# LABOR MARKET REGULATION AND THE WINNER'S CURSE

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*This paper analyzes the impact British Columbia's 1992 Skill Development and Fair Wage Policy (SDFWP) on bid price determination. Econometric analysis of the public school projects tendered between 1989 and 1995 shows that prior to the SDFWP, the common values auction model applied, and bidders facing higher competition surcharged cost estimates in order to avoid the winner's curse. After the SDFWP, collective uncertainty concerning wages declined, and the independent values model became relevant. During this period, bidders responded to rising competition by lowering their bids. This adjustment explains, at least in part, why wage regulation did not raise bid prices.* (*JEL* D44, J38, L74, H57)

## I. INTRODUCTION

In March 1992, the government of British Columbia (B.C.), Canada, introduced the Skill Development and Fair Wage Policy (SDFWP), which mandated the payment of "fair" wages on provincial public construction projects, and promulgated the wage scales for construction crafts. In 1994, SDFWP was enacted as legislation. Similar laws have been enacted in England and the United States in the past, and as Allen's [1983] survey shows, their impact is a subject of controversy. Opponents argue that regulated wages distort the labor market, reduce competition, and increase construction costs. Proponents of the law, on the other hand, not only emphasize its long-term positive effects on the living and working conditions of workers, training, and the consequent productivity increases but also claim that the alleged inflationary effect is counterbalanced by the improved labor and product quality.

In this paper I focus on another consequence of wage regulation, namely, its impact on bidding for public construction contracts. I propose that the wage regulation will affect the construction market not only by changing the costs and quality of inputs but also through the transformation of the nature of the uncertainty that the contractors face during the bidding process. The auction theory predicts that the optimal bid is responsive to the type of uncertainty. Under the so-called common values (CV) model, bidders face some common source of uncertainty regarding the construction cost, and the winner is prone to underestimate the "true" cost. Rational (and experienced) bidders avoid this "winner's curse" by adding a surcharge to their estimated cost. As uncertainty assumes a less "collective" and more "private" nature, however, the winner's curse becomes less of a problem and the rational bidder does not need to resort to the additional surcharge as a protection from underbidding. The SDFWP may result in such a transformation in the bidding environment by reducing the uncertainty over labor costs that are common to all (nonunion) contractors. Elimination of the surcharge, in turn, may even offset the possibly higher labor cost. In this paper, I will test indirectly the hypothesis that the SDFWP influenced the bidding environment in B.C. in this fashion, under the working assumption that contractors follow optimal rules in determining bids. For this purpose, I will use data from 54 public school construction projects tendered between 1989 and 1995 and compare the pre- and post-SDFWP unit bid prices.

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The paper is organized as follows. In section II, I discuss the relevant auction literature and the hypotheses. I state the main hypotheses of the paper concerning the SDFWP and bidding behavior in section III. Section IV describes the data. An empirical model of bid price determination is presented and estimated in sections V, VI and VII. The final section concludes.

## II. BIDDING AND THE WINNER'S CURSE

Bidders for public school construction projects in B.C. submit sealed bids at a specified date, and the lowest bidder wins the contract.[1] Many of the early sealed-bid, first-price optimal bidding models presented in economics, civil engineering, and operations research literatures follow Friedman [1956]. According to these models, bidders are risk-neutral, noncolluding, expected profit-maximizers competing over a *single project*. Friedman suggests that the probability of being the lowest competitor is equal to the product of the probabilities of underbidding each competitor. Probability distributions of the competitors' bids are to be obtained from the data on previous tenders. This approach lays bare critical elements in competitive bidding. First, the contractor faces a trade-off between profitability and the probability of winning the contract. The bid must be high enough to yield a positive profit and low enough to win over other bids. Second, superior cost efficiency enables the contractor to change the parameters of this trade-off in his or her favor. Third, as the number of competitors rise, the optimum bid price declines.

One complicating factor is the nature of uncertainty facing the bidder. The Friedman model is based on the "independent private values" (IPV) assumption according to which uncertainty is purely specific to the bidder and estimation errors of the cost of production across bidders are independent. Since the work of Rothkopf [1969] and Capen, Clapp, and Campbell [1971], however, the possibility of collective uncertainty is recognized. Under the "common values" (CV) assumption, all bidders face collective uncertainty concerning the cost of production, and therefore their cost estimate errors will be interdependent. One important implication of the CV model is the susceptibility of bidders to the "winner's curse." In a sealed-bid, first-price auction for a construction project whose cost is not known with certainty (due to, say, erratic weather conditions), the winner will be the one who underestimates the cost of production the most. Although the expected value of bids *is unbiased, the winning bid is biased downward*. This underestimation problem is known as the winner's curse because the winner, being the most optimistic, is likely to make less than the anticipated profit or even losses.

The winner's curse is a conundrum because its persistence suggests irrational behavior and its reconciliation with the rationality postulate poses a challenge for economists. Wilson [1977], Milgrom [1979], and Milgrom and Weber [1982] base their analyses on symmetric noncooperative Nash equilibrium of the IPV and CV models and underscore the strategic considerations in bidding behavior. The thrust of this line of research is that although a naïve bidder may indeed be subject to the winner's curse, with the accumulation of bidding experience she or he will learn how to avoid it (or otherwise be driven out of the market). Under collective uncertainty, an experienced bidder avoids the winner's curse by presuming that his or her own estimate is the lowest estimate, that is, that she or he will win the contract. The bidder then adds a surcharge to the estimate as a buffer against adverse selection.

