THE EFFECTS OF PREVAILING WAGE REGULATIONS ON CONSTRUCTION EFFICIENCY

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A data file and copies of the computer program used to generate the results presented in the paper are available from Kevin Duncan of the Hasan School of Business, Colorado State University-Pueblo, Pueblo, CO 81001

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[abstract]

We conduct a direct test of the impact of prevailing wage legislation on school construction efficiency. Average technical efficiency for all construction projects in our sample is 94.6 percent. Average efficiency for projects covered by the introductory stage of British Columbia's construction wage legislation is 86.6 percent. By the time of the expansion of the policy 17 months later, the average efficiency of covered projects increased to 99.8 percent. These findings suggest that the introduction of prevailing wage laws disrupted construction efficiency. However, in a relatively short period of time, the construction industry adjusted to wage requirements by increasing overall efficiency.

Keywords: prevailing wage laws; construction efficiency.

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1. Introduction

How do prevailing wage laws affect the technical efficiency of construction? These laws require contractors of covered public projects to pay construction workers what some observers call 'super-minimum wages'. Such wage rates have price-theoretic effects if maximizing contractors increase the marginal productivity of construction labor. Prevailing wages may also 'shock' contractors into more efficient behavior, or compliance with wage regulations may increase administrative duties and reduce managerial efficiency. If prevailing wage laws result in the employment of more union construction workers, productivity may increase (see Allen 1986, and Cavalluzzo and Baldwin, 1993). The net effect of these influences has important policy implications. For example, if wage requirements are associated with higher overall productivity, the impact of prevailing wage policies on construction costs may be limited.

Recent research has focused on the impact prevailing wage laws on the total cost of construction. For example, the cost impacts reported by Dunn, Quigley and Rosenthal (2005) range from 9 to 37 percent.[1] These findings suggest that labor cost pressure is not offset by policy-induced productivity changes. However, others fail to find statistically significant effects of prevailing wage laws on the relative cost of covered versus uncovered projects (see Bilginsoy and Philips 2000, Azari-Rad, Philips and Prus 2003, _____ and _____ 2005). Results of these studies imply substantial productivity changes that offset the cost implications of prevailing wages.

While the effect of prevailing wage laws on construction efficiency is central to the policy's ultimate impact, there has only been one other study that addresses this issue.

Elsewhere, we find that prior to the introduction of prevailing wage requirements, publicly funded school projects were from 16 to 19 percent smaller, in terms of project square feet, than comparable privately funded projects (see _____, _____, and _____ 2006). This size differential did not change with the introduction of the wage policy. This indicates that the production function (ability to produce surface area) did not change, or shift with the introduction of wage requirements. In this follow-up, we examine another aspect of efficiency by determining if projects covered by wage requirements are closer to the best-practice production frontier (more efficient), or further from the frontier (less efficient). Taken together, these studies provide a more complete view of the effect of prevailing wage laws on construction efficiency.

Specifically, this present paper examines the effect of British Columbia's Skills Development and Fair Wage Policy (hereinafter, SDFW) on the productive inefficiency of covered projects, relative to projects that are unaffected by the policy. Since the SDFW was introduced in two stages over time, our data allow us to examine the initial impact of the policy on technical inefficiency, as well as the impact after contractors have acquired experience with wage requirements. The remainder of this paper is organized as follows. The characteristics of the SDFW are explained in the next section. Our data on public school construction, the model, and results are discussed in subsequent sections. The paper concludes with a discussion of policy and research implications.

2. The Fair Wage Policy, Similarity to U.S. Laws, and Possible Efficiency Effects.

The Province of British Columbia introduced the first stage of the SDFW on March 30, 1992. Initially, the policy applied to building construction, with a value of at least CA$1.5 million that was funded by the Province. The second stage of the policy was introduced on

August 20, 1993 with the value threshold reduced to CA$250,000 and coverage extended to other provincially funded projects (roads, dams, etc.). The skills development aspect of the policy sought to increase apprenticeship participation by requiring certified trades persons to supervise apprentices on covered projects. The policy also established the Schedule for Fair Wage Minimum Hourly Rates for construction workers employed on projects covered by either stage of the SDFW.[2] This schedule ranged from 82 to 94 percent, but typically 88 percent, of the corresponding building trade union rate for specific construction occupations (see Globerman, Stanbury and Vertinsky 1993). Consequently, fair wage rates only applied to nonunion contractors since union rates exceeded the minimums.

