The Beacon Hill Institute

Construction Management Methods in Massachusetts: Comparing Construction Management at Risk and Design Bid Build

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Executive Summary

The Commonwealth of Massachusetts has traditionally employed the Design-Bid-Build (DBB) project delivery method, which project owners, the state, cities and towns, applied to the construction of schools, police and fire stations and other public facilities. In 2004, the legislature passed an alternative delivery method, Chapter 149 (a), which enables the state and municipalities to deploy the Construction Management at Risk (CM-R) method for projects over $5 million.[1]

With a near decade of experience with Chapter 149A completed, it is possible to determine which method is more cost-effective for both project owners (i.e. cities and towns) and taxpayers. In this study, the Beacon Hill Institute provides some answers by comparing school construction projects.

Bid cost of Massachusetts school construction projects found in the School Building Authority database provide sufficient information for comparing the costs in towns with, and without, CM-Rs. We found the following:

(i) CM-R projects have higher construction-bid costs than DBB projects; we are more than 99 percent confident of this assertion, based on the available data.

(ii) The finding that CM-R projects have higher construction bid costs is robust, in that:

a. The effect persists even when the data are subdivided, so that the effect is evident separately for small schools, for high schools and non-high school, and for new construction.

[1] This study does not examine Design Build, which was also approved by the legislature in 2004.

b. The effect is larger for smaller school projects and does not hold for larger school projects.

(iii) CM-R projects add an estimated $26.49 per square foot to the *bid* cost of construction (in 2014 prices), representing an almost 10 percent increase in costs over the average DBB project. The bulk of the cost increase derives from the inclusion of the Guaranteed Maximum Price (GMP) and GMP contingency fees associated with CM-R projects.

In sum, there is evidence that CM-R have increased the cost of smaller (those under 141,250 square feet) school construction projects in Massachusetts since 2005. Officials at both the state and local levels should be aware of the higher costs implied by the CM-R method when considering future public school construction projects.

Introduction

To ensure that the billions of dollars it spends on public construction is spent wisely, the Commonwealth of Massachusetts mainly employs two project delivery methods that project owners, namely the state, cities and towns, can apply to the construction of schools, police and fire stations and other public facilities: Construction Management at Risk (CM-R) and Design-Bid-Build (DBB). In 2004, the legislature passed Chapter 149 (a) which enabled the state and municipalities to deploy the CM-R method for projects over $5 million. [2]

DBB is the most common project delivery system used for school construction.[3] In school construction, DBB is required under M.G.L c 149, the public building construction law. Under this system, the school owner (namely the city or town or regional authority) contracts separately with an architect and a general contractor. DBB is a sequential process. The first step in this process is to hire an architect to perform the design. Once the design is completed, the school owner puts the project out to competitive bid in an effort to secure the most cost effective construction price. Contractors who bid are expected to complete the project at the lowest price and meet the specifications of the architect and owner.

While DBB is common and provides a system of checks and balances, there are disadvantages associated with method based upon the fact that no contract exists between the architect and the contractor. Thus, when unexpected problems arise during construction, the problem of resolving differences can slow down construction and expend the time, energy and money of the school owner, who must assume the role of

[2] This study does not examine Design Build, which was approved by the legislature in 2004.
[3] The Associated General Contractors of America, School Construction Guide (2003). https://www.agc.org/sites/default/files/Files/Construction%20Markets/School_Construction_Guide.pdf

mediator. This problem is usually ameliorated in advance if school owner has in-house expertise, is able to review an architect's sub-consultants and and to ensure that all prospective contractors are prequalified or vetted in terms of school construction experience.

M.G.L. c 149A, enacted in July 2004, offers public owners a second option on contracts with cost estimates of $5 million or more. [4] This alternative to the DBB is known as CM-R. The CM-R is a firm which is hired early on by the project owner in the design stage and acts as an overall manager. Owners have the choice or retaining either the CM-R or the architect first; but each entity is involved in the choice of the other entity. So a contractor can choose the architect and, if the architect is chosen first, the CM-R can choose the contractor. Whatever the choices, the CM-R method requires that all three entities — owner, architect and contractor — work together as a team even though the owner holds separate contracts with the architect and CM-R. At some point in the process the owner and the CM-R agree on a guaranteed maximum price (GMP) for the scope of the work.

