An Analysis of Davis-Bacon Prevailing Wage Requirements:

Evidence from Highway Resurfacing Projects in Colorado.

Submitted to:

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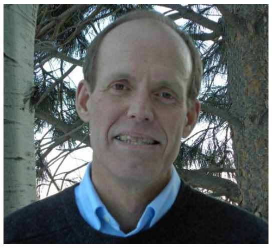

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Executive Summary

This summary provides a brief review of the main findings of the study. A complete technical report is attached that provides detailed explanations of the data and methods used, a review of the research on prevailing wage laws and a complete explanation of the results.

The Davis-Bacon Act of 1931 requires the payment of locally prevailing wages and benefits to construction workers employed on projects funded by the federal government. This study examines the effect of prevailing wage requirements on the relative cost of state and federally funded highway resurfacing projects in Colorado. The regulatory standards of highway projects funded by the State of Colorado are the same as federal standards with the exception of the payment of prevailing wages. Coloradoôs state-level prevailing wage law was repealed in 1985. Recent data on construction costs for state and federal projects provides an opportunity to examine the cost implications in Colorado of prevailing wage legislation.

As recommended by a CDOT official, the study is based on an examination of highway resurfacing projects that allows for an ñapples to applesò comparison between state and federal projects. Consequently, the study is based on federal interstate maintenance projects that involve highway resurfacing (coded IM in CDOT bid archives) and state highway resurfacing projects (coded MTCE in CDOT bid archives). The CDOT official also recommended the use of resurfacing projects after 2005 when CDOTôs estimates of the cost of projects (the engineerôs estimates) were completed by employees with more experience in the construction industry. The engineerôs estimate is used in the statistical analysis to account for size and complexity differences between projects. Consequently, a reliable estimate is necessary. However, an examination of the ratio of winning bids to engineerôs estimates from 2000 to 2005 and from 2005 to 2010 indicates that there is no statistically significant difference in the ratio of winning bids to the engineerôs estimate before and after 2005. This suggests that the engineerôs estimate is a uniform predictor of the winning bid during either period. Regardless, the examination of the relative cost of state and federal projects is conducted for the recommended 2005 to 2010 period and for the 2000 to 2010 period. Between 2005 and the third quarter of 2010, there was a total of 51 resurfacing projects (14 state and 37 federal). This is a relatively small sample size, particularly for state projects. The larger sample of 54 state projects and 68 federal projects from 2000 to the third quarter of 2010 is also used to provide for greater representation. Regardless of the sample used, the results with respect to the relative cost of prevailing wage regulations are the same.

Results indicate that, on average, projects funded by the federal government are substantially more expensive than state-level projects. However, federal projects are larger and more likely to require complex tasks than state-funded projects. For example, federal highway resurfacing projects are more likely to involve the removal of asphalt and other materials and structures. Federal projects are also more likely to require blading of road surfaces prior to resurfacing. These differences contribute to the observed cost difference between state and federal projects. When statistical techniques are used that take into consideration the size and complexity differences between state and federal projects, there is no statistically significant difference between the costs of projects that do, and do not require the payment of prevailing wages. Numerous statistical tests are conducted, using different sample configurations (2005 to 2010 data and 2000 to 2010 data) and test specifications. However, the basic result does not change. No statistical significance can be ascribed to the cost difference between state and federal projects, after taking into account project differences in size and complexity.

At face value, this may appear to be a surprising result because we typically believe that total costs rise when wages increase. However, this notion is not supported by a more careful consideration of the relation between wages, labor productivity and total costs in the construction industry. For example, other research by the author of this report reveals that productivity and the efficiency of construction is higher on projects that pay prevailing wage rates. Therefore, when construction worker wages rise on prevailing wage projects, productivity also increases in a way that stabilizes the total cost of the project. Additionally, data from the Economic Census of Construction indicates that construction labor costs are a low percentage (averaging between 25 to 30 percent) of total construction costs. Given that labor costs are a low percentage of total costs in the construction industry, productivity does not need to increase substantially to offset the effect of prevailing wage rates. The results of the study are also consistent with observations of CDOT employees who are experienced with the estimation of project costs. During interviews conducted by the author, two experienced employees independently confirmed that material costs and contractor productivity rates are major determinants of project costs. However, prevailing wage requirements do not ñplay a big roleò in cost outcomes. The contribution of this study is that prevailing wage requirements do not play a statistically significant role in cost outcomes. Finally, the results imply that the State of Colorado can adopt current federal wage standards without an increase in the cost of construction.

Statistical analysis also indicates that the prevailing wage requirement is not associated with a reduction in the number of bidders on a project. Bid competition is a key component in keeping construction costs low. There is no evidence that prevailing wage requirements limit bid competition in a way that increases construction costs. Additionally, union signatory contractors are no more likely to win bids on projects paying prevailing wages than nonunion contractors. Consequently, there is no evidence that prevailing wage laws favor one contractor over another, or affect the composition of contractor competition in a way that might increase construction costs.

The results of the present study are consistent with the preponderance of the most recent academic studies, using the best methods and data, indicating that prevailing wage laws are not associated with higher construction costs. The latest research confirms that the productivity and efficiency of construction is higher on prevailing wage projects and that productivity-enhancing measures stabilize construction costs.

Introduction to the Study

The Davis-Bacon Act of 1931 requires that construction workers, employed on federal projects, receive wages and benefits that prevail for similar work in the locality of the project. This report uses data from highway resurfacing projects in Colorado to examine implications associated with the payment of Davis-Bacon prevailing wages on projects funded by the federal government. Projects funded by the State of Colorado do not require the payment of prevailing wages and benefits. Other than the prevailing wage requirement, regulatory standards are the same for state and federal highway projects in Colorado. Therefore, the comparison between state and federal projects allows for an examination of the effect of prevailing wage requirements on the level of project winning bids, a measure of the cost of a project. The data also allows for an examination of the effects of prevailing wage requirements on the level of bid competition and the likelihood that a union signatory contractor will win a bid.

The use of highway resurfacing projects was recommended by a CDOT official to provide for an ñapples to applesò comparison of projects funded by the state and federal governments. Data was obtained from the CDOT bid archives that contain information on awarded and rejected projects.[1] Data from awarded projects only is used in this report. CDOT bid tabulations contain detailed information on the number and identity of the bidders, the amount of each bid, the location, timing, type of terrain involved with the project and other project characteristics. The bid tabulation also contains the engineerôs estimate. This is CDOTôs detailed calculation of the expected cost of the project. The detail provided by the bid tabulations allows for comparisons between the cost of state and federal projects, taking into account project differences in project size and scope. Once these differences are appropriately

[1] See http://www.coloradodot.info/business/bidding/Bid%20Tab%20Archives

taken into consideration, the residual difference between state and federal projects may be attributed to the effect of prevailing wage requirements.