The Province of British Columbia collects wage data for union construction workers only, but data from a 1994 Mechanical Contractors Association survey can be used to illustrate the impact of wage requirements on nonunion contractors (see Bergman 1994). For example, in 1994 nonunion contractors paid plumbers between CA$20.00 and CA$22.00 per hour in total compensation for projects that were not covered by the SDFW. However, a bid by a nonunion contractor on a covered public project would include the fair wage minimum of CA$27.63 (CA$23.63 hourly, plus CS$4.00 in benefits) for plumbers. This suggests a substantial increase (from 26 to 38 percent) in wage rates for covered projects. Data from Statistics Canada indicate that labor costs for British Columbian primary contractors of nonresidential buildings ranged between 17 and 19 percent of total operating expenses during the policy period.[3] If labor costs are a low percent of the total costs of construction, the SDFW wage requirements would not have a proportionate impact on the total costs of non-union projects. Union contractors, on the other hand, paid plumbers CA$33.40 in hourly total compensation in 1994. In this example, the fair wage minimum was 83 percent of the corresponding union rate.

Nonunion contractors dominated the British Columbian construction industry at the time of the SDFW. For example, the Construction Labour Relations Association (1992) reports that in 1988, 85 percent of the 9,310 British Columbian contractors were nonunion. By 1991, 89 percent of the 11,487 provincial construction companies were nonunion. Using this information, along with the fair wage schedule, the Quantity Surveyors Society of British Columbia (1993) estimated that the SDFW increased the total cost of construction for nonunion contractors by 6 to 7 percent and cost Canadian taxpayers CA$100 million annually. The policy ended with a change in the provincial government and the passage of the Skills Development and Fair Wage Repeal Act of 2001.

The method developed by Thieblot (1995) can be used to compare the strength of the SDFW with state-level, or 'Little Davis-Bacon Acts' in the U.S.[4] Thieblot ranks state laws based on the level of coverage, the type of worker and work covered, and required wage rates. A point scale, ranging from 2 to 17, compares the weakest to the strongest state-level laws. Using this method to evaluate the characteristics of the SDFW yields a score of 13.[5] The weighted average for the 31 states evaluated by Thieblot is 9.77. So, compared to the strength of prevailing wage laws in the U.S., the SDFW is above average.

The requirements of the SDFW have mixed effects on the construction efficiency of covered projects. For example, while the training of apprentices may result in higher productivity in the future, the immediate effect would be negative as supervisory trades personnel shift time from producing to teaching. On the other hand, the price-theoretic and shock effects described above may increase technical efficiency. Because the training and wage requirements of the SDFW have opposing effects on efficiency, the net impact of the policy is an empirical question.

3. Data and Model

School construction data was obtained from Canadata, an organization that collects and disseminates detailed data on the Canadian construction industry. Our school data extract includes measures of project size (number of square feet), bid price, start date, location, technical characteristics such as the number of stories above ground, and whether the project was new, or an addition. Because the data are at the level of the project owner, we are unable to determine if the general contractors, or sub-contractors, are union or nonunion. Also, our data do not contain measures of worker characteristics such as skill and experience. Our sub-sample consists of 438 public K-12 school projects built between 1989 and 1995 and is used to test the impact of both stages of the SDFW on construction inefficiency.[6]

Stochastic frontier regression is a method of estimating the technical efficiency of individual producers relative to the production frontier (see Aigner, Lovell and Schmidt 1977 and Meeussen and van den Broeck 1977). This approach involves the estimation of a production function with an error term consisting of two components. The first component (v), is the standard, two-sided, random component with mean zero and variance σ_v^2. The second component (u) is a one-sided, non-negative, random variable with variance σ_u^2 that is assumed to be greater than zero. The value of u, ranging from 0 to 1.0, represents the observed level of inefficiency for a producer relative to the best-practice production frontier derived from the sample. For example, a value of u equal to 0.10 represents 10 percent technical inefficiency for the individual producer. This corresponds to 90 percent technical efficiency where the level of efficiency is defined as the ratio of actual to potential production. Therefore, u measures the deviation of observed output from the production frontier. Like v, a value of u is estimated for each observation in the sample.

The usual independence assumptions apply to each of the error components. Each is assumed to be independent of the other and of the independent variables in the equation. There is no theoretical rationale for the particular distribution of u. The results reported below are based on the truncated normal distribution.

Stochastic frontier regression has been used to estimate a variety of production functions ranging from the output of museums to textile and agricultural firms (see Bishop and Brand 2003, Jaforulla 1999, and Nahm and Sutummakid 2005 for examples). Cavalluzzo and Baldwin (1993) employ this technique in their examination of the union efficiency advantage in construction. Previously, we have used this method to examine the impact of the SDFW on construction output, the number of square feet of a project (see ______, _____, and _____, 2006). Specifically, we find that while publicly funded school construction projects are from 16 to 19 percent smaller than privately funded counterparts, this size differential did not change with the introduction of the SDFW. In this follow-up to our previous work, we use stochastic frontier regression to directly test the impact of the SDFW on the measures of the technical inefficiency of construction (u).