This strategic consideration has testable implications. First, in contrast to optimal bidding under the IPV assumption, equilibrium strategies under CV may require the bid price to increase with the number of bidders. This is because the bidder bases his or her bid on the presumption that she or he has the lowest estimate; as the number of competitors rise, the bidder becomes more conservative, and the thicker must be the padding surcharge. This counterbalances the impact of rising *competition that lowers the bid*. Once the number of bidders reaches a certain threshold, the surcharge effect is expected to dominate the competition effect and the bid price starts rising with the number of bidders. Second, the less is the uncertainty over, or the higher is

1. The bidder must be recognized as a reputable contractor as well. In all tenders, bidders were required to post bonds. In the present sample, there were no lowest-bidder contractors who were disqualified on this basis.

the level of information on, the "true" value of the auctioned item, the less is the effect of the winner's curse (and the less is the surcharge). In the present context, this theorem implies that lower uncertainty will put downward pressure on the accepted (lowest) bid and offset the (possibly) higher labor costs.[2]

In practice, it is difficult to delineate private and common uncertainty distinctly, and bidders are likely to face a combination of the two. Which type of uncertainty predominates and the pertinence of the winner's curse are empirical questions. Collective uncertainty and the winner's curse are argued to be prevalent, for instance, in publishing rights, offshore leasing, and free-agent baseball player auctions. Field evidence, as in Mead, Moseidjord, and Sorensen [1984], Hendricks, Porter, and Boudreau [1987], and Hendricks and Porter [1988], comes primarily from outer continental shell (OCS) hydrocarbon lease auctions, which is the quintessential example of the CV model. Bazerman and Samuelson [1983], Kagel and Levin [1986] and Kagel, Levin, Battalio, and Meyer [1989] provide empirical evidence on whether bidders are subject to the winner's curse, whether they learn to avoid it, and if so how long it takes, from laboratory experiments.

In the construction industry, it is not clear which assumption concerning uncertainty is more appropriate. Gates [1971] identifies various sources of uncertainty including drawing errors, plain mistakes (which are more likely to bias the cost estimate downward rather than upward), incomplete plans, interpretation of contract requirements of undetermined need and degree of enforcement, efficiency of the workforce, labor unrest, input prices, and natural conditions. Elements of collective and private uncertainty coexist in these factors. Dyer and Kagel [1996] treat construction contract bidding as a common value auction but also list a host of private value elements embedded in them. The IPV assumption perhaps applies more to a contractor's relationship with its foremen and crew, the crew's expected productivity, the firm overhead, and anticipated capacity utilization. The CV assumption is more pertinent to the future state of the labor market or natural conditions. There are very few empirical analyses of bidding in construction. Gaver and Zimmerman's [1977] analysis of highway contracts follows the Friedman [1956] model. They assume that the IPV model applies and predict bid prices to decline as the number of bidders increase and find evidence confirming the hypothesis. Thiel [1988] tests for the existence of the winner's curse directly by comparing bids and the engineer's estimates under the CV assumption and finds some evidence supporting the hypothesis that contractors pad their bids to avoid the winner's curse in highway construction (see also, however, Levin and Smith [1991]). Dyer, Kagel, and Levin [1989] find that construction executives fell prey to the winner's curse in laboratory experiments. They argue that the absence of contextual clues in the laboratory, which the subjects follow in actual situations, and the presence of IPV elements in the construction industry explain this outcome. Dyer and Kagel [1996] compare the differences between the winning and the next-lowest bid differences between the construction contract and OCS lease auctions and conclude that the potential for adverse selection is far smaller in the former. They also list various construction industry-specific mechanisms by which contractors can avoid the winner's curse.

## III. WINNER'S CURSE AND THE SDFWP

In the case of the B.C. sample, it is not possible to start the search for the winner's curse by comparing bids with the architect estimates because the latter are available for only a subset of the projects in the data set. Furthermore, some of the available cost estimates became out of date by the time bids were submitted because of the changes in construction specifications. Thus, even when they are available, these estimates cannot be taken as the "true" value of the project. In view of this, in this paper I pursue an indirect route to question the relevance of winner's curse in

2. Nash-equilibrium bid functions from which these propositions follow may be found in Rothkopf [1969], Gilley and Karels [1981], Kagel and Levin [1986]. See also Brannman, Klein, and Weiss [1987]. These propositions are also consistent with computer simulations of Capen, Clapp, and Campbell [1971]. The threshold value of the number of bidders depends on the underlying distribution of the information signals. According to Kagel and Levin [1986] the surcharge overtakes the competition effect when the number of competitors is greater than or equal to four. Simulations of Capen, Clapp, and Weiss [1971] state the threshold value as three bidders.

public construction contract bidding.

In B.C. the regulatory environment in public construction changed in March 1992 with the introduction of the SDFWP. The SDFWP mandated the contractors to pay workers "fair" wages and promulgated wage schedules. The "fair" wage was set at about 90% of the collectively bargained wage rate for each construction occupation. Wages constitute about 30% of the total construction cost (excluding land acquisition and architectural costs). Regardless of its immediate impact on the level of construction costs, the predetermined wage schedule is expected to reduce the uncertainty concerning labor costs of the bidder and its competitors alike. As a result of this policy wages became less of an unknown in the competition for the contract. The impact of the SDFWP may also spill over to other possible sources of common uncertainty. Proponents of the prevailing wage laws argued, for instance, that the wage regulation would affect the quality of workers and, consequently, the quality of the product, time of completion, and cost overruns. Thus, the legislated wage may reduce common uncertainty through a variety of possible channels related to the labor market conditions, resulting in an increase in the relative importance of the IPV elements.[3]

It is not possible to know a priori which types of uncertainty applied before and after the SDFWP, but empirical analysis may suggest an answer. I will analyze this question by comparing the impact of the number of competitors on the unit bid prices for the periods before and after the establishment of the SDFWP. Changes in the sign and level of the relationship between the bid prices and the number of bidders suggest which type of uncertainty prevails and if and how it changed with new regulations. For instance, a switch from a positive to negative relationship is indirect evidence for the applicability of the CV model prior to the SDFWP and the IPV model afterward. More generally, if the SDFWP weakens the CV assumption and strengthens the IPV assumption, it is expected that the relationship between unit costs and the number of competitors will be less positive (or more negative) after the establishment of the policy.