When the first shovel is dug into the ground, the CM-R firm assumes the role of General Contractor. CM-R arrangements are attractive because the manager is not only involved from the beginning stage (the planning and design) but also for the construction. This does not come without risks. Under CM-R the school owner does not know the total cost of the project until after the start of construction. Few CM-R firms would take the risk of giving the school owner a fixed price. Moreover, there is no direct contract between the architect and the construction manager.

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[4] Office of the Inspector General, Commonwealth of Massachusetts, Designing and Constructing Public Facilities: Legal Requirements, Recommended Practices, Sources of Assistance (August 2014). http://www.mass.gov/ig/publications/manuals/dcmanual.pdf

Like the DBB method, any conflicts require the time and attention of the school owner including those that occur after the building is occupied. These problems can also be solved by choosing a construction manager based on qualifications not competitively based on the lowest fee, outlining specific scope of work in any agreement and providing an environment for resolving differences.[5]

While both methods share similar features they are fundamentally different. As one trade group noted before the Massachusetts School Building Authority, the key difference can be described as follows: "With CM at Risk – you are *hiring* a professional service firm which builds buildings; With D-B-B – you are *purchasing* a building in accordance with detailed plans and specifications."[6]

As a general rule, CM-R projects are most appropriate for complex projects under strict time and land constraints while DBB projects are better suited for simple projects that spell out the costs up front. A CM-R may be more appropriate if contractors have to work alongside students taught in trailer classrooms, for example, while a DBB faces no such logistical challenge of working around student foot traffic.

Under Chapter 149A, the state Inspector General must approve any application for a CM-R. In 2014, the Office received 15 applications to use the CM-Rmethod, totaling over $623 million in project costs. Included in that figure, which covers all public construction requests, were CM-R applications for six public schools and four charter schools,[7]

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[5] AGC, 34.

[6] See "Understanding Your Choices: Chapter 149 or 149A," a presentation before the Massachusetts School Building Authority (February 2010) http://cms.massschoolbuildings.org/sites/default/files/edit-contentfile/OPM/CM-at-Risk/2_2010_AGC_CMatRsk_Pres.pdf

[7] Office of the Inspector General, Annual Report 2014, (April 30, 2015): 31, http://www.mass.gov/ig/about-us/annual-reports/office-of-the-inspector-general-2014-annual-report.pdf

With almost a decade of implementation of Chapter 149A completed, it is possible to determine which method represents a better deal for school owners and taxpayers.[8] An analysis, properly conducted comparing similar school projects, will help the question and better inform future policy.

The Evidence on CM-R v. DBB

The CM-R construction method has only been allowed recently for public building projects in Massachusetts, so there is less evidence about its cost than there is for the traditional DBB method. To compare CM-R with DBB costs it is necessary to compare construction projects of a similar nature – for instance road repairs – where some projects are done under CM-R, and others under DBB.

We use a suitable "natural experiment" used in a previous academic study that allows us to compare the bid costs of CM-R and DBB projects.[9] Driven by an increase in the student population, and encouraged by financial support from the state, many of the roughly 300 towns and cities in Massachusetts have financed school construction or renovation projects since 2005. Some towns used the CM-R method for construction bidding process while others used the more traditional DBB method. Applying data on construction bid costs, adjusted for inflation with an appropriate construction cost index, we estimated the difference in bid cost per square foot of construction between schools with the CM-R method and schools DBB. Before reporting the results, we present the sources of the data

[8] For a thorough survey of current issues around bidding in Massachusetts see Jack Sullivan, "Contracting System Isn't Saving Money," *CommonWealth*, last modified October 13, 2015, accessed February 3, 2016, http://commonwealthmagazine.org/economy/contracting-system-isnt-saving-money/. For a contrasting view defending the CM-R method, see Correspondence from Robert L. Petrucelli, President and CEO of the Associated General Contractors of MA, "Contracting Group Cites Flaws," *Commonwealth,* Winter 2016 (7-8), http://commonwealthmagazine.org/economy/contracting-system-isnt-saving-money/.