Most of the analysis for this report is based on a sample of 122 highway resurfacing projects (68 are federal projects and 54 projects are funded by the State of Colorado). Data was collected from 2000 to the third quarter of 2010 and extends over two business cycles. A CDOT official knowledgeable of the departmentøs method of calculating the engineerøs estimate recommended that data from 2005 to the present be used in the study. Starting in 2005, engineerøs estimates were calculated by employees with greater background in the construction industry. There were 51 resurfacing projects from 2005 to 2010 (14 funded by the state with 37 federal projects). To determine if the engineersø estimates are reliable predictors of the winning bid and the cost of the project, the ratio of the winning bid and the engineerøs estimate was compared before and after 2005. Tests indicate that there is no statistically significant difference between the ratio of the winning bid and the engineerøs estimate before and after 2005.[2] Regardless, the analysis of relative cost includes results from the larger 2000-2010 sample and the smaller sample from the 2005-2010 period.

Basics of Statistical Analysis

Casual observation reveals that, in general, federally-funded construction projects are more expensive than state-funded projects. But, common sense tells us that we should not ascribe all of the cost difference between these two types of projects to the prevailing wages required on federal work because we may also observe that federal projects are larger and more complex than those funded by the state government. Common sense tells us that if we wish to

[2] The estimated difference between the two periods is ï 4.5 percentage points, however, this difference is not statistically significant at the 0.05 level for a two-tailed test.

measure the cost of prevailing wage requirements, we need to also take into account other factors that contribute to construction costs. This study uses the statistical technique of regression analysis to do what common sense suggests. This method allows for the measurement of cost differences between state and federal projects, taking into account many of the complexities and other characteristics that contribute to differences in building costs. With regression analysis we are interested in measuring the differences between the two types of projects. But, this type of statistical analysis also allows us to determine if a measured result is likely to have occurred due to chance. Throughout the report, measured differences will be referred to as ñstatistically significantò or ñnot statistically significantò. A statistically significant result is unlikely to have occurred due to chance. If a result is not statistically significant, then the measured result is likely to have occurred due to chance. Different levels of statistical significance are used and explained in the body of this report.

Outline of the Report

The remainder of this report provides a review of other studies that have examined the cost impact of prevailing wage regulations. Next is a discussion of how the data on resurfacing projects is combined with different statistical techniques to inform us about the effect of prevailing wage requirements in Colorado. Three statistical tests are conducted. The first examines the effect of prevailing wage requirements on the relative cost of federal and state projects. The second test examines the effect of prevailing wage requirements on the level of bid competition. The third test estimates the likelihood that a union signatory contractor wins a project requiring the payment of prevailing wages.

Review of the Research on Prevailing Wage Laws and Construction Costs

The research that examines the cost implications of prevailing wage laws has evolved over time as new data and statistical methods have been applied to this issue. This section traces out the development of this research. The preponderance of the most recent studies, using the best methods and data, indicate that prevailing wage laws are not associated with higher construction costs.

First Generation, or Labor Cost Studies of the Cost Implications of Prevailing Wage Laws.

Early studies of the cost effects of prevailing wage laws focused on wage comparisons between projects that were covered by the national prevailing wage law (the Davis-Bacon Act) and projects that were not covered by the wage policy (see Gujarati 1967; GAO 1979, 1981; Goldfarb and Morrall 1978, 1981; Gould 1971; Gould and Bittingmayer 1980; and for a more resent example, Keller and Hartman 2001).[3] Bilginsoy and Philips (2000) indicate that the bulk of these studies suggest that the Davis-Bacon wage requirements increase construction costs from 1.5 to 3 percent. However, the study by Bourden and Levitt (1980), which employs that same labor cost method, fails to find any cost effect of this law.

These studies are based on an intuitive approach where the difference between prevailing wage rates and open shop rates are used to calculate the increase in project labor costs on a prevailing wage project, keeping the number of construction workers employed on the project the same. Labor costs are then adjusted to reflect the ratio of labor costs to total construction costs to arrive at the final estimate of the percentage increase attributed to the prevailing wage

[3] The following early studies are exceptions to this method. Allen (1983) adjusts his cost estimate for factor substitution, he still finds a modest Davis-Bacon cost impact of 0.3 to 0.4 percent. Thieblot (1975) pursues a unique approach by taking advantage of President Nixonσs temporary suspension of the Davis-Bacon Act in 1971. Thieblotσs examination of the rebids allowed during the suspension suggests that the absence of the Davis-Bacon wage requirements reduced costs on federal projects by 0.63 percent. Thieblotσs re-examination of the data indicates that a repeal of the Act would result in a cost savings of 4.74 percent (see Thieblot 1986, 105-106).

policy. This is an intuitive approach and is consistent with the notion that if wage rates increase, so will the total construction costs.

While this methodology provides a measure of the impact of a prevailing wage law on labor costs (given fixed labor usage), it does not provide an accurate measure of the total cost of such a policy because it ignores any changes in labor hours that might result from increased productivity due to managerial efficiency, the substitution of equipment for labor, or employing labor with more training. Standard economic theory suggests that as wages rise, the utilization of labor will change as other inputs are substituted for more expensive workers. So, it is not appropriate to assume that labor utilization will remain the same when wage rates rise. If labor utilization or productivity is different, or changes on prevailing wage projects, the labor cost method described above will provide a cost estimate that is too high. Because prevailing wage laws may alter the utilization of labor and the total wage bill, it is important to examine the effect of prevailing wage laws on total construction costs since total costs include any adjustments management has made when wage rates change. An examination of total costs separates second generation studies from earlier analysis.

Second Generation or Statistical Estimates of the Cost Implications of Prevailing Wage Laws.

Second generation studies use more advanced statistical methods (regression analysis) to estimate the effect of prevailing wage laws on the total costs of construction. The preponderance of these studies fails to find a statistically significant prevailing wage cost effect (see for examples Prus 1996, Philips 2003, Azari-Rad, Philips and Prus 2002, 2003, Bilginsoy and Philips 2000, Duncan and Prus 2005, and Duncan, Philips, and Prus forthcoming). The exceptions to the majority of this research are the studies by Sarah Dunn, John Quigley and

Larry Rosenthal (2005) and Martha Fraundorf, John Farrell and Robert Mason (1983). Both of these studies suffer from serious methodological and data errors that limit the ability to draw meaningful conclusions about the effect of prevailing wage laws on construction costs.

The study by Dunn, Quigley, and Rosenthal (2005) is based an examination of residential projects subsidized by the California Low Income Housing Tax Credit and covered by the state prevailing wage law. These authors find that prevailing wage requirements increased costs from 9 to 37 percent. However, there are several problems with this study. First, data from the Economic Census of Construction indicates that construction labor costs range from 25 to 30 percent of total construction costs. Consequently, it is unlikely that the total cost of construction would fall by up to 37 percent from a regulatory change that primarily affects a cost component that accounts for only 25 to 30 percent of total costs.[4] Additionally, the Office of the Legislative Auditor, State of Minnesota (2007) has criticized this report on the basis that the cost of the publicly funded projects included in this study may have been influenced by prevailing wage laws and by other factors such as more exacting HUD construction standards that may also affect construction costs. However, these additional factors are not considered separately from prevailing wage effects. Finally, the study is based on a sample of 205 residential projects, yet the authors can only identify if the prevailing wage law applies, or does not apply to 175 of the projects. Yet, 30 unidentified projects are included in the sample. An appropriate statistical test would be based on the sample of 175 projects because the inclusion of the unidentified projects may bias the cost estimate.