## IV. THE DATA

The data for the analysis come from 54 elementary and secondary school projects tendered between August 1989 and December 1995 in 6 (out of 18) school districts in the Lower Mainland education region of B.C. These auctions were distributed approximately evenly between the pre- and the post-SDFWP periods (25 before and 29 after). All bids were in excess of $250,000, and, therefore, all contracts after March 31, 1992 were covered by the SDFWP. A total of 452 bids were made on these projects by general contractors, yielding an average of 8.37 bids per tender. The number of bidders for each project varied between 4 and 17. (Descriptive statistics on the number of bidders are reported in Table I). A total of 81 general contractors submitted bids, but the distribution of bids across contractors is not uniform. Three contractors made 25%, and ten contractors made 53% of all bids. Fifty-seven contractors made four or fewer bids.[4]

Accepted unit (gross square-meter) bid prices for elementary schools ranged from $965 (Canadian) to $1,764 and from $996 to $1,718 for secondary schools (in 1989 prices).[5] Table II summarizes unit bid price data. The average unit bid price was $1,461, but there is a statistically significant difference between the pre- and post-SDFWP peri-

3. I was unable to compare pre- and post-SDFWP volatility of worker compensation, cost overruns, or completion times in B.C., because of data limitations. Wage data are available only for the unionized workers, while the bidders in the sample are almost exclusively open-shop general contractors. For the sample at hand, information on time to complete or cost overruns does not exist. Some circumstantial evidence on the spillover effects of the wage regulation can be obtained from the change orders, however. Dyer and Kagel [1996] suggest that the price of change orders is one mechanism by which a contractor who has underbid and won the contract can escape the winner's curse. If this is the case, the price of change orders may be expected to be higher under the CV model. In the present sample, the mean value of change orders, measured as a percentage of the winning bid, declined after the SDFWP (from 2.6% to 1.8%).

4. An overwhelming majority of the bidders are nonunion contractors, suggesting that union contractors are practically out of the school construction market. This rules out the comparison of the bidding behavior of the union and nonunion contractor.

5. The seven-city price index is used in deflating bid prices.

**TABLE I**
Number of Bidders per Tender

| | Mean | Median | Standard Deviation | Range |
|---|---|---|---|---|
| All tenders | 8.37 | 8 | 2.55 | 4–17 |
| Tenders before SDFWP | 7.88 | 8 | 2.11 | 4–15 |
| Tenders after SDFWP | 8.79 | 9 | 2.84 | 5–17 |

*Note*: The total number of tenders is 54; 25 are pre-SDFWP and 29 are post-SDFWP tenders.

ods ($p = 0.01$). After the establishment of the policy, the average bid price increased by 12.9%, from $1,362 to $1,538. These figures are consistent with the view that prevailing wage regulation raises the cost of construction.[6] Declining standard deviation of bid prices suggests that the bid dispersion was reduced after the establishment of the SDFWP. Finally, Table II reports that the average differential between the winning and the next-lowest bid declined from 1.91% to 0.93% after the implementation of the SDFWP, indicating that winners left less "money on the table" after the Policy. It is noteworthy that even the higher figure of 1.91% is tiny relative to the 50% figure Hendricks, Porter, and Boudreau [1987] report for the case of offshore drilling where the CV model and the winner's curse are ostensibly pertinent.

I also calculated the *within* auction standard deviation of bids (that is, the square root of the weighted average of individual auction variance estimates). This statistic measures variability among bids within auctions, or how disperse are individual bids from the mean bid price in each auction. These values are 58.36 and 50.48 for the pre- and post-SDFWP periods, respectively, indicating a decline in the within-tender variability of bids after the regulatory change.

## V. AN EMPIRICAL MODEL OF BID PRICE DETERMINATION

The benchmark first-price, sealed-bid auction models are built on a standard set of assumptions. They include:

1. Bidders are risk-neutral;
2. Only one item is auctioned at a time and there are no joint bids;
3. There is no collusion among bidders;
4. Bid preparation costs are negligible;
5. Each bidder has information on the number of its competitors, probability distribution of the competitors' estimates, and their risk attitude;
6. Bidders are symmetric;
7. Private independent or common values assumption applies.

Since these assumptions can only approximate real-life bidding, it is necessary to address to what extent they may be satisfied in school construction projects.

The assumption of risk neutrality focuses the analysis on expected profit-maximization. This assumption may not hold, for instance, if the estimated cost of project presents the contractor with the risk of insolvency. Available information on the annual sales volumes of the contractors and the average project costs in the sample suggests that this is unlikely to be the case. Furthermore, contractors are allowed to pull back their bids prior to the deadline without penalty. The next two assumptions are plausible in the present context. Contracts were tendered almost exclusively one at a time.[7] There are no instances of bids submitted jointly by more than one contractor. Although no analysis of bid rigging is carried out here, the large number of contractors who submitted bids makes this unlikely. I ignore the cost of bid submission because no solid

6. The accepted bid price and the final cost data strengthen the contention that prices were higher in the post-SDFWP period. The accepted average bid price is $1,506 after March 1992, $220 higher than its pre-SDFWP value. Comparing mean prices, we find that all of them increased by approximately 15% after the policy, and this difference is statistically significant at the 1% level.

7. Joint bid was relevant only in one case where two contracts were auctioned jointly and the winning firm submitted the lowest bid for one tender and the next-lowest for the other.

**TABLE II**
Bid Prices (per square-meter in 1989 prices)

| | Mean | Median | Standard Deviation |
|---|---|---|---|
| All Bids: | | | |
| All Tenders | 1461 | 1470 | 227 |
| Tenders before SDFWP | 1362[a] | 1301 | 222[b] |
| Tenders after SDFWP | 1538[a] | 1555 | 199[b] |
| All Tenders: | | | |
| Accepted (Lowest) Bid | 1406 | 1428 | 234 |
| Before SDFWP | 1286[a] | 1231 | 201 |
| After SDFWP | 1506[a] | 1508 | 215 |
| Lowest to Next-Lowest Bid Differential: | | | |
| All Tenders | 1.38 | 0.91 | 1.26 |
| Tenders before SDFWP | 1.91[a] | 1.42 | 1.36[b] |
| Tenders after SDFWP | 0.93[a] | 0.57 | 0.99[b] |

*Notes*: All prices are in Canadian dollars. One hundred ninety-seven bids were made before SDFWP and 255 after. For each variable I tested the hypothesis equality of pre- and post-SDFWP means and standard deviations (one-tailed tests). Superscripts a and b indicate that the hypothesis is rejected at the 1% and 10% levels, respectively.

information is available.[8] The fifth assumption is also likely to hold. The list of contractors who ask for the project drawings prior to bidding is common knowledge, and therefore each contractor has information on potential competitors. Small geographic size of the market and widespread use of subcontractors also facilitate the flow of information on the competition. I maintain the symmetry assumption, which implies that all contractors follow the same optimal bidding rule and each contractor knows that others follow it as well. If contractors are identical as well (for example, in terms of their efficiency, size, and so forth), then their estimated costs of construction would vary only on the basis of the individual information signals. The identical contractor assumption, however, is not plausible, and consequently the differences in bid prices would reflect both individual drawings from the probability distribution of the cost of construction and the contractor-specific characteristics. Thus, it is necessary to control for the latter in the empirical analysis. Finally, I do not make any assumptions on the nature of uncertainty in recognition of the possibility that the nature of uncertainty may change with the regulatory environment.