[9] See David G. Tuerck and Paul Bachman, *Project Labor Agreements and Financing Public School Construction in Massachusetts,*(December 2006), http://www.beaconhill.org/BHIStudies/PLA2006/BHIMASSPLAUpdate061204FINAL.pdf.

that we used, then explain how we adjusted for the rise in construction bid costs over time.

Data Sources

The Commonwealth of Massachusetts keeps detailed information on the schools that are built largely at its expense. We used data provided by the Massachusetts School Building Authority (SBA) and the Massachusetts Office of the Inspector General (OIG) to build out the database. The OIG database provides detailed information on 96 school building projects in Massachusetts for the period 2007 through 2014, including construction companies, architectural firms, the date the bids were received or the contract was executed, the base construction bid, the size of the project measured in square feet, whether the project was bid under CM-R or DBB, the nature of the construction (new or addition versus renovation), and detailed information of the subcontracts.

We further focused our study on school construction projects between 40,000 and 550,000 square feet in size, in order to exclude abnormally small or large projects. Our sample comprises the 96 projects for which data is available, 45 percent of which involved CM-R, the remainder of which did not.

Our sample of schools covers the period 2007 to 2014. In order to compare the construction bid costs of CM-R with DBB schools, it was first necessary to correct for the fact that construction costs rose during this period, so that all costs could be expressed in 2014 prices. Specifically, we used the Producer Price Index Industry data for the "New School Building Construction" industry from 2005 to 2014, using 2014 as the base year.[10]

[10] U.S. Department of Commerce, Bureau of Labor Statistics, Producer Price Index by Industry, New School Building Construction, http://data.bls.gov/pdq/SurveyOutputServlet.

Comparing CM-R with DBB

A comparison of the key characteristics of the school construction performed under a CM-R with those performed under a DBB - is shown in Table 1. A notable pattern in the data is that CM-R projects, on average, cost $5.60 ($252.48 minus $246.88) more per square foot (in 2014 prices) than DBB projects.

Table 1: Summary Statistics for Construction Projects by CM-R Status

Variable	Winning construction bid in millions of 2014 dollars	Size of project (square feet)	Construction bid cost/square foot in 2014 dollars*	New	High School
Mean					
CM-R	$42.22	188,675	$252.48	0.52	0.50
DBB	$36.78	157,261	$246.88	0.71	0.47
Standard Deviation					
CM-R	$26.21	102,408	$80.41	1.00	1.00
DBB	$20.33	85,836	$75.33	.46	0.50
Minimum					
CM-R	$11.48	40,900	$81.39	0	0
DBB	$6.28	57,614	$26.24	0	0
Maximum					
CM-R	$110.22	505,766	$393.22	1	1
DBB	$86.78	464,300	$375.26	1	1

Total sample size is 96, with 44 CM-R projects and 52 DBB projects. Costs are measured in 2014 dollars.

The table shows that the cost per square foot is higher for CM-R than for DBB projects. However, this simple comparison is not conclusive, because it is possible that CMR projects are systematically different – for instance they may be larger, or concentrated on new buildings rather than renovations.

One way to determine whether or not the difference in CM-R versus DBB projects is robust to differences in project size and type is to conduct a formal regression analysis. The dependent variable is the cost per square foot of construction (in 2014 prices). The independent variable of most interest to us is a dummy variable that is set equal to 1 for CM-R projects and to 0 otherwise. We control for whether the project involves new construction or a renovation by including a dummy variable set equal to 1 for new projects and to 0 otherwise. We also control for the impact of a project's scope on the cost per square foot by controlling explicitly for square footage. This is desirable because there may be economies of scale (within reason) in school construction, so that larger schools may have lower costs per square foot. Interestingly, CM-R projects are, on average, larger than the DBB projects so that, if economies of scale exist, one would expect CM-R projects to be less expensive. Also, the DBB projects have a higher concentration of new school construction projects, which would, in general, make them more expensive. Despite these differences, CM-R projects, were, on average, more expensive than DBB projects. The ordinary least squares regression results are presented in Table 2.

