PREDICTING COSTS FOR TOMORROW'S BUILDS: USEFUL WAYS TO FUTURE-PROOF TODAY'S DESIGNS

Using predictive cost data is the key to accurately evaluating future building projects—capturing, analyzing and applying building data work

By C.C. Sullivan, Contributing Editor

Accurately predicting the future costs of construction projects is an essential and growing competency for leaders in the architecture, engineering and construction (AEC) fields. Even when the actual construction start is months or potentially even years into the future, a new set of rigorous, data-oriented techniques are allowing architects and building teams to more successfully and precisely determine project cost impacts and total construction budgets in ways that enhance value while mitigating significant risk.

LEARNING OBJECTIVES

After reading this article, you should be able to:

- **DESCRIBE the impetus and the benefits of recent and increasing use of predictive cost data to make more accurate projections of future construction material and labor costs.**
- **DISCUSS the concepts and technology behind predictive cost data and their potential effects on project delivery.**
- **EXPLAIN how predictive cost data may be employed to inform decision making in the design, construction, and life-cycle and operations phases**
- **LIST two or more case studies demonstrating the application and development of predictive cost estimates for specific building types.**

This is good news considering how difficult it is to confirm project schedules. Moreover, the notion of attempting to predict the future runs counter to the fact-based mindset of A/E firms, construction managers (CMs) and quantity surveyors, for example, who might wonder if a crystal ball is an apt project management tool. Fortunately, the field of predictive cost data is both mature and also focused on measurable, quantitative impacts — as well as deep knowledge and track-record performance. These are exactly the kinds of inputs that drive the world's best building teams and design practices.

Increasing use of predictive cost data in recent years reflects a post-economic crash dynamic. Prior to 2007-2008, the use of historic material and labor prices adjusted with localization factors — the restricting of cost information to a specific place, according to the American Society of Professional Estimators (ASPE) — was seen as a reasonably accurate method for architects and building teams determining construction costs. In recent years, however, project stakeholders have been dissatisfied with those results. A study by the construction technology company Doxel shows that most building projects go over budget, and that a disappointing 98% of large-scale construction works exceed their projected costs. Worse, recent market volatility and labor shortages in key trades have further degraded cost estimating accuracy.

A number of institutional and commercial owners, however, are supplementing or replacing traditional forecasting methods with "robust forecasts at a micro-market level," or predictive cost data, according to architects and building teams reported in Facility Executive Magazine. "The ability to have predictive data that accounts for real market conditions — the amount of construction versus labor availability, and commodity price impacts on material prices — has proved a critical insight in managing the budget from the design through construction," adds [Tim Duggan, director of Cost Analytics OR OTHER T.K.] at Gordian, a provider of cost data and analytics for facilities and construction.

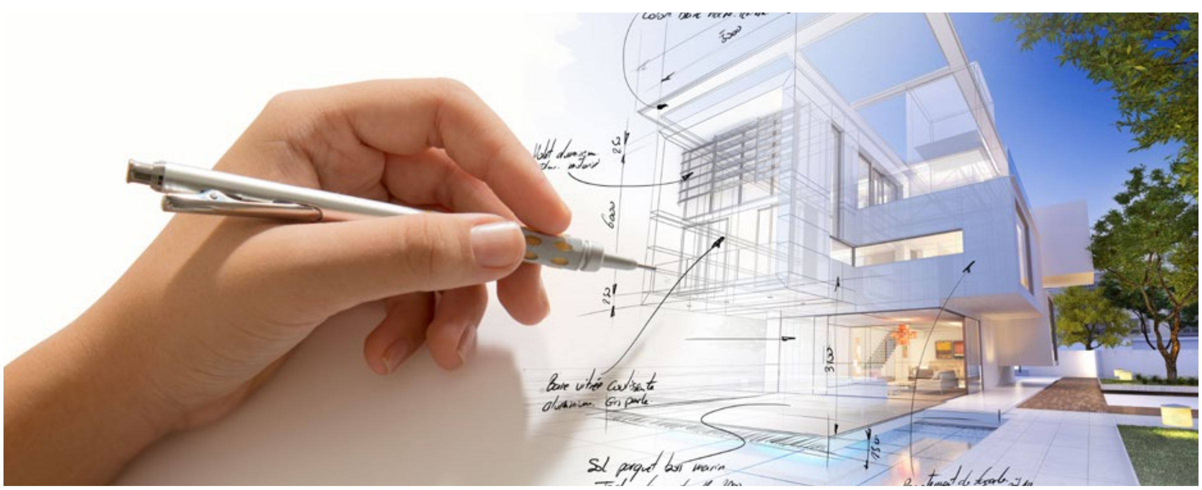
Predictive cost data also complements the architect's fiduciary duty to the client group, which in the recent climate of global trade tariffs and a vigorous construction market has emerged as an even greater challenge. Volatility is increasing as a result, say firms on the BD+C Giants list, necessitating more proactive measures in quantifying cost instability exposure.