In our construction application of stochastic frontier regression, the number of project square feet is the measure of the quantity of output. Allen (1986) and Cavalluzzo and Baldwin (1993) also use surface area measures in their estimation of construction output. Since the project bid price is a composite of factor payments, this price can be used as the input measure. While bid price captures estimated input use at the beginning of the project, it does not include cost overruns that result in additional, and unmeasured inputs included in the final project. This problem is not unique to this study. Bid price is often the only available measure in the studies that estimate construction costs (see Bilginsoy and Philips 2000 and Azari-Rad, et. al. 2003). However, Philips, Mangum, Waitzman, and Yeagle (1995) report that average cost overruns in construction are low, ranging from 2 to 7 percent.[7] This suggests that bid price captures a very high percentage of the inputs used in the final project.

An advantage of using multiple input measures is the estimation of individual input effects on output. However, it is often impossible to obtain measures of all inputs used in production and the omission of relevant input measures may affect the estimate of technical inefficiency. Our single input variable provides a comprehensive measure of the inputs used in construction, but it does not allow for estimates of individual input effects.[8] We also include other project characteristics, that are related to the size of a project, as controls.

Since we are interested in the effect of the SDFW on public school construction inefficiency, we also estimate the inefficiency measure (u) as a function of variables measuring each stage of the SDFW. Many researchers have used a two-stage approach to examine the determinants of technical inefficiency (see Pitt and Lee, 1981; Jaforullah, 1999 as examples). In the two-stage method, stochastic frontier regression is used to estimate a production function to obtain the measures of inefficiency. The measures of u are saved and then regressed on other firm, or production characteristics in the second stage. Following this approach, we would estimate the square footage of a project as a function of the total input bill to obtain the values of

u. We would then estimate u as a function of the policy variables to determine if projects covered by the SDFW are relatively inefficient. However, this two-stage approach is inconsistent with the assumptions regarding the independence of the error terms.

This problem can be avoided by using the single-stage estimation procedure proposed by Kumbhakar, Ghosh, and McGuckin (1991) and Reifschneider and Stevenson (1991) in which the maximum likelihood estimation of construction output is estimated simultaneously with the estimation of u. We use the FRONTIER 4.1 program described by Coelli (1996) to estimate the single-stage stochastic frontier and inefficiency models described below.

Stochastic Frontier Model:

$Ln\ Project\ Square\ Feet = \beta_0 + \beta_1\ Ln\ Real\ Bid\ Price + \beta_2\ X + (v - u)$

Inefficiency Model:

$u = \delta_0 + \delta_1\ SDFW_{92}\ Project + \delta_2\ SDFW_{93}\ Project$

where *Ln Project Square Feet* (in the Stochastic Frontier Model) is the natural log of a project's number of square feet. *Ln Real Bid Price* is the log of a project's bid price. We use the Non-Residential Building Cost Price Index available from Statistics Canada to adjust bid prices for inflation.[9] It is common practice in the stochastic frontier literature to measure continuous variables in log form. So, the coefficient for bid price (β_1) is the elasticity of project size with respect to project expenditure. *X* is a vector of project characteristics that are related to construction output. This vector includes the log of the number of stories above ground, a distinction between new construction and additions, where the project was located, and the time of year, and year, the project started. The error terms are *v* and *u*, as described above.

In the inefficiency model, *u*, the measure of construction inefficiency, is the dependent variable. As mentioned above, *u* may range from 0 to 1.0. $SDFW_{92}$ *Project* is equal to one if the public school was built during the first stage of the SDFW (between March 30, 1992 and August 19, 1993, with a value greater than CA$1.5 million), else zero. $SDFW_{93}$ *Project* is equal to one if the public school project was built during the second stage of the policy (after August 19, 1993 with a value greater than CA$250,000), else zero. The coefficients for $SDFW_{92}$ *Project* and $SDFW_{93}$ *Project* (δ_1 and δ_2) measure the inefficiency differential between projects covered, and not covered, by the SDFW. Negative estimates of δ_1 or δ_2 indicate that, after the introduction of the particular SDFW policy stage, covered public school projects were relatively less inefficient (more efficient) than projects not affected by this stage of the policy. Positive values for these coefficients indicate relatively higher inefficiency for covered projects. We have described above the possible positive and negative impacts of the SDFW on technical efficiency. Given the bone of contention between these two possibilities, and the strong a priori expectations, two one-tailed tests are preferred to a single two-tailed test for these coefficients.

4. Empirical Results

Summary statistics for all public school projects and those covered by each stage of the SDFW are reported in Table 1. Our sample consists of 438 public school construction projects. The nominal bid prices for these projects range from CA$58,700 to CA$31.1 million. Since the range falls below the value thresholds of either stage of the SDFW, our sample contains public projects that were not covered by the policy because they did not meet the value threshold, or because they were built prior to the fair wage regulations. The sample contains 243 projects that were not covered by the SDFW. Seventy-four of the projects were covered by the first stage of the policy (if $SDFW_{92}$ *Project* equals 1). One-hundred-twenty-one were covered by the second stage (if $SDFW_{93}$ *Project* equals 1).