Table 2: Ordinary Least Squares Estimation of Real Construction BID per Square Foot

Variable	Coefficient	Standard Error	p-value (one-tailed test)
Constant	211.88	14.57	0.00
CMR	26.49	11.49	0.01
New	103.39	11.57	0.00
Square Feet	-0.000171	5.95	0.00

Adjusted R^2 is 0.50. Sample size is 96. Square footage is measured in 100,000s.

Our regression results show that CM-R projects add an estimated $26.49 per square foot (in 2014 prices) to the bid cost, controlling for whether or not the project involves new construction, and controlling for the project's square footage. A formal (one-tailed) test of the statistical significance of this coefficient gives a p-value of 0.01, which means that there is a 1 percent chance that we have accidentally found that CM-R projects are more expensive than DBB projects. Put another way, there is a 99 percent probability that CM-R projects really are more expensive than DBB projects, holding other measurable aspects of a project constant. The equation also shows that projects involving new construction, rather than renovations, experience significantly higher costs per square foot, as one would expect.

With an adjusted $R^2 = 0.50$, the equation "explains" a respectable 50 percent of the variation in construction bid costs across towns. Clearly, other factors also influence the cost of construction – the exact nature of the site, the materials used for flooring and roofing, the outside finish, and the like. As a practical matter, collecting viable information at this level of detail, for all 96 projects, would be impractical. Thus, our equation necessarily excludes these unobservable variables.

However, this does not undermine our finding of a substantial CM-R effect. For the CM-R effect shown here to be overstated, it would have to be the case that CM-R projects systematically use more expensive materials, or add more enhancements and "bells and whistles," than DBB projects. The report from the Office of the Inspector General suggests that CM-R projects are not systematically more upscale or substantially different. This gives us confidence that the CM-R effect shown here is real.

Robustness

There are further questions about robustness to be considered. For example, we can ask if there is still a CM-R effect if we only look at high school construction, new projects, and large-size or small-size projects? The results of this exercise are summarized in Table 3.

The first column indicates the sample, or sub-sample, used in estimating the regression equation. The first four rows use the largest possible sample, but vary in which other variables are included in the equation. Our analysis proceeded by running separate regressions for:

1. high and non-high schools;
2. new construction projects and renovations;
3. small projects (defined as below the median of 141,250 square feet) and large projects; and
4. projects that exclude the CMR General Maximum Price (GMP) fee and GMP contingency fee.

The "CMR effect" column shows the estimate of the effect of building with CM-R on the cost of construction (in dollars per square foot, in 2014 prices), and the adjoining "p-value" column measures the statistical significance of these coefficients. In all but three cases, the CM-R effect is statistically significant at the 10 percent level or better. The size of the CM-R effect differs somewhat, depending on the sample examined and the other variables that are included. The results of the "baseline" regression analysis presented in Table 2 are reproduced here in the first row; this equation has the virtue of including as many observations as possible, while being parsimonious in the use of variables.

TABLE 3. REGRESSION ESTIMATES OF THE "CM-R EFFECT" FOR DIFFERENT SUB-SAMPLES AND MODEL SPECIFICATIONS

	CMR effect ($/sq ft)	p-value	Other variables included	Sample size (# of CMR projects)	Adjusted R^2	Mean cost/sq ft DBB projects	CMR projects
Bid cost/sq ft							
All observs.*	**26.49**	**0.011**	**New, sqft**	**96 (44)**	**0.50**	**246.9**	**252.5**
All observs.	25.40	0.015	New, sqft, sqft2	96 (44)	0.50	246.9	252.5
All observs.	31.88	0.002	New, sqft, high,	96 (44)	0.55	246.9	252.5
No GMP fees	10.94	0.138	New, sqft, high,	96 (44)	0.57	234.79	219.98
Weighted by Sqrft	20.59	.0251	New, sqft,	96(44)	0.32	246.9	252.5
High schools	37.58	0.016	New, sqft,	47 (21)	0.56	240.01	256.73
Non high schools	29.82	0.024	New, sqft,	49 (21)	0.60	252.98	248.22
New	23.35	0.010	Sqft	58 (20)	0.09	281.55	304.01
Renovations	31.27	0.102	Sqft,	38 (20)	0.17	163.66	195.75
Large projects[a]	23.94	0.110	New, sqft,	47 (28)	0.52	224.25	204.20
Small projects	31.63	0.012	New, sqft,	49 (16)	0.53	241.59	244.14

Notes: *Observations. Maximum sample size: 96. Baseline regression is in first row (boldface) and reproduces the results shown in Table 2. [a] Greater than 141,250 square feet (median project size in sample).