The impetus transcends the current financial conditions, however: Between the first concept planning meeting and the final punchlist, any building project is subject to dramatic swings in unit material and labor costs, in part because the nature of construction work is protracted and episodic, according to Project Management for Construction, the seminal handbook by Carnegie Mellon University professor and environmental engineer, Chris Hendrickson.

Sophisticated Approach, Simple Concept

Applicable to this sea-change in the field once known quaintly as cost estimating are such emerging disciplines as "big data" and predictive analytics, a broad term encompassing the application of data mining, statistics, modeling, machine learning, and artificial intelligence (AI) to analyze current data to make predictions about future. Yet the premise of predicting the costs of future builds is surprisingly simple: Can today's cost databases and information networks serve building teams in conceptualizing build costs down to the square foot, up to three years into the future?

"Most of the tools available today make it difficult to plan and budget for future construction, especially more than one year out," adds Noam Reininger, an expert in data-as-service and chief data officer for Gordian. "Today, architects and building teams can benefit from novel methods delivering much-improved accuracy that commonly used approaches have lacked." Examples include project owners such as Tri-County Technical College in in Pendleton, S.C., which recently built a data center and employed construction cost estimating that predicted a budget that was "spot-on," says Richard Macbeth, who lead complex projects for the school.



Fortunately, the answer is yes, says Reininger, who has worked with both small businesses and Fortune 500 corporations: The most powerful software suites tap existing cost data archives totaling more than 10 billion data points across 15 years [link]. These sources include project fillings and indexes from public government bodies as well as private sources such as Moody's, the financial analysis company.

Behind the predictive cost data applications are carefully developed statistical analyses and sophisticated algorithms that sift through and share useful, future-looking costs of material, finishes and building systems as well as trade labor. Advances in back-testing the data are used to show the efficacy of predictive extrapolations. The results considered highly effective prove accurate to a maximum error rate of less than 3%, according to experts in predictive cost data.

The approaches fueled by predictive data can help with multiple project types, to "fill in the gaps for large demolition projects in areas where we don't possess a great deal of historical pricing or personal experience," according to Jack Anderson, chief engineer, with Kestrel Management, an engineering and construction firm in Prairie du Sac, WI.

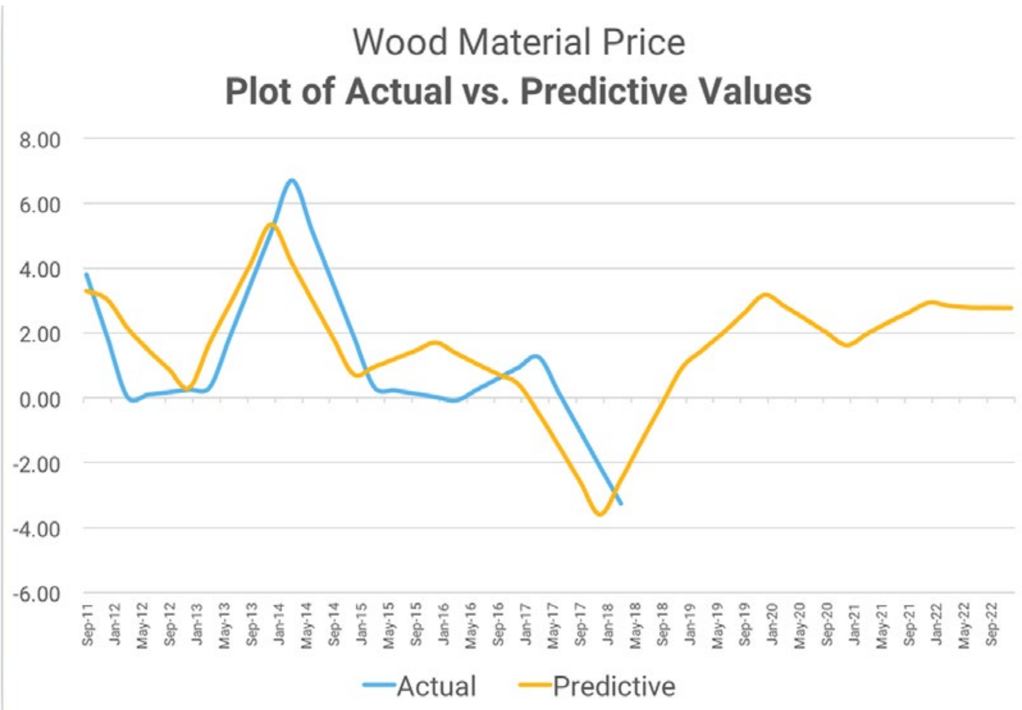
Future-Proofing: Accounting for Changes Over Time