[4] The authors provide "rough" data specific to housing construction in selected California cites indicating that labor's share of construction costs range from 42 to 46 percent of total costs. Even if labor costs are 46 percent of total costs, it is unrealistic to assume that total costs would fall by up to 37 percent. The implication is that labor's share of total costs would fall from 46 percent to about 17 percent (0.46 x 0.38 reduction if the wage laws was repealed). This figure for labor's share of total cost (17 percent) is unrealistically too low.

The study by Fraundorf et al. is based on the cost comparison between federally funded and privately funded construction projects (federally funded projects are covered by the Davis-Bacon Act, private projects are not). Results of this study indicate that federally funded projects cost from 26 to 35 percent more than privately funded projects. The authors ascribe this cost difference to the effect of prevailing wage requirements. There are several problems with this study and its conclusions. Like the cost estimates provided by Dunn, Quigley, and Rosenthal, this cost estimate is unrealistically too high given the data from the Economic Census of Construction indicating that labor costs range from 25 to 30 percent of total construction costs. This suggests that the Fraundorf estimate of the cost differential between federally and privately funded construction is too high to be entirely attributed to the wage changes required by the Davis-Bacon Act. A better explanation of the higher costs of federal projects is that many factors such as the prevailing wage law, federal regulations, and construction practices on federal projects influence the total construction cost of projects funded by the U.S. government. For example, the fittings and components in public buildings may be more expensive. Project life expectance may be higher on government projects. Or, quality and workmanship specifications may be higher. In general, the fact that public owners are under different economic and political pressures compared to private owners may lead to higher costs associated with public buildings, independent of prevailing wage regulations. Unfortunately, the data used by Fraundorf et al. do not allow for the kind of distinctions necessary to separate other influences from the effect of the prevailing wage law.

Numerous studies build on the work by Fraundorf by examining differences in the relative cost of publicly and privately funded projects between jurisdictions with and without prevailing wage laws (see for examples Prus 1996, Philips 2003, Azari-Rad, Philips and Prus

2002, 2003). Others compare total constructions costs for public projects, or the cost differential between public and private projects, before and after the introduction of prevailing wage laws (see for example, Bilginsoy and Philips 2000, Duncan and Prus 2005, and Duncan, Philips, and Prus forthcoming). All of these studies cited above employ different data sets and statistical tests to estimate the cost of these policies in Canada and the U.S. Despite these differences, these studies all share the common finding that prevailing wage laws are not associated with higher construction costs. An explanation of how wages can rise, yet costs remain stable on prevailing wage projects is the subject of current, or third generation research.

Third Generation Studies

As mentioned above, one possible reaction to prevailing wage policies is that there are concomitant changes in the crew mix, the substitution of equipment for labor, or other changes that alter the productivity and efficiency of construction. This is the focus of the current, third generation prevailing wage studies that apply a method of estimating production efficiency (stochastic frontier regression) to the topic of prevailing wage laws. For example, in an examination of the effect of prevailing wage laws on construction efficiency in British Columbia, Canada, Duncan, Philips, and Prus (2006) find that prior to the introduction of the wage legislation, public school projects were from 16% to 19% smaller, in terms of square feet, than comparable private structures. This size differential did not change after the policy was in effect. These results suggest that prevailing wage requirements do not alter labor or other input utilization in a way that significantly affects the relative size of covered and uncovered projects.

In a follow-up to this study the authors use data from public school projects in British Columbia to provide a more direct test of the effect of prevailing wage policies on the efficiency of construction (see Duncan, Philips, and Prus 2007 and 2009). Results indicate that average technical efficiency for all construction projects included in the sample is 94.6 percent (100 percent is optimal efficiency in terms of maximizing output from inputs). Average efficiency for projects covered by the introductory stage of British Columbiaôs construction wage legislation is 86.6 percent. This policy mandated apprenticeship training that required journeymen to divide time between teaching and building. This may explain the decrease in efficiency when the policy was introduced. However, 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 construction efficiency in a way that is consistent with stable costs.

CDOT Highway Resurfacing Data and Statistical Methods

Data for the study was obtained from CDOT bid archives that contain information on awarded and rejected projects.[5] Only data from awarded projects are used in this report. As recommended by a CDOT official, the study is based on an examination of highway resurfacing projects that allow for an ñapples to applesò comparison between state and federal projects.[6] Resurfacing projects are maintenance projects as opposed to new construction. Consequently, it is easier to compare costs of resurfacing projects because of the rough similarity of this type of work. New construction projects, or other repair projects, such as bridge repairs, differ substantially making it very difficult to adequately capture differences in project complexity.

Specific projects included in this study involve all projects where the significant component of the project involved some aspect of resurfacing maintenance. That is, projects

[5] See http://www.coloradodot.info/business/bidding/Bid%20Tab%20Archives

[6] Specifically, the resurfacing projects included in this report are federal interstate maintenance projects (identified in the bid tabs by the CDOT code ñIMò) and state maintenance projects (with the CDOT code ñMTCEò).

were selected for use in this study if the CDOT project description included such resurfacing work as overlay of hot mix asphalt, surface treatment, patching, chip seal, crack seal, replacement of concrete pavement, etc. The contract ID numbers for the projects included in the study are provided in Appendix 1. The projects included in the study involve the same group of contractors that specialize in highway resurfacing work.

Federal resurface projects take place on interstate highways (I-25, I-70 and I-76) that are located in CDOT regions 1 through 4 and 6. Consequently, there are no federal resurfacing projects in CDOT region 5 (the southwest portion of Colorado). For balance, state-funded resurfacing projects that occurred in CDOT region 5 are not included in the results reported below. However, results with these projects included are discussed.

CDOT bid tabulations contain detailed information on the specifics of a project. The tabulations report the number and identity of the bidders on the project, the amount of each bid, the location, time frame and type of terrain involved with the project. The bid tabulations also contain an item description for each of the tasks required of the project as well as the ñquantityò of the required item. For example, projects requiring asphalt patching will list the estimate of the quantity of the material, in this case tons of hot mix asphalt, required for this work. The item descriptions are provided to bidders who estimate their cost for each item. The total bid for each competing contractor is the sum of all item costs. The winning bid is the lowest bid listed on the bid tabulation. The bid tabulations also contain the engineerõs estimate that is CDOTõs estimate of the cost of each item of the project and the estimate of the total cost of the project. The engineerõs estimate contains the item and expected unit price. So, with the asphalt patching example above, the engineerõs estimate would include the tons of material needed for the work and an estimate of the unit price (the cost of the material and the cost of applying the material).

