by state may not affect the price.[8] As shown in Table 4, the average cost for All Superpave is about $.32 higher in Georgia than in South Carolina. The other category, Superpave 12.5 mm, indicates that the

TABLE 4
Hot Mix Asphalt Comparisons for Georgia and South Carolina (January 2001-December 2003)

All Superpave	English Tons	Costs	Weighted Average Cost
South Carolina	444,672	$ 15,801,384	$ 35.53
Georgia	10,840,731	$ 388,640,426	$ 35.85
Superpave 12.5 mm			
South Carolina	292,533	$ 10,643,311	$ 36.38
Georgia	3,466,705	$ 123,104,573	$ 35.51

Source: State Mean Item Summary Data from each state's Department of Transportation.

average cost for Superpave 12.5 mm in Georgia is about $.87 less than Superpave 12.5mm in South Carolina.

To statistically analyze the weight average costs between these two states, Georgia's and South Carolina's weighted average costs per paired months are compared by a means test. Table 5 presents the results of the means test, which indicate that the appearance of a difference in weighted average costs is a spurious effect for the All Superpave category. For the Superpave 12.5mm category, the analysis indicates that the difference is statistically significant.

TABLE 5
Statistical Comparison of Hot Mix Asphalts for Georgia and South Carolina

Types of Asphalt	Georgia compared to South Carolina	
	t Statistic*	p-value
All Superpave	0.167	0.868
SuperPave 12.5 mm	-2.245	0.031

Note: * Hypothesis tested is that there is no difference between the means.

When we disaggregate the data to account for variation and standard deviation in price, Georgia's and South Carolina's average costs per ton in the All Superpave category of hot mix asphalt shown in Table 5 is not statistically different. When we interpret the Superpave 12.5mm category we find that the weighted average costs for Superpave 12.5mm in Georgia is statistically significantly less than the weighted average price in South Carolina.

CONCLUSION

In this study we examined the price of liquid asphalt cement using two different contracting systems, a price index system and a fixed price system. Although the analysis is limited in time and the number of comparative states, we find little indication of a price impact for the volatile petroleum product, liquid asphalt cement, due to a fix price contracting system. We find little evidence to support either the interviewee's or the cost-sharing literature assertion that the price index system reduces the price of liquid asphalt cement to the states using this system. Although the quantitative results do not indicate a price impact, we contacted liquid asphalt cement suppliers in the examined states to ascertain this lack of a finding. Some of the suppliers indicated that the lack of a price difference may be due to the fact that the suppliers have been guaranteeing the price of asphalt cement in long term contracts for the state of Georgia. The suppliers indicated that they will quote the price of liquid cement into the future for up to three years by providing a ceiling price to the contractors. This in effect places the volatility of the market price adjustments and the risks associated with the changes in liquid asphalt cement upon the suppliers. This occurrence may mask the true impact of a fix price system when compared to a price index system for liquid asphalt cement. Although we found little monetary benefit of the price index system, the intangible benefits were not measured. We therefore conclude that the impact of a price index system is limited to those alternative intangible benefits. Although survey, interviews, and prior literature inferred that a cost savings was possible through the use of the price index system, little evidence is shown in the costs evaluations.

NOTES

1. Moral hazard is defined as the effect of insurance coverage on the decision to undertake an activity that might change the likelihood of incurring a loss and adverse selection is defined as a trade that is biased due to asymmetric information about a market transaction favoring either the seller or the buyer (Nicholson 1995).
2. The term, Freight on Board (FOB) originated when mills began to ship via rail. They would F.O.B. a rail car at the closest rail siding. This means the mill (the seller) would get it loaded onto the rail car and pay for all charges (shipping and handling) related to getting it loaded. Once loaded, the receiver would be responsible for all freight charges, insurance, damage, etc. Sometimes they would F.O.B. the siding, which means they would only pay to get it to the siding and not loaded onto a rail car, ship, truck, etc.
3. The state of Georgia surveys its liquid asphalt suppliers monthly to determine an average price of liquid asphalt cement although it uses a fixed price system.

4. Data for the states includes price index data for the border states and quoted prices for Georgia.
5. Georgia and South Carolina provided complete information by item code for the analyses. The data were then compared by month and item code. Ideally, all the HMA items would be compared, however due to differences in the two states HMA types, only the Superpave items could be statistically compared. The other item types lacked enough statistical degrees of freedom to be included in the analysis.
6. All polymer mixes including SMA, OGFC, and PEM are not used in the analysis. The analysis is limited to non-polymer mixes due to data limitations.
7. The independent t-test looks at differences between groups (Georgia and South Carolina). The t-test is based on equality of means. To perform the test, matched samples are used for each month of data. Therefore, the samples are required to have similar monthly data (Example: Data for May 2001 must be available in each state)
8. We find that there is a statistically significant correlation for Superpave 12.5mm and the weighted average price. The correlation is -.448 (significant at a p-value of .001), a moderate relationship. The negative sign indicates as the tonnage increases the weighted average price decreases. The R^2 for the two variables is .20, which shows that 20% of the variance in the weighted average price is explained by tonnage. This may explain the t-test results that show that the price of Superpave 12.5mm is less in Georgia than South Carolina. When looking at the correlation for All Superpave and the weighted average price, a weak negative correlation is found (correlation of -.160); however this correlation is not statistically significant (p-value .276) and therefore is considered equal to zero.

REFERENCES

Bajari, P., & Tadelis, S. (2001). "Incentives versus Transaction Cost: A Theory of Procurement Contracts." *RAND Journal of Economics,* 32 (3): 387-407.

Reichelstein, S. (1992). "Constructing Incentive Schemes for Government Contracts: An Application of Agency Theory." *The Accounting Review*, 67 (4): 712-731.

Cox, J. C., Isaac, M. R., Cech, P.-A., & Conn, D. (1996). "Moral Hazard and Adverse Selection in Procurement Contracting." *Games and Economic Behavior, 17* (2): 147-176.

McAfee, R. P., & McMillian, J. (1986). "Bidding for Contracts: Principal-Agent Analysis." RAND *Journal of Economics, 17* (3): 326-338.

Thai, K. V. (2005). *Introduction to Public Procurement*. Herndon, VA: National Institute of Governmental Purchasing, Inc.