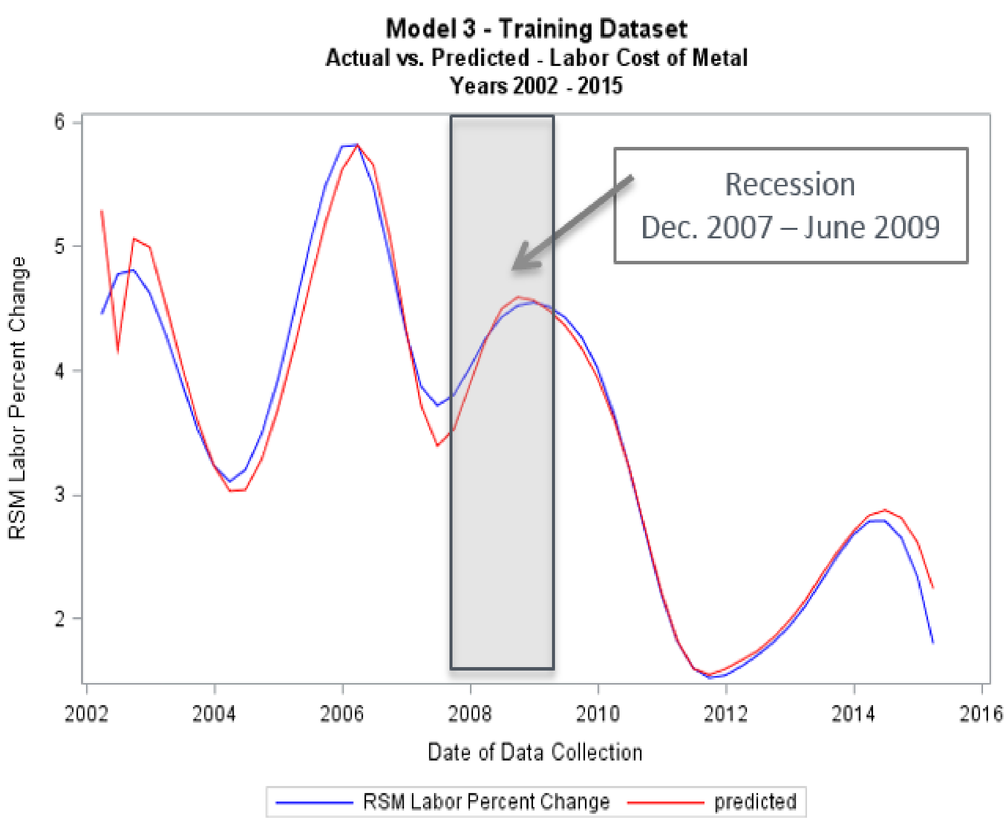
Construction cost data is simple in theory: Material costs are based on commodities and manufacturing costs and profits, and labor costs generally reflect availability and the dynamics of supply and demand. Combine material, labor and equipment costs — rolled up with factors for such variables as productivity — and that's the total project cost.