The CDOT engineer's estimate is based on the same standards and regulations regardless of whether the project is funded by the state or federal government. That is, the engineer's estimate is based on the same federal standards and regulations (including Davis-Bacon prevailing wage requirements), even if the project is funded by that State of Colorado. So, the labor cost portion of the engineer's estimate is based on the prevailing wages in a region, regardless of whether the state or federal government is funding the project. Returning to the illustration of the asphalt patching example above, the engineer's estimate of the cost of this item would be based on the cost per ton of the asphalt material and the cost of applying this material. The labor costs associated with applying the material would be based on the applicable prevailing wage rate. Consequently, the CDOT engineer's estimates are scaled by the same wage rate (the prevailing wage rate), regardless of whether the project is funded by the federal or state government. CDOT does not use different wage rates when estimating the cost of state and federal projects.[7]

CDOT also reports construction cost indexes for specific construction types. These indexes are used to adjust for inflation. The base year is 1987. The CDOT indexes are based on the cost of materials, not labor cost. The results below are based on the resurfacing index, but results based on the asphalt pavement index and the composite index are discussed.

Most of the analysis for this report is based on a sample of 122 highway resurfacing projects (68 are federal projects and 54 are funded by the State of Colorado). Data was collected from 2000 to the third quarter of 2010 and extend over two business cycles. A CDOT official, knowledgeable of the department's method of calculating the engineer's estimate, recommended

[7] There may be additional administrative processes (forms and paperwork), but these are not related to construction costs.

that data from 2005 to the present be used in the study. Starting in 2005 engineer's estimates were calculated by individuals with greater background in the construction industry. There were 51 resurfacing projects from 2005 to 2010 (14 funded by the state with 37 federal projects). To determine if the engineer's estimates are reliable predictors of the winning bid and the cost of the project, the ratio of the winning bid and the engineer's estimate was compared before and after 2005. There is no statistically significant difference between the ratio of the winning bid and the engineer's estimate before and after 2005, holding other project characteristics constant.[8] Regardless, the analysis of relative costs includes results from the larger 2000-2010 sample and the smaller sample from the 2005-2010 period. The data on state and federal highway resurfacing projects are used to estimate the following model:

(1) Ln Real Winning Bid = $\beta_0 + \beta_1$ Federal Project + β_2 # Bidders + β_3 Ln Real Engineer's Estimate + β_4 X + β_5 Z + μ

where Ln Winning Bid is the natural log of the project winning bid. This is the measure of the cost of the project. Federal Project is equal to one if the project was funded by the federal government and this variable is equal to zero is the project was funded by the State of Colorado. Federal projects require the payment of prevailing wage laws while state-funded project do not. Other regulatory standards for state and federal projects are the same. Federal projects included in this study are interstate maintenance projects on interstate highways 25, 70 and 76. State-level projects are resurfacing projects on state highways across Colorado. # Bidders is equal to the number of contractors bidding on the project. Ln Real Engineer's Estimate is the natural log of CDOT's estimate of the cost of the project. X is a vector of project characteristics such as

[8] The estimated difference between the two periods is – 4.5 percentage points, however, this difference is not statistically significant at the 0.05 level for a two-tailed test.

whether the project required the removal of asphalt or other materials and structures, blading of the road surface prior to resurfacing, etc. Z is a vector of broad project characteristics including the CDOT region the project is in, the type of terrain involved, the extent of the project over multiple counties and whether the project involves a fixed completion date, or specifies a number of working days. This vector also includes dummy year variables. The error term is µ. Dollar measures are adjusted with the CDOT construction cost index for resurfacing projects.[9] This specification allows for a test of the difference between federal and state projects, holding constant much of the detailed now-wage characteristics of projects that contribute to cost differentials.

The variables listed above are also used to estimate the following two additional models:

(2) $\ln_e [P_i/(1ï P_i)] = ß_0 + ß_1$ Federal Project + $ß_2$ Ln # Bid Items + $ß_3$ X + $ß_4$ Z + µ

where P_i is the probability that a union signatory contractors wins a bid. Therefore, $\ln_e [P_i/(1ï P_i)]$ is the log of the odds ratio of a union contractor winning a bid. This odds ratio is the dependent variable in the logit regression. Ln # Bid Items is the number of items included in the bid tabulation and is a measure of the size of a project. This model allows for a test of whether union contractors are more likely to win bids on federal projects, controlling for the size of the project and other project characteristics included in vectors X and Z described above.

(2) Ln # Bidders = $ß_0 + ß_1$ Federal Project + $ß_2$ Ln Real Winning Bid + $ß_3$ X + $ß_4$ Z + µ

This specification allows for an examination of the effect of the prevailing wage requirements of federal projects on the number of bidders. This is a test to determine if prevailing wage laws

[9] See http://www.coloradodot.info/business/eema

limit bid competition, controlling for the size (measured by the level of the winning bid) and other characteristics of the project (measured by vectors X and Z).

Results of Statistical Analysis

Summary statistics for the 54 state and 68 federal projects included in the study are reported in Table 1. These data indicate that winning bids are substantially higher on federal projects ($1.94 million for the average federal project, in 1987 dollars, versus less than $300,000 for the typical state resurfacing project). But, CDOTös estimate of the cost of federal projects is also higher (about $2 million for the average federal project versus $320,000 for the typical state-funded project). The bid tabulations for federal projects also contain more items indicating that federal projects are larger and more complex than state projects. For example, the average federal project includes about 60 identified items or tasks, while the average state project includes about 12 items. While the data suggest that federal projects are more expensive than state projects, the data also indicate that federal projects are larger and more complex.

Table 1
Summary Statistics for CDOT Highway Resurfacing Projects, 2000-2010

Variable	Federal Project Mean	State Project Mean
Real Low Bid	$1,939,695[a]	$298,104
	(1,373,638)	(269,705)
Log of Real Low Bid	14.247 [a]	12.308
	(0.76)	(0.77)
Engineerǒs Estimate	$2,038,366 [a]	$321,868
	(1,388,466)	(298,039)
Log of Engineerǒs Estimate	14.291 [a]	12.395
	(0.80)	(0.741)
# of Bid Items	60.912 [a]	11.926
	(26.36)	(13.56)
Asphalt Removal	0.897 [a]	0.352
(Planing)	(0.04)	(0.06)
Removal (other than asphalt)	0.574 [a]	0.148
	(0.06)	(0.05)
Blading of Road Surface	0.647 [a]	0.019
	(0.06)	(0.02)
Seeding & Mulching	0.574 [a]	0.037
	(0.06)	(0.03)
Concrete Pavement/Slabs	0.059 [a]	0.093
	(0.03)	(0.04)
# Bidders	4.221 [a]	3.741
	(1.39)	(1.92)
Fixed Completion Date	0.191 [a]	0.815
	(0.05)	(0.05)
Three or More Counties	0.015 [a]	0.093
	(0.01)	(0.04)
Region #1: Central-East	0.294 [a]	0.222
	(0.06)	(0.06)
Region #2: South-East	0.191 [a]	0.056
	(0.05)	(0.03)
Region #3: North-West	0.221 [a]	0.037
	(0.05)	(0.03)
Region #4: North-East	0.103 [a]	0.444
	(0.04)	(0.07)
Region #6: Denver Area	0.191 [a]	0.241
	(0.05)	(0.06)
Mountainous Terrain	0.338 [a]	0.185
	(0.06)	(0.05)
Rolling Terrain	0.368 [a]	0.278
	(0.06)	(0.06)
Plains Terrain	0.118 [a]	0.296
	(0.04)	(0.06)
Urban Terrain	0.118 [a]	0.296
	(0.04)	(0.06)
N =	68	54

Source: CDOT Bid Archives. Standard deviations in parentheses (deviations for dummy variables are the standard deviations of the sample proportions). [a] The mean for federal projects is different at the 0.05 level from the comparable mean for state projects.