8. Project estimation cost may be captured by the size of the bidding firm (an explanatory variable used below), but in the absence of evidence, this remains a conjecture.

The model presented here attempts to predict the bid price submitted by expected profit-maximizing contractors. The dependent variable is the gross square-meter bid price. Explanatory variables attempt to capture the cost of construction, the degree of competition, and firm characteristics. These are the school type, the state of the construction business cycle, the number of bidders per tender, contractor size, the time trend, and school district controls.

The type of school may potentially control for several factors. One systematic difference between the elementary and secondary schools is that secondary schools take approximately twice as long to construct as the elementary schools. If there are economies of scale to longer construction period, as Gaver and Zimmerman [1977] argue, then secondary school unit price would be lower. Expansive sports fields are also more common in secondary schools, further driving down the unit cost. There are reasons to expect secondary schools to have higher unit cost, however, including the fact that they are generally two-story buildings and likely to contain higher unit cost structures such as laboratories.

The general market condition is captured by the construction business cycle. The expected cost of production is expected to be procyclical because of the cyclical nature of material costs. Varying levels of competition over the business cycle, however, may influence the bid price in either direction. As competition becomes more intense during a recession, for instance, the firm may be forced to lower its markup in order to remain competitive. It may also be argued that the markup is countercyclical as a result of the attempts of the firm, say in a boom, to protect its market share from new entrants to the market.

The number of bidders per tender is a measure of the degree of competition. As discussed above, the direction of the impact of the number of competitors is indeterminate. If the IPV model applies, the optimal bid price declines with the number of bidders; if the CV assumption dominates, it rises once the number of bidders exceed the threshold figure. One important issue raised by Gilley and Karels [1981] and Hendricks, Porter, and Boudreau [1987] in the OCS auction literature is that the number of bidders can be an endogenous variable and therefore not an appropriate measure of the degree of competition. Firms that are already drilling in the tracks adjacent to the auctioned tracts may have a very low estimates of the value of the auctioned tracks therefore prefer not to bid. In the current sample simultaneity is not likely to be as serious a problem because school construction is a far more standard item and the scope of differential information is not as wide as what is observed in OCS lease auctions.[9]

On the cost side, contractors are assumed to be price takers in input markets. The bid price, however, may be affected by the characteristics of the contractor. Gaver and Zimmerman [1977, 283] suggest capacity and efficiency as two potential factors. As the firm operates closer to full capacity, the bid price may increase or decrease depending on how the marginal cost changes. Second, the more efficient is the firm, the lower will be the optimal bid price.

The final variable is the (monthly) time trend. Bid prices may change over time for reasons other than those listed above. Rising productivity and improved cost estimation technology and methods are expected to lower bid prices over time. Another relevant factor is specification changes in construction. In B.C., in the late 1980s and early 1990s, school construction specifications, including building, mechanical, and electrical codes were changed in order to make structures more earthquake resilient. I do not have complete information on the sequencing of these changes, but since they have taken place gradually, bid prices are expected to have a positive trend. Finally, concerning the SDFWP, the adjustment of contractors to the new legal regime may be gradual, which may again be reflected in the time trend. Although it cannot distinguish between the individual effects of these factors, the trend captures any secular changes that affect unit bid prices.

I measure the construction business cycle as the percentage difference between the actual and linear trend values of real annual nonresidential building permits issued in B.C. over the 1989–95 period.

Measurement of the capacity and efficiency of the bidding firm presents problems. Data on the capital stock of the contractor or the number of foremen and supervisors on the payroll—obvious though imperfect candidates to measure capacity—are not available. Peculiarities of the industry also present difficulties. Where subcontracting is prevalent, it is difficult to define the capacity of a general contractor. Efficiency, in turn, is generally argued to be related to the size of the firm, but the direction of this relation is contentious. Larger size may imply economies of scale (and higher efficiency), as well as high overheads (and lower efficiency). Data permitted construction of series of average annual sales of each contractor. Several sources

9. A related issue, which does not introduce simultaneity problems, is whether the number of bidders varies with the regulatory environment. Table 1 suggests that both the mean and the median values of the number of bidders increased after the establishment of the SDFWP, but neither change is statistically significant. Still, a systematic relationship emerges between the number of bidders and the labor market regulation once the time trend is taken into account as well. Regression of the number of bidders on the SDFWP dummy, time trend and their interaction yields the following estimates:

$$\underset{}{\textit{Number of bidders}} = \underset{(2.5)}{4.1} + \underset{(3.5)}{8.4}\ \textit{SDFWP} + \underset{(2.4)}{0.1}\ \textit{Time} - \underset{(3.1)}{0.2}\ \textit{SDFWP}\cdot\textit{Time},$$

where *SDFWP* is a dummy variable taking the value of one if the project is tendered after the regulatory change and zero otherwise, and *Time* is the monthly time trend. The coefficient of determination of this equation is 0.20, but as the t-statistics in parentheses indicate, the estimated coefficients are statistically highly significant. The analysis of the factors underlying this pattern will be the subject of future research.

provide information on sales. The *Canadata* database lists all projects in B.C. undertaken by each contractor in each year during the period under analysis. I also utilized the *Journal of Commerce*'s "Substantial Performers" and "Leaders" reports of the leading contractors for 1992, 1995, and 1996. These listings provide information on the largest construction companies doing work in the four Western provinces and two Northern territories of Canada. I classified contractors into six categories in terms of average volume of sales: less than \$15 million, \$15–\$30 million, \$30–\$60 million, \$60–\$100 million, \$100–\$200 million, and above \$200 million. Ideally, one would like to have information about both the size (capital stock) and the capacity utilization of contractors. Admittedly, the sales volume does not adequately distinguish between the capacity and efficiency of the firm and may reflect the effect of both variables. Thus, I do not have any priors on the relationship between the bid price and the firm size. If there are economies of scale associated with higher sales, bid prices should decline with the sales size of the firm. If higher sales imply higher overheads or capacity utilization, bid prices are expected to rise.