Yet it's not that easy. All building projects share a first challenge: the estimators involved need to accurately convert the project scope into material, labor, and equipment quantification and then successfully apply any relevant factors. Those variables range from the murky to the crystal-clear:

- 1. How far in the future will construction begin (and end)?
- 2. What's the project location and how will local market activity impact the costs and work progress?
- 3. What's the contracting method?
- 4. How will global commodity price swings influence the project?
- 5. What's the context scope — defined as "the realities of the site such as ongoing operations, soils conditions, access/egress, security, safety, site layout, and environment protections," according to Bellingham, Wa.-based professional estimator Rory Woolsey, CEP – and how will it impact work progress?
- 6. What's the process scope, or the extent to which project management practices are formally applied to the work?

Gordian internal data





Other challenging factors for accurate cost estimating today arose following the 2008 recessionary market crash. It began with attrition: A significant number of subcontractors and smaller contractors left the construction industry. A few years later, owners and other frequent builders began to slowly plan for regrowth. However, in the midst of this planning, the construction labor force had shrunk by three-fifths. Thus, the impact of volatility in commodity markets on the final cost of finished goods had a dramatic impact on the cost to build. Historical build costs and estimating factors used in previous years became obsolete. Project investors, developers and corporate and institutional boards became acutely focused on cost escalation as an organizational planning hurdle.

These dynamics led the owner-developers to hold their construction and design teams more strenuously accountable to manage to their forecasted budgets. This and other effects led to changes in building teams. “Smaller, niche construction firms have been able to carve out their place in the economic playground,” concluded Forrest Burnson, a market researcher with Software Advice, adding that contractors on the Inc. 5000 List saw average three-year growth has more than double by 2014. Many of these AEC companies saw better cost estimating as essential to successful project management.

Among the enhanced competencies in the new breed of post-recessionary building teams has been better planning for the weak spots in project delivery: contract negotiation issues, front-end scheduling, lack of training for key trades, poor interdisciplinary coordination, and insufficient documentation, among others. A common result of these and other weak spots is a delay in project delivery, which stakeholders and building teams abhor. “Delays on construction projects are a universal phenomenon… almost always accompanied by cost and time overruns,” according to a study by Florida International University for the state’s Department of Community Affairs. “Construction project delays have a debilitating effect on parties (owner, contractor, consultant) to a contract in terms of a growth in adversarial relationships, distrust, litigation, arbitration, cash-flow problems, and a general feeling of apprehension towards each other.”

This dynamic, exacerbated by the post-recessionary markets, has been among the most compelling cases for adapting predictive data. Architects and building teams have trained attention on the common causes of project delays, which are often outside the realm of control of the client group and any project team members:

- approvals
- permitting
- weather
- unforeseen circumstances, including lawsuits or hidden conditions.

These challenges have led building teams to adopt improved models for weather forecasts, modern imaging technologies to reveal hidden underground conditions, and even to encourage local jurisdictions to reinvent approval processes. Yet they have also increased interest in predictive cost data, which transcends those individual challenges to allow better estimating of costs in spite of unexpected delays. These predictive techniques have been validated with 95.6% predictive values were within +/- 3% percent of year-over-year actual values over the approximately 56,000 surveyed materials.What’s behind them?

What Is Predictive Data?

Traditional forecasting data, which have been developed during a time of far less computing power and available data than exist today, have not lived up to today’s post-recession expectations accuracy. In terms of both planning and budgeting, these long-established conventional methodologies fall short – which is not news to most construction experts. As long ago as two decades ago, Stanford University’s Paul M. Teicholz advanced ideas for better and more accurate computational methods for forecasting budgets in his prescient articles for Journal of Computing in Civil Engineering and many others.

“While most cost systems are able to collect total budget and to-date cost, budget, and quantity data, there is often less capability to use this data to forecast the final cost of a project,” said Teicholz, adding that “cost forecasts for unstarted work” could not “reflect the overruns or underruns that are recorded early in the life of a project.”

There were other challenges, too. Experts and building teams noted through experience that the older methods simply do not predict market swings or sharp cost escalations well. Teicholz and others attempted to use algorithmic solutions for these deficiencies, testing them against actual construction project outcomes. These results were helpful but not complete solutions, in part because they did not go beyond econometric or macroeconomic influences such as inflation and economic growth, to name only two of many. Moreover, those approaches did not have the benefit of today’s data mining technologies. Early approaches to data clustering and “block modeling” were making advances 30 to 40 years ago, but they were not in wide use.