Other data reported in Table 1 identify some of the specific differences between state and federal projects. For example, about 90 percent of federal projects require the removal of asphalt while only 35 percent of state projects require this type of additional work on resurfacing projects. Similarly, about 57 percent of federal projects require the removal of other materials and structures relative to 15 percent for state projects. Approximately 65 percent of federal projects involve the blading of the road surface while only two percent of state projects require this kind of work. While federal projects are more likely to involve seeding and mulching, state projects are more likely to involve concrete pavement.

The average number of bidders on a federal project is 4.2 and 3.7 for a state project. Other data indicate that state projects are more likely to require a fixed completion data (versus allowing for a given number of working days) and to extend over three or more counties. Federal projects are more likely to be in CDOT regions 1, 2 and 3, but less likely in regions 4 and 6, relative to state projects. Federal projects are more likely to take place in mountainous and rolling terrain, but state projects are more likely on the plains and in urban areas. All of the differences between state and federal projects are statistically significant at the 0.05 level.

Regression results of the winning bids are reported in Table 2. Models 1 through 3 are based on highway resurfacing that took place between 2001 and Q3 of 2010. These models report the estimated cost impact of federal projects as measures of project size and complexity are added. Model 4 is based on highway resurfacing projects that occurred between 2005 and the third quarter of 2010. Robust standard errors are reported for regression coefficients that provide for asymptotically valid standard errors to correct for hetereoskedaticity. [10] Results for

[10] The assumption of constant error variance does not hold in this cross-section sample of projects. For example, the Breusch-Pagan/ Cook Weisberg test statistics when models 3 and 4 are estimated with OLS are 10.00 (p-value = 0.0016) and 9.31 (p-value = 0.0023), respectively.

Model 1 indicate a coefficient for Federal Projects that is large (1.990) and statistically significant at the 0.01 level. According to Kennedy (1981) the correct interpretation of the percentage change for a coefficient for a dummy variable in a semi-log estimate is given by ($e^{ɓi}$ï 1), or in this case, $e^{1.99}$ï 1= 6.32, indicating that federal projects are approximately six times more expensive than state-funded projects. This estimated coefficient for Federal Project is close to the ratio of raw average cost differences between federal and state projects reported in Table 1 ($1,939,695 / $298,104 = 6.5). This effect is measured when only general project information is included in the estimate. The estimated relative cost of federal projects is too large to be fully attributed to any wage disparity between federal and state projects given that labor costs in construction range from 25 to 30 percent of project total costs. The federal dummy variable is measuring cost differences that are unrelated to any expected labor cost differences. Other results for Model 1 indicate the absence of statistically significant effects for the number of bidders, whether the project requires a fixed completion date instead of a number of working days, or whether the project extends over more than two counties. Results also indicate that costs do not vary between regions or terrains in terms of statistical significance. The trend in the year variables suggests that costs were lower in each year compared to 2000, with significantly lower costs in 2002 and 2008. This trend is not consistent with observed trends in resurfacing materials costs in Colorado over this time period. Overall, the model explains about 69 percent of the total variation in the log of winning bids.

Table 2
Regression Results for Winning Bids for CDOT Highway Resurfacing Projects, 2000-2010
Dependent Variable = Natural Log of Low (Winning) Bid

	Coefficients			
Variable	Model 1	Model 2	Model 3	Model 4
Federal Project	1.990***	1.131***	0.068	0.051
	(0.311)	(0.354)	(0.077)	(0.150)
Log of Engineerôs Estimate	ï	ï	0.976***	0.959***
			(0.026)	(0.047)
Asphalt Removal (Planing)	ï	0.713***	0.003	0.032
		(0.232)	(0.040)	(0.080)
Removal (other than asphalt)	ï	0.208	0.040	0.065*
		(0.158)	(0.034)	(0.039)
Blading of Road Surface	ï	0.580***	0.060*	0.045
		(0.207)	(0.033)	(0.067)
Seeding & Mulching	ï	0.150	ï 0.029	ï 0.039
		(0.198)	(0.039)	(0.058)
Concrete Pavement/Slabs	ï	0.403	0.013	ï 0.021
		(0.434)	(0.093)	(0.099)
# Bidders	0.020	ï 0.048	ï 0.030***	ï 0.037**
	(0.041)	(0.036)	(0.008)	(0.016)
Fixed Completion Date	ï 0.040	0.033	0.006	0.006
	(0.304)	(0.268)	(0.043)	(0.082)
Three or More Counties	ï 0.073	ï 0.033	0.006	ï 0.041
	(0.343)	(0.260)	(0.060)	(0.093)
Region #1: Central-East	0.127	0.134	0.083**	0.080
Region #2: South-East	0.122	ï 0.025	0.082**	0.107
Region #3: North-West	ï 0.053	0.016	0.078	0.086
Region #4: North-East	0.062	ï 0.191	0.035	ï 0.023
Mountainous Terrain	ï 0.062	ï 0.252	ï 0.048	ï 0.067
Rolling Terrain	ï 0.100	ï 0.188	ï 0.048	ï 0.037
Plains Terrain	0.382*	0.177	0.034	ï 0.013
2001	ï 0.484	ï 0.107	0.081	ï
2002	ï 0.634*	ï 0.391	0.086	ï
2003	ï 0.298	ï 0.138	0.154*	ï
2004	ï 0.083	0.165	0.214**	ï
2005	ï 0.600	ï 0.580*	0.122	ï
2006	ï 0.362	ï 0.273	0.1145*	ï 0.016
2007	ï 0.622	ï 0.647*	0.1143*	0.009
2008	ï 1.076**	ï 0.721**	0.231**	0.093
2009	ï 0.340	ï 0.452	0.096	ï 0.051
2010 (to Q3)	ï 0.989	ï 0.272	0.052	ï 0.114
Constant	12.629***	12.499***	0.145	0.557
	(0.438)	(0.431)	(0.346)	(0.568)
N =	122	122	122	51
F=	16.92	19.42	619.46	341.59
R^2 =	0.687	0.762	0.991	0.994

Source: CDOT Bid Archives. Robust standard errors in parentheses. * significant at the 10 percent level, ** significant at the 5 percent level, ***significant at the 1 percent level (two-tailed tests).

Model 2 includes more detailed measures of project characteristics. When these measures are included the cost impact of federal projects falls to approximately 200 percent ($e^{1.13}$ ï 1= 2.09). Again, this measured cost differential is too high to realistically reflect any labor cost difference due to prevailing wage requirements and is affected by unmeasured characteristics of the projects. Other results for Model 2 indicate that projects requiring the removal of asphalt (planning) or blading of the road surface add about 7 and 6 percent, respectively to the costs of a project. These differences are statistically significant at the 0.01 level. However, projects that require the removal of structures or material other than asphalt, seeding and mulching or concrete pavement are not different, in terms of statistical significance than projects that do not require this type of work. The results for Model 2 with respect to the other, general measures of project characteristics, are similar to those reported for Model 1. That is, no statistical significance can be ascribed to the effect of the number of bidders, the requirement of a fixed completion date, work that extends over more than one county or differences between regions and different terrains. The trend in the year variables suggests lower costs relative to the reference year of 2000 with statistically lower costs in 2005, 2007 and 2008. Again, this estimated trend is inconsistent with the nature of observed resurfacing material costs in Colorado over this time period. The exception is the estimate for 2004 that suggests higher costs in that year, though this effect is not statistically significant. With the addition of more measures of project characteristics the R-squared increases to 76 percent.