(Insert Table 1 here)

The averages indicate that only projects covered by the 1992 provisions of the SDFW are larger, more expensive, and have more stories when compared to the overall sample of school projects. The differences for the 1992 projects are significant at the 0.05 level. Projects covered by either stage of the policy are less likely to be built in Vancouver and to be additions. Projects covered by the 1993 provisions are less likely to be started during the high precipitation months of December through March. These differences are statistically significant at the 0.05 level.

Since our primary interest involves the effect of fair wage requirements on construction efficiency, we focus first on the estimate of the inefficiency model. Several specifications of the inefficiency model are reported in Table 2. Results reported for Model A are based on the specification described above. The stochastic frontier associated with Model A is reported in Table 3 and is discussed below. The stochastic frontier estimates associated with inefficiency models B and C are reported in Appendix Table A.[10] Regardless of the particular model, the dependent variable is the measure of technical inefficiency. Consequently, a positive coefficient indicates higher inefficiency (or lower efficiency) in construction. A negative coefficient implies less inefficiency (or higher efficiency).

(Insert Table 2 here)

The coefficient for $SDFW_{92}$ *Project* (from Model A) is positive and significant at the 0.10 level (for a one-tailed test). This finding indicates that the construction of the 74 public projects covered by the first stage of the SDFW (from March 30 1992 to August 19 1993) was relatively less efficient, by about 9 percentage points, than other public school projects.[11] This result indicates a disruption in technical efficiency with the introduction of the policy.

The coefficient for $SDFW_{93}$ *Project* is negative suggesting that the projects covered by the second stage of the SDFW (from August 20 1993 to the end of our data in 1995) were characterized by lower inefficiency. The difference between these projects and those that are not covered by this stage of the SDFW is statistically significant at the .03 level, for a one-tailed test, and at the 0.06 level, for a two-tailed test. Additionally, this coefficient is relatively large indicating a 31.8 percentage point efficiency advantage for projects covered by the second stage of the SDFW. Considered together, the results for $SDFW_{92}$ *Project* and $SDFW_{93}$ *Project* suggest that the introduction of the SDFW in March of 1992 was associated with a decrease in construction efficiency. However, by the time of the expansion of the policy 17 months later, the construction industry had adjusted to wage requirements by increasing efficiency.

It is possible that the differences in coefficients for SDFW_{92} and SDFW_{93} are driven by the value differences of the projects covered by each stage of the policy. For example, the 1993 provisions of the SDFW include less expensive projects. If efficiency is relatively higher on cheaper, smaller projects, we may expect that some of the projects captured by SDFW_{93} would be more efficient regardless of the policy. This issue is addressed, to an extent, since the inefficiency model is estimated simultaneously with the production function, which controls for project cost. However, to investigate these implications further, we also estimated the inefficiency model with the variable $\mathrm{SDFW}_{93,>\mathrm{CA\$1.5m}}$. This variable equals one if the project was covered by the 1993 provisions of the policy and had a value of more than CA$1.5 million. Hence, we compare projects covered by each step of the policy that have the same minimum value threshold. Of the 121 projects covered by the 1993 law, 68 had nominal values greater than CA$1.5 million. The results of the inefficiency estimate with SDFW_{92} and $\text{SDFW}_{93,>\text{CA\$1.5m}}$ are reported under Model B in Table 2.

The results of this estimate exhibit the same trend as those reported for Model A. The coefficient for SDFW_{92} suggests an increase in inefficiency (of 10 percentage points) for projects covered under the first stage of the policy. The results for $\text{SDFW}_{93,>\text{CA\$1.5m}}$ indicate a substantial decrease in inefficiency (41 percentage points) for projects covered by the second stage of the policy. The significance values are relatively higher in Model B. These results indicate that even among projects with the same minimum value thresholds, efficiency initially decreased and then increased sharply with the introduction of each stage of the policy.

We also estimated the inefficiency model with a single measure of the wage policy. For example, $\textit{SDFW}_{92\&93}$ *Project* equals one if the public project was covered by the 1992, or 1993 stage of the construction wage policy. These results are reported under Model C. The coefficient for $\textit{SDFW}_{92\&93}$ *Project* is positive, suggesting an increase in inefficiency for projects covered by the SDFW in general. However, this coefficient is small in terms of magnitude and is statistically insignificant. This result suggests that when the SDFW policy period is considered as a whole, the wage requirements did not have a meaningful impact on construction efficiency.

We briefly discuss the results of the maximum likelihood estimate of school construction output (Stochastic Frontier Model) that are reported in Table 3. The coefficient for *Ln Real Bid Price* is statistically significant, but less than one indicating diseconomies of scale in school construction. The coefficient for *Ln Stories* indicates that more stories above ground are associated with more square feet, holding building expenditure constant. This result confirms the efficiency of multi-storied buildings that add to size, without requiring additional foundation work, holding expenditures constant. Schools built in Vancouver are approximately 10 percent larger, holding project expenditure constant. This statistically significant difference for projects located in the capital city may be due to greater access to input markets and more developed infrastructure.