Those changes have come, however, and they have affected a wide range of industries and professions including construction through the exceptionally valuable field of predictive data. The trend reflects an increasing preference to rely on real facts and figures — rather than algorithms, individual experience or subjective opinions — to drive successful pursuits in the sciences, business, control systems, agriculture and more. “By using predictive data, design professionals can consider all future factors at play in a region, including local labor rates and material costs,” says Reininger. “This makes it much easier to complete a project within the planned budget.”

Behind the application of predictive data for construction cost estimating — called predictive cost data — are advances in such cutting-edge arenas as data analytics and predictive cost modeling and optimization. While these are beyond the purview of the building team’s needs, there are a few mathematical concepts that architects and other AEC professionals should understand, at least in basic terms, to better serve project stakeholder needs in the near future.

1. Not theory, but rather evidence. First, traditional forecasting approaches derive from macroeconomic theory, ideas about the economy as a whole. Yet macroeconomic indicators and models based on them have been shown to be very poor predictors for any kind of forecast, including future materials and labor cost estimates. How poor? “Statistically insignificant,” says one expert. Another, Srinivas Thiruvadanthai, director of research at The Jerome Levy Forecasting Center, says, “The problem with them is that they are, by their very nature, extremely linear and do not pick out the turning points.”

Predictive cost models are based instead on data. Rather than employ theory, empirical evidence based on large-scale datasets become the basis for drawing forecasting conclusions, as discussed recently in The Construction Specifier. According to the author, “extensive exploratory data analysis and pattern-seeking visualizations of historical cost information with economic and market indicators” has been validated by academic research as well as building project applications. In the acclaimed 2009 book Macroeconomic Patterns and Stories by Edward Leamer, professor of global economics and management at the University of California, Los Angeles (UCLA), the expert author shows why only economic indicators proven through exploratory analysis should be seen as reliable candidates for evidence-based models and resulting predictive cost estimates.

2. Gathering all the data available. As a second precept, predictive cost data uses a key tool to significantly improve traditional econometric modeling: lots of data. Novel data mining techniques offer a family of processes and analyses proven since the 1990s that blend classic statistical principles with more recent methods in computer science and machine learning, a branch of A.I. that automates the creation of analytical models to better analyze data.

Data mining runs on a few key inputs: massive increases in computing power, first, and updated statistical procedures that help identify key signals in the noise. New and automated approaches to data visualization also help reveal the patterns quickly and clearly. Those signals and patterns are, in fact, drivers of change in construction material and labor costs. Today, organizations in multiple industries measure those drivers and identify their interrelationships as they impact construction costs. Their methods also account for associated lead or lag times, creating an accurate statistical algorithm.

The result is robust and accurately forecasted cost data — an ability to predict future values for a defined material and location.