Following standard practice, our regressions use ordinary least squares (OLS), which means that each observation (here, a school building project) carries equal weight in the regression. However, we also estimated our preferred equation using weights, where each project is given a weight that is in proportion to the square footage that it represents. This means that a project of 150,000 square feet, for instance, would have twice as much weight in the equation as a project of 75,000 square feet. The weighted regression shows a CM-R effect of $20.59/sq.ft., again statistically significant, and similar to the "baseline" regression.

In analyzing the robustness of our results, four points are worth making. First, there appears to be a significantly larger CM-R effect for high schools ($37.58/sq.ft.) than for elementary and middle schools ($29.82/sq.ft.) Perhaps secondary-level schools are more complex to build. Second, the CM-R effect for new construction ($23.35/sq.ft.) is smaller than for renovations ($31.27/sq.ft.). Perhaps renovations are harder to predict accurately. Moreover, for renovation projects, the statistical p-value of 0.102 barely breeches the 10 percent level, which means we are less than 90 percent certain that finding is not by chance. Third, the CM-R effect for large projects – defined as those over 141,250 sq. ft. – is, at $23.94/sq.ft, similar to that for the sample as a whole ($26.49/sq.ft.). However, similar to high schools, the p-value surpasses the 10 percent mark, meaning that we are less than 90 percent certain of this finding.

The last case in which the p-value breaches the 10 percent level is with the GMP fee and contingency fees are removed from the cost of the project in order to get to the effect of CM-R on core construction costs. The cost differential between CM-R projects and DBB projects drops to $10.94 per square foot. However, the p-value is 0.138, which renders the cost differential not statistically significant. As a result, we can conclude that a large portion of the cost difference lies in the GMP fee and GMP contingency fee.

Bid costs only give us part of the picture. As one newsletter states "what's sorely needed is data that compares *final* construction costs on structures that are *similar*."[11] However, sufficient data to build a sample on completed projects is limited, since many of the projects on record have only recently been put out to bid. Nevertheless, as many of these projects finish over the next year, the sample should become even more adequate for an analysis. We will tackle the issue at a later time.

[11] *Cockshaw's Construction Labor News + Opinion* 33(5):8, (May 2003)

Conclusion

The use of the CM-R construction method for public construction projects in Massachusetts has gone on for less than a decade. Proponents of CM-R argue that including the general contractor early in the design portion of a project prevents misunderstandings and issues that drive up costs and break budgets. However, the general contractor earns extra fees and does not disclose the final price for the project until it is nearly complete. Until recently, there has not been a statistically robust study to determine whether the use of the CM-R method increases or decreases construction costs. Our study provides an answer to that question. By using the SBA database, which includes bid information about school construction projects undertaken in Massachusetts since 2005, and comparing the costs in towns with and without CM-Rs, we found the following:

(i) CM-R projects have higher construction-bid costs than DBB projects; we are more than 99 percent confident of this assertion, based on the available data.

(ii) The finding that CM-R projects have higher construction bid costs is robust, in that:

   a. The effect mostly persists even when the data are subdivided, so that the effect is evident separately for small schools, for high schools, for other schools, and for new construction.

(iii) CM-R projects add an estimated $26.49 per square foot to the *bid* cost of construction (in 2014 prices), representing an almost 10 percent increase in costs over the average DBB project. The bulk of the cost increase derives from the inclusion of the GMP and GMP contingency fees associated with CM-R projects.

In sum, there is evidence that the CM-R method has increased the cost of school construction in the Boston area since 2005. Officials at both the state and local level should be aware of the higher costs associated with the CM-R method when planning and building future public schools,

About the Authors

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The Beacon Hill Institute at Suffolk University in Boston focuses on federal, state and local economic policies as they affect citizens and businesses. The Institute conducts research and educational programs to provide timely, concise and readable analyses that help voters, policymakers and opinion leaders understand today's leading public policy issues.

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