(Insert Table 3 here)

The sign of the coefficient for Wet Season suggests that projects started during high precipitation months (December through March) are smaller for a given expenditure. However, this effect is not statistically significant. Additions are associated with fewer square feet, holding expenditures constant. This difference is statistically significant at the 0.01 level. Additions, particularly those involving renovations, are likely to involve fewer square feet per dollar of expenditure compared to new construction because these projects must contend with the constraints and uncertainties imposed by working around and within existing structures.

The sign of the coefficient for Year suggests that projects decrease in size by approximately 3 percent with the passage of each year. The difference is statistically different at the 0.01 level. Battese and Coelli (1995) use *Year* in a stochastic frontier regression to account for Hicksian neutral technological change, which in our application would imply technological change associated with smaller structures. However, in this construction setting the time variable may also capture the effect of the business cycle. For example, Casselton (1992) reports that reduced input costs during depressed British Columbian construction activity in the early 1990s were associated with final charges that were often below initial bids. As input costs increased as the sector recovered in the mid 1990s, project owners would have paid more for a given project size. Or, as the sign of the time variable suggests, the later period of the study was characterized by smaller projects, holding expenditures constant.

A likelihood ratio test of the one-sided residuals indicates that the maximum likelihood model is a significant improvement (at the 0.05 level) over an OLS estimate.[12] Variance parameters reported in Table 3 indicate that sigma-squared (σ^2), the sum of the variances of the two error terms (or, $\sigma^2 = \sigma^2_v + \sigma^2_u$), equals .097. Gamma is the proportion of the total variance in the model that is attributed to the inefficiency effects (or, (= [$\sigma^2_u/(\sigma^2)$]). This parameter indicates that 1.0 percent of the total variance is explained by the inefficiency effects. This implies that the random effects (v) are more important in explaining the total variance of the model than are the inefficiency effects (u). This suggests substantial variation in the production frontier across school construction projects, but relatively little variation of observed output beneath the frontier.

The average level of technical efficiency for all school projects included in the sample is 94.6 percent. This represents a very high level of technical efficiency compared to other stochastic frontier studies. For example, Nahm and Sutummakid (2003) find an average efficiency of 90.4 percent for agricultural production in central Thailand. At the other extreme, Bishop and Brand (2003) report an average efficiency of 45.5 percent for museums located in South West England. Cavalluzzo and Baldwin (1993) report an average efficiency ranging from 73 to 89 percent for U.S. construction completed in 1972 and 1973. Elsewhere we have reported an average efficiency of approximately 87 percent for private and public schools constructed in British Columbia (see _____, _____, and _____ 2006).

The FRONTIER 4.1 program also provides estimates of technical efficiency, ($1-u_i$), for each observation in the sample. We have sorted these values for projects covered by each stage of the SDFW and by projects that were not covered by the policy. These data are reported in Table 4 where the average for the overall sample is the reference category. These averages were obtained from the estimate of Inefficiency Model A discussed above. Projects constructed under the first stage of the SDFW were 86.8 percent efficient. The difference between this group of projects and the overall sample average is significant at the 0.05 level. Projects covered by the 1993 stage of the policy were among the most efficient in the sample with an average of 99.8 percent. The difference between this group and the overall average is significant at the 0.05 level. Projects that were not covered by either stage of the policy are not different, in terms of averages efficiency, than the overall sample. We also report the average efficiency for projects covered by the 1993 policy stage with a value greater than CA$1.5 million (if $SDFW_{93,>CA\$1.5m} = 1$). This average was obtained from the estimate of Inefficiency Model B described above. Average efficiency for these projects is also significantly higher than the average for all projects and is also higher than the average for projects with the same minimum value threshold that were covered by the 1992 policy. The trend in these averages is consistent with the inefficiency results reported in Table 2. The averages indicate a decrease in construction efficiency at the time of the introduction of the SDFW in 1992. They also suggest that the construction industry adjusted to wage requirements by increasing efficiency by the time of the expansion of the policy in 1993.

(Insert Table 4 here)

5. Conclusion

Our examination of the impact of prevailing wage legislation on construction inefficiency reveals that the introduction of the fair wage policy in British Columbia was associated with a statistically significant decrease in the technical efficiency of covered public school projects. However, by the time of the expansion of the policy 17 months later, the technical efficiency of covered projects was substantially higher than other public school projects. The short-lived efficiency decrease, followed by a sharp increase in productivity, may explain why others have failed to find statistically significant impacts of the SDFW on the cost, or size of British Columbian school construction projects (see Bilginsoy and Philips 2000 and _____, _____, and ____ 2006).

This conclusion is based on an analysis of the sequential application of the policy, that is, the impact of the introduction and expansion of the SDFW. When the two policy periods are combined into a single policy measure, results indicate that the construction wage requirements did not have a meaningful impact on construction efficiency in terms of magnitude, or statistical significance.