Model 3 includes a more comprehensive list of variables that measure the size and complexity of projects. With the addition of the engineerôs estimate of the project cost, the federal dummy variable decreases substantially in size (to approximately 7 percent) and is no longer statistically significant. The t-value for Federal Project is 0.89 with a p-value of 0.378

suggesting that the effect of this variable in not statistically significant at either the 0.05 or 0.10 level for a two or one-tailed test. The 95 percent confidence interval for Federal Project ranges from ï 0.081 to 0.222 and includes zero. This finding indicates that when more complete controls are added to the estimate of the winning bid, there is no statistically significant cost differential between federal projects that are covered by Davis-Bacon prevailing wage requirements and state projects that are not covered by the wage standard. This effect is not altered with changes in the sample or use of different cost indices. For example, when the state projects from Region 5 are added to the sample, the number of observations increases to 141. The estimate of Model 3 with this sample yields similar results with respect to the effect of the Federal Project variable. The estimated coefficient is 0.053, the robust standard error is 0.067 and the t-value is 0.78. Once again, this effect of Federal Project on project cost is not statistically significant at either the 0.05 or 0.10 level for either a two or one-tailed test. When other CDOT cost indexes are used, the results with respect to Federal Project do not change. Results from Model 3 are based on the use of the CDOT resurfacing cost index to adjust variables measured in dollar terms for inflation. When the CDOT asphalt cost index is used, the coefficient for Federal project is 0.073, the robust standard error for this coefficient is 0.078 and the t-value is 0.93 (with a p-value of 0.355). When the CDOT composite cost index is used, the coefficient for Federal project is 0.070, the robust standard error for this coefficient is 0.078 and the t-value is 0.89 (with a p-value of 0.373). Again, neither of these effects is statistically significant at the 0.05 or 0.10 level for a two or one-tailed test.

The model with 122 observations was also used to estimate the ratio of the winning bid to the engineerõs estimate (in log form) as the dependent variable. This specification allows for a test of whether state projects are relatively less expensive compared to CDOTõs estimate of the project cost. Since the engineerôs estimates are based on prevailing wage rates, it is possible that this variable is picking up some, or all of the effect of the wage policy. This may explain why the coefficient for Federal Project in Model 3 in Table 2 fails to indicate statistically significant cost differences between federal and state projects when the engineerôs estimate is included in the equation. The engineerôs estimate may be capturing the effect of the policy. If the prevailing wage policy is associated with higher costs and if the engineerôs estimate is based on prevailing wage rates, then winning bids on state projects should be lower relative to the engineerôs estimate. This hypothesis is tested with the log of the ratio of the winning bid to the engineerôs estimate as the dependent variable with the same independent variables included in Model 2 (the log of the number of bid items is included to control for project size and complexity). The coefficient for a the dummy variable identifying a state project from this estimate is ï 0.066, suggesting that winning bids on state projects are approximately 7 percent lower than CDOTôs estimate of the project, compared to federal projects that are covered by the prevailing wage law. However, the t-statistic for the State Project coefficient is ï 0.82, indicating that no statistical significance can be ascribed to the estimated difference.[11]

Recent empirical studies in the auction literature have raised concern over the possible endogeneity of the number of bidders when using this measure in the estimate of winning bids (see Porter and Zona, 1999 and Bajari, 2001). If the decision by a contractor to submit a bid is endogenous, the parameter estimates reported above will be biased. To address this issue, the number of bidders was replaced with a variable measuring the expected number of bidders using the technique of instrumental variables estimation. This new variable is constructed by using additional information on the requirements of the project. For example, if work on a resurfacing

[11] The estimate of the ratio of the winning bid and the engineerôs estimate has the same independent variables as Model 3, but the log or the engineerôs estimate is omitted and the log of the number of bid items is included to control for difference in project size.

project extends over, or requires work on a bridge, some contractors may decide not to bid on the project. Contractors who are relatively unprepared for this additional work may expect higher costs and bids that are not competitive.[12] The results for Model 3 with respect to Federal Project are invariant to the use of the expected number of bidders (replacing the number of bidders). When Model 3 is estimated with the expected number of bidders, the coefficient for Federal Project is 0.119 with a t-value of 0.87. The main difference is that the expected number of bidders is not statistically significant in this estimate. The coefficient for the expected number of bidders is 0.015, t-value = 0.18 for Model 3.

Since both the winning bid and the engineerǿs estimate are measured in Table 2 in terms of natural logs, the coefficient in an elasticity. This means that a one percent change in the engineerǿs estimate is associated with a 0.976 percent change in the winning bid. This effect is statistically significant with a t-value of 38.15. Including the engineerǿs estimate increases the R-squared to 0.991. Other studies report similar results with respect to the engineerǿs estimate. For example, the study by De Silva, Dunne and Kosmopolou (2003) reports a double-log coefficient of 0.953 for the engineerǿs estimate and an R-squared of 0.974 when the engineerǿs estimate is used to estimate the winning bid for highway projects in Oklahoma.

The engineerǿs estimate is a comprehensive measure of the size and complexity of the project and when this measure is included in the equation many of the effects of the previously included measures of project characteristics (asphalt planning, removal of other structures and materials, seeding and mulching, and concrete pavement) diminish in terms of magnitude and statistical significance. The cost effect of blading remains statistically significant.

[12] Regression estimates of the log of the number of bids on a project indicate that if the project involves work on a bridge, the number of bides decreases by approximately 6 percent. This effect is statistically significant at the 0.09 level for a one-tailed test.

Including the engineerôs estimate has the effect of improving the overall explanatory power of the estimate (as indicated by the R-squared), but the addition of the variable is also associated with other changes that are consistent with a priori expectations. For example, the effect of another bidder on the winning bid in negative and statistically significant indicating that one more bidder is associated with a reduction in project cost of approximately 3 percent. When the number of bidders is measured in log form, the corresponding elasticity is 0.08 percent indicating that if the number of bidders increases by 1 percent project costs decrease 8-hundreths of a percent. Regions one and two have higher and statistically significant costs compared to reference region six. There is no statistically significant difference between the different terrain types. The trend in year variables is now consistent with observed highway construction material costs in the state with statistically significant higher costs starting in 2003, 2004 and 2006 through 2008. After the peak of the business cycle in 2009 and 2010, real costs are not higher, in terms of statistical significance, than the level in 2000.