The school type is captured by a dummy variable taking the value of one for secondary schools and zero otherwise. Five district dummies are used to control for location effects.

## VI. ESTIMATION RESULTS

In order to determine whether the response of bid price to explanatory variables varied across the two regulatory regimes, I estimated the following equation for the pre- and post-SDFWP periods separately:

$$(1)\quad \ln(Bid_{ij}) = \beta_0 + \beta_{1j}\,School\ type + \beta_{2j}\,Construction\ cycle + \beta_{3j}\,(1/Number\ of\ bidders) + \beta_{4k,ij}\,Firm\ size_k + \beta_{5mj}\,District_m + \beta_{6j}\,Time + \eta$$

where $i$ and $j$ are indices of bids and tenders, respectively. *Bid* is the real square-meter bid price. *Construction cycle* is the percentage deviation from annual trend of the real value of nonresidential building licenses issued. *Number of bidders* is the number of bidders per auction. *Firm size* is a vector of $k(=1, \ldots, 5)$ dummy variables for contractor sales size, and *District* is a vector of $m(=1, \ldots, 5)$ dummy variables for school districts. *Time* is the monthly time trend. $\eta$ is the error term. The total number of bids used in the regression analysis was 452; 197 of these were made before the establishment of the SDFWP and 255 afterward. District dummies are included in all regressions but their estimated coefficients are not reported.

Both ordinary least squares (OLS) and random effects (RE) methods are used in estimation. The problem with the OLS method is that it understates the standard errors because any auction-specific variables that are actually observed by bidders but omitted from the regression equation for the lack of data would result in errors being correlated across bids within auctions. Given that there are, on the average, eight bidders per auction, standard errors of auction-specific variables would be understated by approximately $\sqrt{8}$ if the errors were perfectly correlated.[10] Fixed and random effects models are the common methods to solve this problem of "auction" effects. Because of the perfect collinearity between fixed effects and the auction-specific regressors, I chose not to use this method. I contend that the RE model is more appropriate for the problem at hand because observations in the dataset are not exhaustive of all new schools in the region, and therefore the RE method is more appropriate to make inferences about the population. There are also no obvious reasons to expect the "auction" effects to be correlated with other regressors. Whether the RE performs the appropriate adjustment of the standard errors may be assessed at the empirical level as well. Since the OLS standard errors could be overstated by as much as $\sqrt{8}$, the credibility of the RE standard errors can be ascertained by comparing the OLS and RE es-

10. I thank an anonymous referee of this journal for drawing my attention to this problem and pointing out its potential magnitude.

**TABLE III**
Determinants of Bid Prices (Excluding the Time Trend)

| | OLS | | | RE | | |
|---|---|---|---|---|---|---|
| | Whole Period | Before SDFWP | After SDFWP | Whole Period | Before SDFWP | After SDFWP |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Constant | 7.284<br>(279.46)*** | 7.364<br>(228.25)*** | 7.090<br>(217.87)*** | 7.284<br>(99.57)*** | 7.323<br>(87.23)*** | 7.077<br>(84.39)*** |
| School type | 0.051<br>(3.68)*** | 0.111<br>(6.21)*** | 0.037<br>(2.32)** | 0.065<br>(1.83)* | 0.107<br>(2.42)** | 0.036<br>(0.98) |
| Construction Cycle | 0.005<br>(4.62)*** | −0.004<br>(1.55) | 0.003<br>(2.97)*** | 0.005<br>(1.75)* | −0.005<br>(0.84) | 0.003<br>(1.27) |
| 1/(No. of bidders) | −0.633<br>(3.84)*** | −1.798<br>(7.54)*** | 0.998<br>(5.13)*** | −0.599<br>(1.37) | −1.562<br>(2.84)*** | 1.145<br>(2.31)** |
| Firm Size 2<br>($15–30 million) | −0.025<br>(2.23)** | −0.029<br>(1.90)* | −0.018<br>(1.61) | −0.013<br>(3.72)*** | −0.014<br>(2.35)** | −0.013<br>(2.93)*** |
| Firm Size 3<br>($30–60 million) | −0.032<br>(1.55) | −0.083<br>(2.86)*** | −0.029<br>(1.47) | −0.023<br>(3.42)*** | −0.026<br>(2.22)** | −0.022<br>(2.83)*** |
| Firm Size 4<br>($60–100 million) | 0.001<br>(0.03) | −0.014<br>(0.38) | −0.016<br>(0.59) | 0.000<br>(0.04) | −0.002<br>(0.16) | 0.002<br>(0.17) |
| Firm Size 5<br>($100–200 million) | 0.059<br>(1.67)* | 0.058<br>(1.43) | 0.066<br>(1.56) | 0.019<br>(1.69)* | 0.011<br>(0.65) | 0.034<br>(2.07)** |
| Firm Size 6<br>(>$200 million) | −0.028<br>(0.50) | −0.039<br>(0.53) | −0.092<br>(1.51) | 0.035<br>(1.69)* | 0.061<br>(2.00)** | −0.004<br>(0.15) |
| District Dummies | Included | Included | Included | Included | Included | Included |
| $R^2$ | 0.46 | 0.60 | 0.57 | | | |
| Adj. $R^2$ | 0.44 | 0.57 | 0.55 | | | |
| $F$ | 28.23*** | 20.74*** | 24.50*** | | | |
| LM | 1007.85 | 365.73 | 777.07 | | | |
| Log Likelihood | | | | 776.75 | 322.61 | 476.25 |
| Observations | 452 | 197 | 255 | 452 | 197 | 255 |

*Notes*: Dependent variable is natural log of square meter bid price. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

timates to observe the extent to which this is the case. Another method to check on the RE standard errors is to run regression (1) only for the winning bids and compare results with those obtained from the RE estimation. Since the former regression uses only one observation from each auction, it precludes the problem of within auction correlated errors.[11] Finally, the Breutch-Pagan Lagrange multiplier test may be used to determine whether the data favor the RE as opposed to the OLS. The following estimation results pass these tests. All these factors, taken jointly, provide evidence for the suitability of the RE method in estimating equation (1).