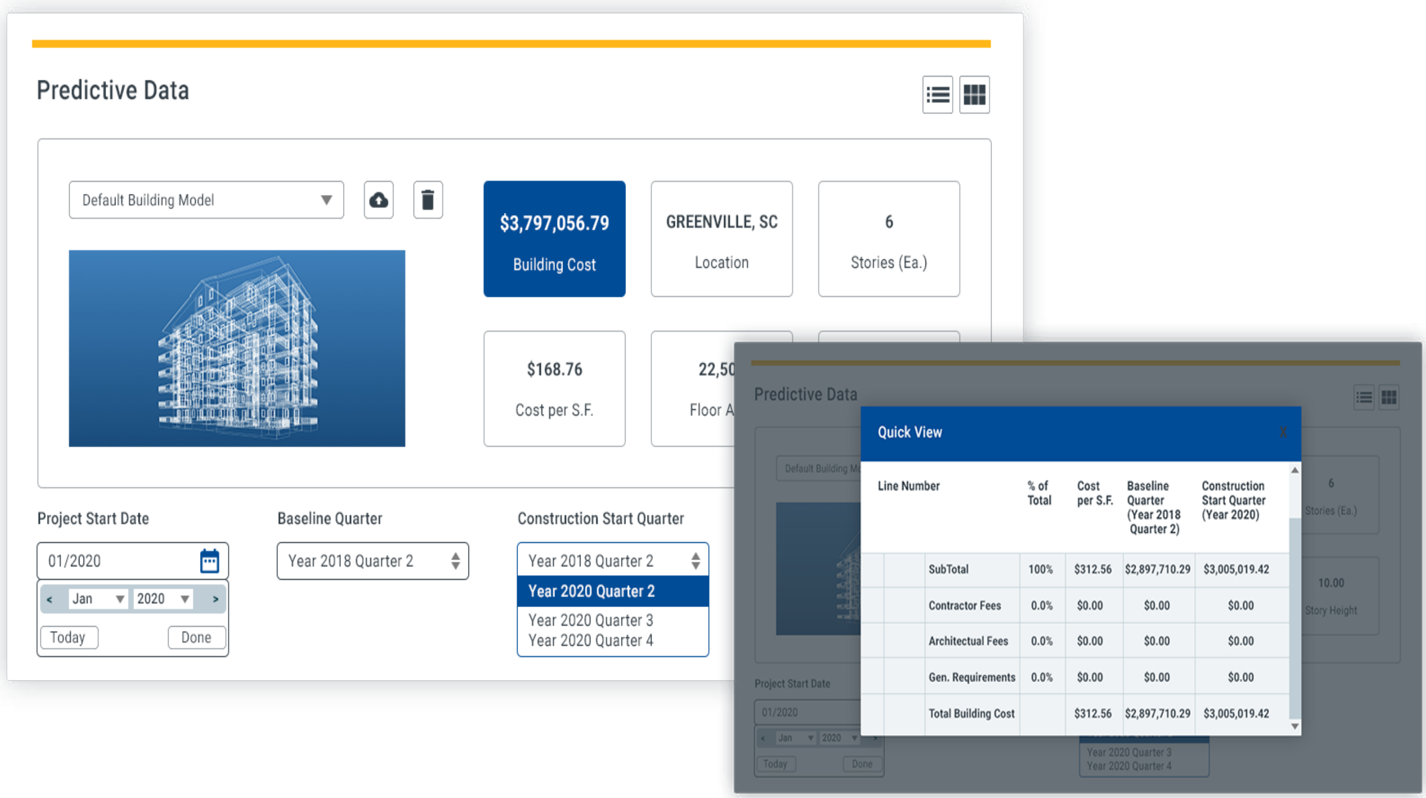
How Predictive Data Impacts Building Teams

Architects and building teams can benefit from close integration of evidence-driven forecasting and data mining that contribute to predictive cost data. The main benefit is more accurately predicting "the costs of future builds," says Gordian's Duggan, and a number of A/E firms, CMs and contractors – as well as owners and developers – are using predictive data today. General benefits include ties to general business planning, more accurate and localized cost data, and improved grounds for enhanced business cases, site selection and project budgeting.

Predictive cost estimating also optimizes the building team or architect's ability to build to the owner's specifications while reducing the number of staff or billable hours devoted to generating estimates, since it allows the creating of more accurate early estimates, some up to about 36 months in advance, according to studies by industrial engineering experts at the University of Pittsburgh and California Polytechnic University at San Luis Obispo. The bottom line? "Cost estimation predictive modeling" using such techniques as regression analysis and neural networks can offer advantages in accuracy and model creation.

Design Impact. In their practical application to building projects, predictive data informs design by better managing the budget presented by the architecture and contractor teams. For a fast food franchise planning a five-year rollout of 75 new locations nationally, for example, the building team must account for different locations and, in time, the rising and falling of material and labor costs in each different market. Applying predictive data, each location project can benefit from not only an estimate of the total cost or even scaling cost over time, but also an optimized build schedule that allows for tactical determinations of when and where the next restaurant property should be erected.

Designers benefit, as they can "manage to the budget and provide clients with better visibility to contractor costs," says Frank Sherman, principal architect with Ecotone Design LLC. "It enhances negotiations with contractors and reduces



cost overruns." Tasked to prepare preliminary budgets for the renovation of a nonprofit organization's facility, Sherman notes that predictive cost estimates allowed the client group "to get the funding they needed for the project."