Given CDOTôs concern over the calculation of the engineerôs estimate prior to 2005, the complete model is estimated using highway resurfacing data from the 2005 to 2010 period. This estimate is based on a sample of 51 projects. While the estimate of the differential impact of Federal Project is smaller when comparing the results between models 3 and 4, the results are similar with respect to statistical significance. The results for Model 4 suggest that federal projects are approximately 5 percent more expensive than state projects, but this difference is not statistically significant. The 95 percent confidence interval for the federal project dummy variable ranges from -0.132 to 0.356 and includes zero.

Other results for Model 4 indicate that one more bidder is associated with an approximate 3.7 percent decrease in the winning bid. Blading is not significant in this estimate, but the effect of material removal (other than asphalt) is statistically significant with the use of the smaller sample. The sample used for Model 4 fails to show statistically significant cost differences between regions. The year trend is now based on the reference year of 2004 and indicates lower real costs in 2005, 2009 and 2010. But, no statistical significance can be ascribed to these measured differences. The R-squared is similar to the level reported for Model 3.

In sum, the results of the regression analysis indicate the absence of statistically significant cost differentials between federal and state highway resurfacing projects when measures of project characteristics are included. This result persists regardless of the sample that is employed or which cost index is used. These results indicate that the prevailing wage requirements of federal projects do not add to the relative cost of these projects. This finding is consistent with the preponderance of empirical studies of prevailing wages that fails to find statistically significant cost effects.

Do Prevailing Wage Laws Limit Bid Competition and Favor Union Signatory Contractors?

A common impression is that union signatory contractors who employ unionized construction workers benefit from prevailing wage laws because these laws limit competition. Summary data from CDOT resurfacing projects provide support for the first claim, but not for the second. For example, union signatory contractors were awarded 35 percent of the federal projects, but only 26 percent of the state projects. On the other hand the average number of bids of a federally-funded project is 4.2 and 3.7 for a state project. While these data imply that the prevailing wage law favors union contractors, the average bid data do not imply that competition is lower on projects covered by the wage policy. The limitation of this analysis based on averages is that it does not take into consideration other factors that affect the award of a bid or the number of bidders. For example, the number of projects awarded to union contractors is based on a state-wide comparison. However, awards may vary across regions where there are differences in union/nonunion contractor concentrations. Consequently, it is important to examine the effect of the federal wage policy on the likelihood that that a union contractor wins a bid, taking into account regional and other factors that influence the outcome of a bid. Similarly, the simple comparison between the average number of bids for federal and state projects ignores other factors such as the size, location and other characteristics of the project that also affect bid competition. Additional statistical analysis is presented below that explores these issues in more detail. For example, logistic regression analysis is used to determine if union signatory contractors are more likely to win federal resurfacing projects in Colorado, taking into account other project characteristics. Also, regression analysis is used to determine if the number of bidders is lower on federal projects, taking into account other relevant project characteristics.

The logit regression results of the likelihood that a union contractor is awarded a federal project (versus a state project) are presented in Table 4. It is important to keep in mind that unionization in the Colorado construction industry is not high with 6.4 percent of construction workers covered by a collective bargaining agreement in 2010 (that national rate is 13.7 percent for the same year).[13] Only seven of the 89 contractors that submitted bids on resurfacing projects between 2000 and 2010 were union signatory contractors. Only 3 of these union contractors won bids over this time period.

[13] See http://www.unionstats.com/

Table 3
Logit Regression Results of the Probability that the Winning Bid is by a Union Signatory Contractor, CDOT Highway Resurfacing Projects, 2000-2010
Dependent Variable = 1 if the Project was Awarded to a Union Signatory Contractor.

Variable	Odds Ratio
Federal Project	3.742
	(0.95)
# Bid Items	0.951*
	(ï 1.90)
Asphalt Removal (Planing)	4.633*
	(1.82)
Removal (other than asphalt)	2.403
	(1.06)
Blading of Road Surface	0.284
	(ï 1.22)
Seeding & Mulching	5.561¶
	(1.34)
# Bidders	0.473¶
	(1.52)
Fixed Completion Date	1.465
	(0.41)
Three or More Counties	0.689
	(ï 0.32)
Region #1: Central-East	11.648¶
Region #2: South-East	8.163¶
Region #3: North-West	31.514¶
Region #4: North-East	62.152**
Mountainous Terrain	0.061*
Rolling Terrain	0.012***
Plains Terrain	0.024**
2001	1.131
2002	0.230
2003	0.920
2004	0.571
2005	2.951
2006	0.547
2007	0.114
2009	2.227
2010 (to Q3)	1.537
N =	103
Log Likelihood	ï 47.670
Likelihood Ratio Chi-Squared	39.17
Pseudo R^2 =	0.291

Source: CDOT Bid Archives. Z statistics in parentheses. * significant at the 10 percent level, ** significant at the 5 percent level, ***significant at the 1 percent level (two-tailed tests). ¶ significant at the .010 level for a one-tailed test.

The logit coefficients have been converted to odds ratios from logit coefficients for ease of presentation. If the odds ratio is greater than one, the odds of a union contractor winning the bid increases, given a unit change in the independent variable. If the odds ratio is less than one, the odds of a union contractor winning the bid decreases, given a unit change in the independent variables. The logit regression includes many of the project characteristics that are included in the cost estimates presented in Table 2 above. The sample size is smaller because there were no projects won by union contractors in 2008, nor were any projects involving concrete pavement awarded to union signatories. Consequently, 19 observations were dropped and 103 observations remain. The odds ratio for a federal project from Table 3 is 3.7 suggesting that a union contractor is about 3.7 times more likely to win a federal project than a nonunion contractor. However, no statistical significance can be ascribed to this effect (z statistic = 0.95). This result did not change with the estimate of a probit model (Federal Project coefficient = 0.311 with a z statistic = 0.41). The logit results for Federal Project did not vary, in terms of statistical significance when the model was estimated without measures of the real low bid, asphalt planning, removal of structures, blading of the road surface, seeding and mulching and the number of bidders. [14]

Other results reported in Table 3 indicate that the size of the project, indicated by the number of bid items, is associated with a decreased likelihood that a union contractor will win a project. This indicates that the union contractors included in the sample are not effective competitors on large highway resurfacing projects. This effect is statistically significant at the 0.10 level. Union contractors are also more likely in terms of statistical significance to win bids on projects that require asphalt planning and seeding and mulching, but, are no more likely to

[14] The logit coefficient for Federal Project in the estimate described above is 0.145 with a standard error of 0.75 (z score = 0.19). The chi-squared for this estimate has a p-value of 0.49.

win bids for projects that require blading of road surfaces or the removal of structures. An increase in the number of bidders decreases the likelihood that a union contractor will win the bid. This effect is statistically significant at the 0.10 level (one-tailed test). The terms of the contract with respect to completion date and projects extending over three counties does not have an effect on the likelihood of a union contractor winning a project. Union contractors are more likely to win bids in all the regions relative to region 6 (this region includes the greater Denver area). The regional differences are statistically significant at the 0.01 level or lower (for one and two-tailed test) and are quite large. For example, a union contractor is approximately 62 times more likely to win a contract in region 4 than in region 6. Union contractors are less likely to win bids in terrains outside of urban areas. These terrain effects are statistically significant. The likelihood that a union contractor wins an award does not seem to vary over the business cycle. The computed likelihood ratio chi-squared statistic is 39.17 indicating that the null hypothesis that all slope coefficients are equal to zero can be rejected at the 0.035 level.[15]

To address the issue of the endogeneity of the number of bidders, an instrumental variable probit model was estimated similar to the endogenous estimate of the number of bidders in Model 3 above. The results with respect to Federal Project are invariant to the use of the instrument for the number of bidders. The coefficient for Federal Project is ï 0.1256 with a z-statistic of ï 0.21). The effect of an increase in bid competition is strongly significant with the use of the expected number of bidders. The coefficient for the expected number of bidders is -0.781 with a z statistic of ï 12.26. The test statistic for the Wald test for exogeneity is 6.04 (p-value = 0.014) indicating that using the instrumental variables approach for the number of bidders is the appropriate decision.