There are several explanations of how the fair wage policy may have negatively, or positively impacted construction efficiency. For example, the introduction of the skills development requirement (the training and supervision of apprentices) may explain the initial decrease in productivity. On the other hand, the SDFW created incentives to increase efficiency due to the unequal impact of this legislation. Because union rates exceeded fair wage rates, the SDFW only affected nonunion contractors bidding on covered public projects. To maintain competitive bids on these projects, nonunion contractors had incentives to increase technical efficiency. These contractors may have selected their most productive employees for work on covered projects and may have used fair wages as rewards for these workers. Fair wages may have also had efficiency wage effects. Or, capital may have been substituted for all grades of labor. As mentioned above, nonunion contractors dominated the British Columbian construction industry at the time of the SDFW. If the sub-sample of school projects is similarly dominated, our measured increase in construction efficiency in 1993 may be capturing the effect of adjustments made by nonunion contractors.

While our data do not allow us to examine the specific reaction of contractors facing fair wages, others have found evidence of the type of adjustments described above. For example, in an examination of the national minimum wage in Great Britain, Heyes and Gray (2004) use interview data and find that an increase in the minimum wage was associated with managerial steps to increase work intensity. Additionally, Brown and Grossman (2000) find that employers seek higher quality workers in response to an increase in the national minimum wage. Regardless of particular alterations contractors made when confronted with fair wages, time and learning may have been necessary to adjust to the new environment. Any lag associated with learning and implementing new production techniques and managerial strategies may explain why efficiency did not increase until the time of the expansion of the SDFW in 1993.

Price theory suggests that changes in factor utilization and relative marginal productivities follow changes in relative input costs. So, we would expect the responses of nonunion contractors to fair wage requirements to result in higher labor productivity and lower marginal productivities for other inputs. However, the stochastic frontier results capture the net change in efficiency, not the change attributed to one input. The results for 1993 suggest that whatever changes contractors made, they were associated with an overall increase in the efficiency of construction, not simply an increase in the productivity of labor.

The trend in productivity associated with the introduction and expansion of the SDFW may also be explained by the selection of efficient builders. For example, prior to the SDFW, public school construction may have consisted of a mix of efficient and inefficient contractors. The introduction of the SDFW may have disrupted construction efficiency for all builders. But, by the time of the expansion of the policy in 1993, only the most efficient contractors, those able to cope with the requirements of the SDFW, remained in the covered sector. However, since our data are at the level of the project owner, we are unable to examine this explanation further because we are unable to track contractor entry and exit over the policy period. We have found evidence of changes in construction efficiency when prevailing wage laws are introduced. How the construction industry specifically adjusts to these policies is the subject of future research.

The results described here are based on an examination of school projects. Further research may confirm, or contradict these findings through an examination of other building types. Additionally, our results examine the efficiency impact of the wage policy when construction output is defined by project size. Prevailing wage laws may also affect project quality. Finally, we examine the effect of prevailing wage legislation of technical efficiency. These laws may also have affect allocative efficiency.

Footnotes

1. Keller and Hartman (2001) report a cost impact of 2.25 percent, but their estimate is based on a comparison of labor costs on covered and uncovered projects, holding labor utilization constant. This approach was common in the early literature that is summarized in Bilginsoy and Philips (2000). The recent studies cited above avoid the restrictive assumption of constant labor utilization by estimating the impact on total construction costs.

2. The fair wage schedule did not change over the life span of the policy. Compliance with the SDFW relied on contract requirements and declarations. Additionally, contractors were required to post the fair wage schedule at the sites of all covered projects. Audits of compliance and investigations of disputes were conducted by the Employment Standards Branch of the Ministry of Labour and Consumer Services.

3. See CANSIM Table 034-0001, 1998-2000. A shortcoming of these data is the inclusion of subcontract work and the omission of capital expenditures in the calculation of operating expenses. The former results in an estimate of percent labor costs that is too low, while the latter omission is associated with a percentage that is too high. Data from the 1992 U.S. Census of Construction Industries may provide a better estimate of percent labor costs in North American construction. For example, construction worker payroll (wages and benefits paid by general contractors of industrial buildings) is 21.1 percent of the net value of the construction work performed by these contractors. The net value measure of revenue omits subcontract work and captures capital usage. Construction cost data from either country omit land and architectural costs.

4. See Thieblot (1995) also for descriptions of these state-level prevailing wage policies.

5. The comparison of the SDFW to state-level prevailing wage laws is based on the following criteria. Lower contract limits mean stronger policies because more projects are covered by wage requirements. Thieblot assigns 2 points to contracts of US$2,000, or less and 0 points for contracts over US$50,000. Even taking into account currency purchasing power differences, the contract thresholds of CA$1.5 million and CA$250,000 for both stages of the SDFW suggest that many projects were not covered. Consequently, we assign 0 points for this category. Thieblot assigns 2 points (based on a 0-3 scale) if the state law extends to local jurisdictions to capture the level of enforcement. Since the SDFW covers all projects in the Province, we also assign 2 points for this category. The breadth of work covered and administrative requirements also indicate the rigor of a prevailing wage law. The SDFW required contract declarations, posted fair wage schedules, and audit compliance by the Ministry of Labour. The SDFW also applied to provincial projects other than building construction, but only covered construction workers. Thieblot's scale for this category ranges from –1 to 5, depending on exclusions. Since the SDFW was relatively strong in terms of breadth of work, we assign 4 points. In the U.S., the Davis-Bacon Act requires that counties where 50 percent plus one of the wages in any occupation are the same, the modal rate (typically the union rate) is the "prevailing wage". Otherwise, the average wage rate prevails. Many state-level laws also employ this switching