Construction Impact. Another benefit of predictive data is going beyond cost estimates strictly used for budgeting purposes, such as conceptual square foot estimates, which may vary as much as +/- 20% of actual build costs. Rather than providing full data for accurate, complete construction build costs, they are typically used only for capital planning or organizational budgets. On the other hand, statistical tests show that by tapping into a truly predictive, multivariate database including individual material, labor and equipment data points costs can be projected within 3% of actual costs up to three years in advance of the construction event.

"This means owners, architects, engineers and other construction professionals can confidently predict future costs by applying a predictive cost dataset to conceptual construction square foot models," according to Gordian's data chief, Reininger.

Project Life-Cycle Impact. As was demonstrated by Sherman and Ecotone Design's experience with their nonprofit client, preliminary budgets and capital planning can become more accurate. The advantages of predictive cost data go well beyond the design and construction phases also, say savvy building teams, helping to anticipate the project's life-cycle and operational impacts. Using predictive data and proprietary algorithms applied to client-specific models and facilities, result in highly accurate budgetary estimates early, including at the capital planning stage.

Effective capital planning is essential to both public- and private-sector construction campaigns. The cost and availability of financing, revenue projections, and profit-and-loss impacts all hinge on accuracy in the planning stage. In addition to the accuracy needed to complete construction projects within a reasonable budget, long-term organizational benefits of accurate cost data include:

- Forecasting building life-cycle costs.
- Quantifying existing deferred maintenance liabilities.
- Providing a basis for efficiently modeling current replacement value (CRV).
- Introducing a pricing mechanism for efficient execution.

Correct assumptions mean increased opportunity, for example, for a university to optimize its capital budgets. That means effective long-range planning, which enhances administrative decisions, faculty recruitment and even student life. It means that a building project like a residence hall opens under budget and more likely on schedule, for example, adding quantifiable value by allowing for increased campus enrollments and attractiveness to prospective attendees.

Real Estate / Development Impact. Accurate knowledge of various cost factors provides for better decision making information. As an example, one of the most useful is the location factor, which can be identified in each CSI division and material/assembly type. "When real estate negotiations take place, several factors are considered," says Reininger. "Site selection and cost of land reside at the top of the list. Predictive cost data dives deep, providing a view into the market for labor availability and material price increases that could support building in the identified location."

On top of that, real estate organizations negotiating build-to-suit developments or tenant installations (TIs) and fitouts must assess the price of myriad items – everything from concrete for sidewalks to steel studs – up to two years in advance. If the price of concrete or steel has increased by the time construction begins, the overall project is presumed over budget, even before demolitions begin or a shovel hits the dirt. Increasingly seen as a safeguard against these vagaries, predictive cost data allows real estate divisions to properly evaluate markets for labor availability and more accurately predict material prices to negotiate better future contracts. The potential for increased ROI through long-term project success is seen as a reality, not a holy grail.

Accurate cost data also benefits asset management and facilities maintenance and repair, including valuable preventive maintenance. Predictive data creates a positive environment for architects and building teams to deliver real benchmarking, more useful established costs, and reporting to determine the efficiency of contractor teams and specialty contractors. In general, some corporations and small businesses are using predictive data as metrics and insights into new best practices and improvement opportunities. For example, predictive cost data can be incorporated into construction cost reviews, according to Ronald Semel, Cost Reviewer, State of Virginia Department of General Services.

In summary, design professionals and building teams stand to benefit significantly from the econometric principles, empirical evidence, AI and data mining concepts that at first may seem far removed from the world of building design and construction. Predictive data may seem like the brave new world, but really it's simply a new standard of good practice.

The ability to use predictive data means today's architects and building teams can account for commodity price impacts – such as swings in volatile steel and concrete pricing – and real market conditions, such as the amount of construction versus labor availability. In a world of narrowing margins and intensive competition, predictive data can confer critical advantages beyond their clearest benefit: keeping designs in line with budgets. Architects, construction professionals, and top building teams are already using predictive data to more accurately forecast their budgets as far ahead as three years. Even when the teams finally break ground, predictive data continues to provide a resource for accurate estimating and forecasting – and for greater client confidence in their designs and the teams delivering the built reality.