Table III and IV report the OLS and RE estimates of two alternative specifications of equation (1), with and without the time trend. In both tables, the equation is estimated for the whole, pre-SDFWP and post-SDFWP period samples.

In Table III, comparison of the standard errors of the OLS and the RE estimates indicate that in the case of the OLS they are indeed understated (or the t-statistics are overstated)

11. This comparison is done in Section VII.

**TABLE IV**
Determinants of Bid Prices (Including the Time Trend)

| | OLS | | | RE | | |
|---|---|---|---|---|---|---|
| | **Whole Period** | **Before SDFWP** | **After SDFWP** | **Whole Period** | **Before SDFWP** | **After SDFWP** |
| | **(1)** | **(2)** | **(3)** | **(4)** | **(5)** | **(6)** |
| Constant | 7.138 | 7.178 | 7.300 | 7.114 | 7.131 | 7.265 |
| | (247.32)*** | (109.19)*** | (154.47)*** | (89.29)*** | (44.69)*** | (59.05)*** |
| School type | 0.066 | 0.099 | 0.006 | 0.070 | 0.094 | 0.016 |
| | (5.22)*** | (5.58)*** | (0.39) | (2.22)** | (2.14)** | (0.44) |
| Construction Cycle | 0.001 | –0.004 | –0.005 | 0.007 | –0.006 | –0.004 |
| | (6.36)*** | (1.99)** | (2.97)*** | (2.44)** | (1.00) | (0.89) |
| 1/(No. of bidders) | –0.356 | –1.214 | 1.295 | –0.308 | –0.981 | 1.481 |
| | (2.30)** | (4.12)*** | (6.83)*** | (0.77) | (1.46) | (2.99)*** |
| Firm Size 2 ($15–30 million) | –0.030 | –0.027 | –0.011 | –0.014 | –0.014 | –0.013 |
| | (2.89)*** | (1.83)* | (1.04) | (3.75)*** | (2.34)** | (2.89)*** |
| Firm Size 3 ($30–60 million) | –0.052 | –0.082 | –0.015 | –0.023 | –0.026 | –0.022 |
| | (2.70)*** | (2.87)*** | (0.82) | (3.49)*** | (2.23)** | (2.80)*** |
| Firm Size 4 ($60–100 million) | –0.005 | –0.010 | –0.009 | 0.000 | –0.002 | 0.002 |
| | (0.21) | (0.29) | (0.36) | (0.02) | (0.16) | (0.18) |
| Firm Size 5 ($100–200 million) | 0.067 | 0.007 | 0.055 | 0.020 | 0.011 | 0.034 |
| | (2.03)** | (1.74)* | (1.39) | (1.72)* | (0.67) | (2.06)** |
| Firm Size 6 (>$200 million) | –0.076 | –0.059 | –0.058 | 0.033 | 0.060 | –0.004 |
| | (1.46) | (0.83) | (1.02) | (1.60) | (1.97)** | (0.13) |
| Time | 0.002 | 0.004 | –0.004 | 0.003 | 0.005 | –0.004 |
| | (9.03)*** | (3.23)*** | (5.83)*** | (3.72)*** | (1.40) | (1.99)* |
| District Dummies | Included | Included | Included | Included | Included | Included |
| $R^2$ | 0.46 | 0.60 | 0.57 | | | |
| Adj. $R^2$ | 0.44 | 0.57 | 0.55 | | | |
| $F$ | 28.23*** | 20.74*** | 24.50*** | | | |
| LM | 1115.23 | 361.71 | 701.44 | | | |
| Log Likelihood | | | | 782.90 | 323.56 | 478.11 |
| Observations | 452 | 197 | 255 | 452 | 197 | 255 |

*Notes*: Dependent variable is natural log of square meter bid price. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

by two to three times. The reported Lagrange multiplier tests provide compelling evidence to favor the RE model instead of the OLS. Even after the adjustment of standard errors, however, results remain intact. Column 5 reports that prior to the establishment of the policy, secondary school bid prices were 10.7% higher than those of the elementary schools. The state of the construction market did not have a statistically significant effect on the bid price. Most important, the bid price was positively related to the number of bidders. All else being constant, a unit increase in the number of bidders raised the bid price by 2.5%, or approximately $34 (at the pre-SDFWP means). This is consistent with optimal bidding behavior in the presence of the winner's curse. Contractors faced common uncertainty on the cost of the project, and their bid prices increased with the degree of competition. There is also some indication that bid prices declined with the size of the contractor, at least for the three smaller size categories. Relative to firms with the smallest volume of business (<$15 million), the average bid price of firms in the $15–30 and $30–60 million ranges were 1.4 and 2.6% lower, respectively. This monotonic relationship, however, did not persist for firms of larger sizes. Instead, average bid price of firm size of 6 was higher than that of the smallest firm by 6.1%.

After the establishment of the SDFWP, according to column 6, the elementary and secondary school bid prices were not significantly different. Thus, one impact of the SDFWP was to bring the elementary and secondary school bids closer together, although it is not clear why this should be the case (I test for the equality of coefficients across the periods below.) The coefficient of the construction cycle remains statistically insignificant. Again, the most interesting effect of the SDFWP concerns the impact of the number of bidders on the bid price. The sign of the coefficient is negative: an increase in the number of bidders now lowered the average bid price by 1.5%, or approximately $23 per square meter (at the post-SDFWP means). In comparison with the pre-SDFWP period, the reversal in the sign of the impact of the degree of competition on the bid price suggests a change in the type of uncertainty facing the bidders. It is now the IPV model that is more relevant to the bidding process, not the CV model. Another change following the establishment of the SDFWP is that the firm size no longer makes any statistically significant difference for the bid prices.