method. Thieblot uses a 0 to 8 point scale to assess the strength of wage requirements (0 for closer to market rate and 8 for same as the union rate). Since the SDFW clearly sets a minimum wage that is relatively close to the union rate (typically 88 percent of the union scale), we assign 7 points to this category (7/8 = 88 percent). The point total for all categories (0+2+4+7) is 13.

6. Our data file also contains 90 private school projects that were not affected by the SDFW. However, results of a likelihood ratio test indicate that it is inappropriate to pool private and public school projects. This test is based on the specification described below. The value of the log likelihood function (LLF) for the public school sample reported in Table 3 is –84.444. The LLF from the pooled sample of private and public schools is –153.428. The critical chi-square value is 15.507 (with 8 degrees of freedom at the 0.05 level). The computed value is 137.960.

7. These authors also find that cost overruns in Utah road construction were lower when prevailing wage laws were in effect.

8. Stochastic frontier regression involves the estimation of output as a function of inputs. Standard production theory assumes that inputs and outputs are measured in physical units. While physical measures of output are relatively common, in application it is often difficult, or impossible to obtain physical measures of inputs (such as capital, or energy). Many researchers have estimated output, in physical units, as a function of inputs, measured in physical units and/or expenditures. For example, Bishop and Brand (2003) use stochastic frontier regression to estimate the number of visitors to museums (the output measure) as a function of labor hours, maintenance costs, and other operational costs.

9. This price index measures contractor's selling price changes of non-residential construction (commercial, industrial and institutional). The index excludes land costs and real estate fees, but includes equipment, material and some labor costs, overhead, profits, federal and provincial taxes. The labor cost measures that are included in this price index are based on changes in the union wage scale. Because the fair wage schedule was lower than union rates, the price index will not control for the legislative wage changes that affected the costs of non-union contractors. Instead, this effect will be captured by the variables in the model. The index is available for seven Canadian cities. We use the index for Vancouver. For more details see Statistics Canada.

10. The stochastic frontier estimates associated with inefficiency models A and B are similar with respect to coefficient values, significance levels, and signs (comparing results in Table 3 with results under "Stochastic Frontier for Model B" in Appendix Table A). Additionally, the results of the likelihood ratio (LR) test are similar. This test of a one-sided error is a test for inefficiency effects (the test statistics are reported in Table 3 and in Appendix Table A). If the null hypothesis is accepted, the inefficiency effects are not present and the model can be estimated with OLS. The results of this test indicate that the inefficiency effects associated with models A and B are statistically significant (the critical value presented in Kodde and Palm (1986) is 8.761 at the 0.05 level and 4 degrees of freedom for both estimates). The low LR Test statistic reported in Appendix Table A for Model C (0.840) indicates the absence of significant

inefficiency effects for this specification. The corresponding critical value is 7.045 (at the 0.05 level with three degrees of freedom).

11. One may also hypothesize that the efficiency difference between the two school types is due to the characteristics of contractors who specialize in public school construction. However, since the contractors who built the projects included in our sample are qualified and licensed to build public and private schools, there are no barriers to entry that would result in specialization.

12. The likelihood ratio test for a one-sided error is a test for inefficiency effects. If the null hypothesis is accepted, inefficiency effects are not present and the model can be estimated with OLS. This test has a mixed chi-square distribution. The critical value, given in Kodde and Palm (1986), is 8.761 at the 0.05 level (with 4 degrees of freedom).

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Table 1
Summary Statistics for Public School Construction, British Columbia, 1989-1995.

Variable	All Public Schools Mean	$SDFW_{92}$ Projects Mean	$SDFW_{93}$ Projects Mean
Ln Square Feet	9.413 (1.08)	10.109[a] (0.72)	9.576 (1.05)
Square Feet	[21,923f^2]	[31,973f^2]	[24,760f^2]
Ln Real Bid Price	14.062 (1.19)	14.982[a] (0.63)	14.259 (1.08)
Real Bid Price	[CA$2,486,807]	[CA$4,024,302]	[CA$2,780,428]
Ln Stories	0.126 [1.2] (0.28)	0.212[a] [1.3] (0.33)	0.150 [1.2] (0.30)
Vancouver	0.349 (0.02)	0.311[a] (0.06)	0.339[a] (0.05)
Addition	0.651 (0.02)	0.527[a] (0.06)	0.603[a] (0.05)
Wet Season	0.272 (0.02)	0.284 (0.06)	0.240[a] (0.05)
N =	438	74	121

Source: Canadata, 1989 to 1995.
Standard deviations in parentheses (deviations for dummy variables are the standard deviations of the sample proportion). Conversions for square feet, Canadian dollars and number of stories in brackets.
[a] The mean for $SDFW_t$ Projects is different at the 0.05 level from the comparable mean for All Public Schools.