[15] The critical likelihood ratio statistic is 37.65 at the 0.05 level with 25 degrees of freedom

The regression results for the estimate of the number of bids are reported in Table 4. The dependent variable is the log of the number of bids tendered for each of the highway resurfacing projects. The negative coefficient for Federal Project suggests a reduction in bids of about 16 percent on projects covered by the prevailing wage law. However, this coefficient fails to achieve conventional levels of statistical significance for a one, or two-tailed test (t-value = ï 1.07). Projects that involve asphalt planning and concrete pavement and slab work attract more bidders. These effects are statistically significant at the 0.05 level. The size of the project, as indicated by the log of the real winning bid and other project characteristics such as involving the removal of structures, blading, seeding and mulching, a contract with a fixed completion date and projects extending over three or more counties do not have statistically significant differences in the number of bidders. Only region 4 has a statistically significant, and lower, number of bidders relative to reference region 6. This difference is significant at the 0.05 level. Projects on rolling terrain or on the plains attract more bidders in a statistically significant way. There were significantly more bidders, in terms of statistical significance, in 2002, 2003, 2004, 2008 and 2009 relative to the reference year of 2000.

Table 4
Regression Results for the Number of Bids Tendered on CDOT Highway Resurfacing Projects, 2000-2010
Dependent Variable = Natural Log of the Number of Bids

Variable	Coefficient
Federal Project	ï 0.178
	(0.166)
Log Real Low Bid	ï 0.045
	(0.051)
Asphalt Removal (Planing)	0.359***
	(0.13)
Removal (other than asphalt)	0.128
	(0.11)
Blading of Road Surface	0.133
	(0.11)
Seeding & Mulching	ï 0.086
	(0.12)
Concrete Pavement/Slabs	0.582**
	(0.23)
Fixed Completion Date	ï 0.185
	(0.16)
Three or More Counties	0.051
	(0.22)
Region #1: Central-East	ï 0.052
Region #2: South-East	0.189
Region #3: North-West	ï 0.207
Region #4: North-East	ï 0.420**
Mountainous Terrain	0.156
Rolling Terrain	0.253*
Plains Terrain	0.246¶
2001	0.164
2002	0.333¶
2003	0.497**
2004	0.543**
2005	0.058
2006	0.109
2007	0.304
2008	0.565**
2009	0.596*
2010 (to Q3)	0.0138
Constant	1.350*
	(0.70)
N =	122
F =	2.50
R^2 =	0.360

Source: CDOT Bid Archives. Robust standard errors in parentheses. * significant at the 10 percent level, ** significant at the 5 percent level, ***significant at the 1 percent level (two-tailed tests). ¶ significant at the .010 level for a one-tailed test.

Conclusion

The results of this study indicate that prevailing wage requirements on highway resurfacing projects in Colorado are not associated with statistically significant higher construction costs. At face value, this may appear to be a surprising result because we typically think that total costs rise when wages increase. However, this notion is not supported after a careful consideration of the relation between wages, labor productivity and total costs in the construction industry. For example, other research by the author of this report reveals that productivity and the efficiency of construction is higher on projects that pay prevailing wage rates. Therefore, when construction worker wages rise on prevailing wage projects, productivity also increases in a way that stabilizes the total cost of the project. Additionally, data from the Economic Census of Construction indicate that construction labor costs are a low percent (averaging between 25 to 30 percent) of total construction costs. Given that labor costs are a low percent of total costs in the construction industry, productivity does not need to increase substantially to offset the effect of prevailing wage rates.

The results of this study are also consistent with other studies that have examined the effect of prevailing wages on highway construction costs and the effect on bid completion and union contractor involvement with prevailing wage projects. For example, the Construction Labor Research Council (2004) finds that states with the highest wages for highway construction workers have the lowest total cost per mile (and vice versa). The underlying assumption is that high construction worker wages are associated with higher labor productivity that contributes to lower highway construction costs. In addition, the results presented above are consistent with a recent study of five northern California cities by Philips and Kim (2009). In an examination of public works projects in five northern California cities (Palo Alto, Mountain View, San Carlos, San Jose, and Sunnyvale) with different municipal prevailing wage laws, these authors fail to find evidence suggesting that wage policies affect the bid process or outcome in a way that increases construction costs. For example, the results do not support the view that wage policies discourage bidding by nonunion contractors, reduce the number of bidders, or prevent nonunion contractors from winning bids on prevailing wage projects. Additionally, these authors fail to find statistically significant differences between the winning bid and two measures of project costs (the engineerøs estimate and the median bid). This suggests that prevailing wage laws of northern California cities are not associated with higher construction costs.

In sum, the results of this study indicate that the State of Colorado could adapt the current federal construction wage policy without experiencing an increase in total construction costs.

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Appendix 1: CDOT Contract ID numbers for projects included in the study

Contract ID	C13932	MM4042	MM5041	C15914
C12282R	C13982	MM4043	MM6059	C16060
C12731	C14002	MM4044	MM6050	C16312B
C13048	MM1014	MM4045	MM4061R	C15763
MM2003	MM1015	MM4046	C15160	C16172
MM5004	MM1016	MM5022	C15517	C16055
C12635	MM1017	MM5024	C14614	C16492
C13008	MM3010	MM6014	C15320R	C16629
C13433R	MM4019	MM6029	C15067RB	C16719
C13441	MM4021	C13535	C15195	C16537
C13498R	MM4022	C13977	C15290	C16466
MM1007R	MM4023	C14483	C15406	C16467
MM2004	MM5009	C14560	C14633	C16781
MM2006	MM5011	C14587	MM5048	C16813
MM3002	MM5013	C14613	MM5049	C16809
MM4004	MM5020	C14849	C15562	C16830
MM4005	MM6010	C14948	C15429	C16891
MM4006	MM6020	C15007	C14986	C16944
MM4007	C13978	M1040	MM1056	C17391
MM4008	C14215	M5034R	MM4066	C17746
MM5006	C14305	MM4049	MM5050	C17254R
MM5008	C14323	MM6045	MM6067	C17730R
MM6003R	M6033	MM6046	C15361	C17714
C12864	MM1023	C15039	M6072	
C13066	MM1024	C14950	C15746	
C13449	MM1025	C15032	C15832R	
C13534	MM1026	C14819	C15922B	
C13831	MM1030	C15053	C15927	
C13854	MM3014	C15028R	C15766	
C13931	MM4040	C14838	C16108	