In order to test the hypotheses of the equality of individual coefficients across the two periods, I used intercept and slope dummies and ran the following regression over the entire sample by RE:

$$\ln(Bid_{ij}) = \sum_h [\beta_h^B X_h + (\beta_h^A - \beta_h^B) X_h \cdot SDFWP] + \mu, \qquad (2)$$

where $X$ stands for regressors introduced in equation (1) (including the intercept term), *SDFWP* is a dummy variable taking the value of zero for the pre-SDFWP period and one otherwise, and $\mu$ is the error term. $\beta_h^B$ and $\beta_h^A$ are the regression coefficient vectors for the pre- and post-SDFWP periods, respectively.[12] The equality of coefficients of any variable across the two periods can be tested by the null hypothesis $\beta_h^A - \beta_h^B = 0$. The null hypotheses of the equality of coefficients of the number bidders variable is rejected with comfortable margins. The estimated t-value is 3.66 ($p = 0.0003$). The data did not reject the hypothesis of equality of coefficients for any other variable, including *School type*.

In order to compare bid prices before and after-SDFWP, I predicted bid prices using regressions (5) and (6) of Table III under the assumptions that the number of bidders is eight, there is no deviation from the trend permits, and dummy variables are equal to zero. The predicted square-meter cost is $1,247 before the SDFWP and $1,366 after. Thus, the average cost of production has increased by $119 or 9.6% for the described project, 3.3 percentage points lower than what is obtained from the mean values reported on Table II.

In the next set of regressions reported in Table IV, the time trend is added as an explanatory variable. Comparison of t-statistics of the OLS and RE in this table indicates, once again, that the standard errors are understated by a factor of two to three in the OLS regressions. Comparing the fifth columns of Table III and IV, we observe that the introduction of the time trend makes few changes on the pre-SDFWP outcomes reported in Table III. Although the coefficient of the number of bidders is still negative, it is no longer statistically significant at the conventional levels ($p = 0.15$). The coefficient of the time trend is positive but not statistically significant. Estimated coefficients of other explanatory variables are not altered.

In the post-SDFWP period, however, the bid price was again inversely related to the number of bidders. A unit increase in number of bidders reduced the bid price by 1.9%. When equation (2) is estimated for this specification, the hypothesis of equality of the coefficient of the number of bidders variable is rejected again, with the t-value of 3.00 ($p = 0.003$). One interesting outcome is the secular decline of the bid price after the establishment of SDFWP: average square-meter

12. These regressions are not reported separately in the paper. They are available from the author upon request.

bid price declined on average by approximately 0.4% per month.

In order to compare the bid prices under the two regimes, the regression results of Table IV were once again used to make predictions under the assumptions mentioned above. According to these calculations, the unit cost is $1,110 on January 1989 and climbs to $1,326 by March 1992. Unit bid price in April 1992, the first month under the new regime, jumps to $1,492 and then declines gradually. Within 34 months, by January 1994, the unit bid price declines to its March 1992 level.

These findings underscore a much smaller bid price differential than that obtained from the bivariate "before and after-SDFWP" comparison. The behavior of bidders, who are cognizant of the winner's curse, seems to be an important factor in lowering of the bid differential between the two periods.

## VII. ANALYSIS OF ACCEPTED BID PRICES

It may be argued that, from the owners' perspective, only the lowest bid matters and what is really important is the question of the response of the lowest bid, rather than bid prices, to the explanatory variables. In order to address this issue, I replaced the dependent variable of equation (1) by the accepted bid price and reestimated the regression coefficients using the sample of 54 tenders. This estimation also serves as a check on the t-statistics of the RE estimates reported earlier because correlation of individual errors within auctions is no longer pertinent in this narrower data set. The OLS estimates of these regressions are reported in Table V. In these estimations, coefficients of firm size dummy variables turned out to be statistically insignificant, and, in order to gain a few more degrees of freedom, they are omitted from the regression. District control dummies are included in the estimations but not reported.

Estimates reported on Table V are consistent with the previous results. The accepted bid price varies directly (inversely) with the number of bidders during the pre- (post-) SDFWP period. The hypothesis of equality of the coefficients of the number of bidders variable across the two periods is tested by applying equation (2) to the sample of winning bids. The equality hypothesis is rejected for both specifications of the equation in Table V with respective t-values of 4.15 and 3.34.

In order to predict the behavior of the accepted bid price, I carried out a procedure similar to that reported in the previous section. Assuming that the bids are for an elementary school, the number of bidders is eight, and the industry is at its trend growth rate, the predicted accepted bid prices of the first specification for the pre- and post-SDFWP periods are $1,202 and $1,285, respectively. The latter is within the 95% confidence interval of the pre-SDFWP prediction ($1,056–$1,369). Thus, there is no statistically significant difference between accepted bid prices across the two periods. According to the second specification, the accepted square-meter bid price on March 1992, just before the establishment of the SDFWP is found to be $1,319. On April 1992, the price jumps to $1,439. It then takes about 20 months for the price to decline to its March 1992 level.

Once other factors are controlled for, the statistically significant 17.1% differential between the pre- and post-SDFWP accepted bid prices observed in Table II disappears. For the period under study, there is no evidence supporting the hypothesis that the lowest bid prices have increased after the establishment of the SDFWP. Prominent among these other factors is the switch from the CV to the IPV model after the changing of the regulatory environment and the subsequent adjustment of the contractors' behavior model.

## VIII. CONCLUSION

Opponents of the prevailing wage laws argue that these regulations raise labor costs and the cost of construction, and create a burden for taxpayers. Bivariate comparison of bid prices for new public school construction projects before and after the introduction of the SDFWP in B.C. seems to provide supporting evidence for this position. In this paper, I identified an additional channel through which bid prices may be affected. Bid prices reflect, in addition to the estimated costs of construction, the uncertainty faced by contractors. If expected profit-maximizing contractors were subject to common uncertainty concerning costs of construction, then economic theory suggests that they will add sur-