Table 2
Stochastic Frontier (Maximum Likelihood) Estimate of School Construction Inefficiency.

Inefficiency Models:

Model A		**Model B**		**Model C**	
Y = U		**Y = U**		**Y = U**	
Variable	**Coefficient**	**Variable**	**Coefficient**	**Variable**	**Coefficient**
Constant	0.056 (0.044)	**Constant**	0.067 (0.053)	**Constant**	0.140 (1.244)
SDFW$_{92}$ Project	0.086^{τ} (0.055)	**SDFW$_{92}$ Project**	$0.103^{\tau\tau}$** (0.051)	**SDFW$_{92\&93}$ Project**	0.046 (0.061)
SDFW$_{93}$ Project	$-0.318^{\tau\tau}$* (0.165)	**SDFW$_{93,>CA\$1.5m}$ Project**	$-0.411^{\tau\tau\tau}$*** (0.018)		
N =	438		438		438

Source: Canadata, 1989 to 1995. Standard errors in parentheses.
*** significant at the 0.01 level (two-tailed test)
** significant at the 0.05 level (two-tailed test)
* significant at the 0.10 level (two-tailed test)
τττ SDFWt coefficient is significant at the 0.01 level (one-tailed test)
ττ SDFWt coefficient is significant at the 0.05 level (one-tailed test)
τ SDFWt coefficient is significant at the 0.10 level (one-tailed test)

Table 3
Stochastic Frontier (Maximum Likelihood) Estimate of School Construction Output.

Stochastic Frontier **Y = Ln Square Feet** **Variable**	**Coefficient**
Constant	-1.611*** (0.231)
Ln Bid Price	0.805*** (0.016)
Ln Stories	0.191*** (0.061)
Vancouver	0.098*** (0.032)
Wet Season	-0.012 (0.034)
Addition	-0.246*** (0.034)
Year	-0.032*** (0.010)
Log Likelihood =	-84.444
LR Test (one-sided error)=	57.368
Variance Parameters:	
Sigma-squared (u)=	0.097
Gamma =	0.010
Mean Efficiency=	0.946
N =	438

Source: Canadata, 1989 to 1995. Standard errors in parentheses.
*** significant at the 0.01 level (two-tailed test)
** significant at the 0.05 level (two-tailed test)
* significant at the 0.10 level (two-tailed test)

Table 4
Average Technical Efficiency for Private, Public, SDFW 92, SDFW93 School Projects

Type of Project	Average Technical Efficiency
All Public Schools [n= 438]	0.946 (0.042)
$\mathbf{SDFW_{92}}$ Project [n= 74]	0.868[a] (0.003)
$\mathbf{SDFW_{93}}$ Project [n= 121]	0.998[a] (0.002)
Projects not covered by SDFW [n= 243]	0.943 (0.003)
$\mathbf{SDFW_{93,>CA\$1.5m}}$ Project* [n= 68]	0.997[a] (0.002)

Source: Canadata, 1989-1995. Standard deviations in parentheses. [a] The efficiency average for this school type is significantly different at the 0.05 level from the efficiency average for all public school projects.

* The average for this variable was obtained from inefficiency Model B.

Appendix Table A
Stochastic Frontier (Maximum Likelihood) Estimates of School Construction Output Used to Obtain Inefficiency Models B and C

Stochastic Frontier Y = Ln Square Feet Variable	Stochastic Frontier For Model B Coefficient	Stochastic Frontier For Model C Coefficient
Constant	-1.549***	-1.583*
	(0.261)	(1.231)
Ln Bid Price	0.801***	0.805***
	(0.017)	(0.017)
Ln Stories	0.184***	0.188***
	(0.061)	(0.061)
Vancouver	0.098***	0.102***
	(0.032)	(0.032)
Wet Season	-0.010	-0.017
	(0.035)	(0.034)
Addition	-0.244***	-0.247***
	(0.035)	(0.034)
Year	-0.029***	-0.012
	(0.010)	(0.012)
Log Likelihood =	-91.135	-112.706
LR Test (one-sided error)=	43.982	0.840
Variance Parameters:		
Sigma-squared (u)=	0.095	0.098
Gamma =	0.018	0.051
Mean Efficiency=	0.927	0.852
N =	438	438

Source: Canadata, 1989 to 1995. Standard errors in parentheses.
*** significant at the 0.01 level (two-tailed test)
** significant at the 0.05 level (two-tailed test)
* significant at the 0.10 level (two-tailed test)