**TABLE V**
Determinants of Accepted Bid Prices

| | Specification 1 | | | Specification 2 | | |
|---|---|---|---|---|---|---|
| | Whole Period (1) | Before SDFWP (2) | After SDFWP (3) | Whole Period (4) | Before SDFWP (5) | After SDFWP (6) |
| Constant | 7.255 (85.64)*** | 7.348 (76.29)*** | 6.978 (73.11)*** | 7.080 (75.23)*** | 7.057 (40.19)*** | 7.228 (51.64)*** |
| School type | 0.081 (1.99)* | 0.133 (2.62)** | 0.049 (1.16) | 0.085 (2.31)** | 0.112 (2.33)** | 0.033 (0.85) |
| Construction Cycle | 0.007 (1.92)* | −0.009 (1.23) | 0.007 (2.29)** | 0.008 (2.56)** | −0.010 (1.50) | −0.002 (0.51) |
| 1/(No. of Bidders) | −0.695 (1.37) | −2.048 (3.26)*** | 1.448 (2.57)** | −0.391 (0.83) | −1.172 (1.59) | 1.811 (3.37)*** |
| Time | | | | 0.003 (3.24)*** | 0.007 (1.92)* | −0.005 (2.28)** |
| District Dummies | Included | Included | Included | Included | Included | Included |
| $R^2$ | 0.46 | 0.71 | 0.68 | 0.56 | 0.76 | 0.75 |
| Adj. $R^2$ | 0.36 | 0.56 | 0.55 | 0.47 | 0.62 | 0.63 |
| $F$ | 4.76*** | 4.81*** | 5.28*** | 6.29*** | 5.41*** | 6.25*** |
| Observations | 54 | 25 | 29 | 54 | 25 | 29 |

*Notes*: Dependent variable is natural log of square meter accepted bid price. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

charges to the estimated bid price in order to avert the winner's curse. Data do not allow direct testing for the presence of the winner's curse. It is possible to test for the nature of uncertainty indirectly however, through one testable prediction of the economic theory. Under the CV assumption, the higher is the degree of competition in terms of the number of competitors, the higher will be the surcharge; under the IPV assumption, however, an increase in the number of competing contractors will force each to reduce the bid price. I hypothesized that the SDFWP reduced the uncertainty concerning labor costs, which is common to all contractors. If the hypothesis is true, then optimal bid prices are anticipated to be more positively (or less negatively) related with the number of bidders in the pre-SDFWP than in the post-SDFWP period. Econometric results support the hypothesis in its strongest form: bid prices increase with the number of bidders in the pre-SDFWP period and decline with the number of bidders in the post-SDFWP period. On average, there is no statistically significant difference between the bid prices of the two periods. These findings hold even when the analysis focuses on the accepted bid prices exclusively, although the declining number of observations makes statistical inference more tentative. The result remains that there is no evidence supporting the claim that the SDFWP raised the school construction bids prices in B.C. over the period under analysis and that the changing nature of uncertainty contributed to this outcome.

## REFERENCES

Allen, Steven G. "Much Ado About Davis-Bacon: A Critical Review and New Evidence." *Journal of Law and Economics*, October 1983, 707–36.

Bazerman, Max, and William Samuelson. "The Winner's Curse: An Empirical Investigation," in *Aspiration Levels in Bargaining and Economic Decision Making*, edited by Reinhard Teitz. Berlin and New York: Springer-Verlag, 1983, 186–200.

Brannman, Lance, J. Douglas Klein, and Leonard W. Weiss. "The Price Effects of Increased Competition in Auction Markets." *Review of Economics and Statistics*, February 1987, 24–32.

Capen, E. C., R. V. Clapp, and W. M. Campbell. "Competitive Bidding in High-Risk Situations." *Journal of Petroleum Technology*, June 1971, 641–51.

Dyer, Douglas, and John H. Kagel. "Bidding in Common Value Auctions: How the Commercial Construction Industry Corrects for the Winner's Curse." *Management Science*, October 1996, 1,463–75.

Dyer, Douglas, John H. Kagel, and Dan Levin. "A Comparison of Naïve and Experienced Bidders in Common Value Offer Auctions: A Laboratory Analysis." *Economic Journal*, March 1989, 108–15.

Friedman, Lawrence. "A Competitive Bidding Strategy." *Operations Research*, February 1956, 104–12.

Gates, Marvin. "Bidding Contingencies and Probabilities." *Journal of the Construction Division*, November 1971, 277–303.

Gaver, Kenneth M., and Jerold L. Zimmerman. "An Analysis of Competitive Bidding on BART Contracts." *Journal of Business*, July 1977, 279–95.

Gilley, Otis W., and Gordon V. Karels. "The Competitive Effect in Bonus Bidding: New Evidence." *Bell Journal of Economics*, Autumn 1981, 637–48.

Hendricks, Kenneth, and Robert Porter. "An Empirical Study of An Auction with Asymmetric Information." *American Economic Review*, December 1988, 865–83.

Hendricks, Kenneth, Robert Porter, and Bryan Boudreau. "Information, Returns and Bidding Behavior in OCS Auctions: 1954–1969." *Journal of Industrial Economics*, June 1987, 517–42.

Kagel, John H., and Dan Levin. "The Winner's Curse and Public Information in Common Values." *American Economic Review*, December 1986, 894–920.

Kagel, John H., Dan Levin, Raymond C. Battalio, and Donald J. Meyer. "First-Price Common Value Auctions: Bidder Behavior and the 'Winner's Curse.'" *Economic Inquiry*, April 1989, 241–58.

Levin, Dan, and James L. Smith. "Some Evidence on the Winner's Curse: Comment." *American Economic Review*, March 1991, 370–75.

Mead, Walter J., Asbjorn Moseidjord, and Phillip E. Sorensen. "Competitive Bidding under Asymmetrical Information: Behavior and Performance in Gulf of Mexico Drainage Lease Sales, 1959–1969." *Review of Economics and Statistics*, August 1984, 505–08.

Milgrom, Paul R. *The Structure of Information in Competitive Bidding*. New York and London: Garland Publishing, 1979.

Milgrom, Paul R., and Robert J. Weber. "A Theory of Auctions and Competitive Bidding." *Econometrica*, September 1982, 1,089–122.

Rothkopf, Michael H. "A Model of Rational Competitive Bidding." *Management Science*, March 1969, 362–73.

Thiel, Stuart E. "Some Evidence on the Winner's Curse." *American Economic Review*, December 1988, 884–95.

Wilson, Robert. "A Bidding Model of Perfect Competition." *Review of Economic Studies*, October 1977, 511–18.