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# Utilization and Calculation of Cost index for highway construction using Current Trends

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## ABSTRACT

Project planning and budgeting need an awareness of the local building market. Transportation construction cost indexes (HCCIs) are often used by state highway authorities to assess current market circumstances. FHWA was the first to propose the HCCI as a means to gauge the national highway building market. Even state transportation departments (DOT) began building their own HCCIs to better reflect the construction markets of their states. However, several state DOTs complained that there was no direction on how to maintain or improve their HCCIs. A literature study and countrywide questionnaire survey are used in this article to determine how HCCIs are currently calculated and used. Item level and categorical market baskets are used to build construction item bundles for the computation of HCCI. According to the FHWA and the IMF, the Fisher index is the most often used indexing formula among state DOTs (IMF). HCCIs have a low number of current users in state DOTs, despite the large number of people who may benefit from them.

**Keywords:** Highway construction cost index (HCCI); Construction market; Construction budgeting; Construction planning; Data driven decision making.

## 1. INTRODUCTION AND BACKGROUND

For future fiscal years, accurate construction cost projection is critical throughout the early phases of project planning and programming. The project scope will be lowered, the project will be cancelled, or the owner will have to seek more funds if the construction costs are underestimated. Construction expenses overestimation restricts the number of projects that may be undertaken at any one moment. Nevertheless, since the project's scope has not yet been completely defined, calculating early costs is a difficult task to take on. Construction market volatility adds to the difficulty of estimating. According to the FHWA's Bid Price Index (BPI), successful contract awards included bid prices for different bid components, which were then utilised to generate NHCCI, a more accurate reflection of current highway construction market conditions (FHWA 2014). To develop and maintain their own cost index data, numerous state transportation departments (DOTs) have

accepted suggestions from the Federal Highway Administration (FHWA) (HCCIs).

Indicators like the HCCI index are useful for determining the present market circumstances and buying power of state DOTs (White and Erickson 2011). Future market conditions may be predicted by looking at past patterns. An early warning system for future price changes, the HCCI may therefore be used. Construction expenses may be tracked using HCCIs, and the current dollar amount spent on building roads can be converted into a fixed amount (FHWA 2014a). PIERCE et al. (2012) employed material specific cost indexes for price adjustment clauses, and a proposal to use HCCI's historical trend to establish gasoline tax rates was made (Dodier 2014). An other use for HCCIs is assessing how natural catastrophes affect the building industry (Cheng and Wilmot 2009).

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Many state DOTs have complained about a lack of direction in developing and updating their state-level HCCIs, despite their relevance and possible application areas (Walters and Yeh 2012). Their HCCI calculation methods are constantly being improved. With the use of published research and a wide-ranging questionnaire, the researchers want to discover and document the present techniques for calculating and implementing health care cost containment initiatives (HCCIs).

**“Cost Indexing Theories”**

It is necessary to utilise data from two different time periods in order to compile the cost indices. Based on the base year's figures and the current year's unit prices, an index is customarily constructed (International Monetary Fund 2010). The Lapsers index is the name given to this indexing formula.

According to the theory, these two indices are "twins" (IMF 2010). Estimators for the same notion may be compared and the most accurate one is found by averaging their results. To put it another way, averaging eliminates both the positive and negative biases introduced by the twins. However, the average of these two indices may be calculated in a variety of ways. The Fisher index may be determined by taking the geometric mean of the two indices previously mentioned and multiplying it by the following formula:

As an alternative, some people prefer using indexes that take into account both past and present prices and quantities, such the Fisher and Walsh indices. Superlative indexes handle the prices and quantities of both eras in the same way (IMF 2010). To use the term "ideal" index, we say that the Fisher index passes all acceptable conditions that may be applied to index numbers.

FHWA calculates the NHCCI using the chained Fisher index in the highway industry in the United States (FHWA 2010). Two successive periods are compared in order to compute a chained index. In order to generate a relative index between two time periods, the indexes between the two periods are combined.

$$\text{Chained index}_{i,j} = I^{i:i+1} X I^{i+1:i+2} X \dots X I^{j-1:j}$$

Where  $I_{i:j}$  is the period-to-period relative index. For inventory management, weights may be shifted and new goods added or removed from a linked index (International Labor Office et al. 2004). When new or removed items from the market basket are taken into consideration, index chaining becomes very vital to keep track of (IMF 2010). According to the FHWA and the IMF, the Fisher index is expected to outperform the Laspeyres index.

**History of HCCIs in U.S.**

BPI was created in 1987 by FHWA utilising bid

data from federally funded projects worth more than \$500,000. (FWA 2011, 2014b). Common excavation, bituminous concrete pavements, Portland cement concrete pavements, reinforcing steel, and structural steel and concrete pavements were all included in the index. In Hanna et al., the FHWA BPI adjustments are explained in depth (2011). On the basis of data from the Oman System Bid-Tabs software, FHWA created a Fisher-index based NHCCI (FHWA 2014). There were 31 categories of bid goods in the new index.

To be fair, since it measures the national trend rather than local trends, the FHWA NHCCI may not accurately reflect market circumstances in each individual state. It is possible for states to demonstrate varying growth rates in building activities as a consequence of variable increases in competitiveness, supply/demand, and construction prices. Because of this, More accurate market information may be found in the HCCI reports published by each states' transportation departments (DOTs). According to the FHWA, many states have established new HCCIs using Fisher indexes; however, others are still using the Lapsers-based HCCI method (Walters and Yeh 2012).

**ANALYSIS OF SURVEY RESULTS**

This is what we found out when we sent out a questionnaire to everyone in the community back in June. The bulk of participants were from the Federal Highway Administration, which responded to the survey. Data on how often HCCIs are calculated, how the basket of products is selected, and how third-party indexes are used were collected in a survey meant to gather information.

**State DOTs that Calculate HCCIs**

A idea that has been around for a long time, yet fewer than two thirds of the states who responded to our survey calculated HCCI's for their respective states. In the near future, Vermont and Maryland seek to construct a composite HCCI. If the absence of resources or direction is the reason, it might be because of this. Third-party HCCIs are being tracked by certain state DOTs. The usage of third-party indexes will be discussed in a later section of this document.

**HCCI Calculation Methodologies**

Figure 1 depicts a common method used by state DOTs for calculating HCCIs. A bidding system's data is first cleansed and transformed for use in HCCI calculation. According to respondents, data cleansing and transformation is one of the most difficult processes in the HCCI calculation process since state DOTs employ literally hundreds of bid components. State DOT officials may more quickly and accurately establish their HCCIs with the use of automated data cleansing.

The utilization and availability of resources determine the frequency at which HCCI is computed (e.g., quarterly, annually, biannually). Next, the market basket or building products may be determined by classifying

their bid goods or utilizing item-level data directly. Thereafter, the data is evaluated for the frequency of use and average unit price of different products. Their state's HCCIs are then calculated using an indexing algorithm.

### ***Frequency of HCCI Calculation***

More than a dozen of the 12 states' transportation departments do at least one HCCI calculation per quarter (three months). Only once a year are the HCCIs of five state DOTs computed. Data for missing items from prior quarters are utilised to compute HCCIs when there are not enough bid items to create quarterly HCCIs. In several states, HCCIs are calculated both quarterly and annually by the state DOTs. Developing quarterly HCCIs has the considerable advantage of reflecting construction market seasonal influences.

### ***Identifying Basket of Construction Items***

State DOTs have utilised a variety of methods to come up with a list of construction items for the sake of figuring up HCCIs. Prior to using an indexing algorithm, several state DOTs categorise products into distinct groups.' A good example is the seven types of bid items used by the Wisconsin Department of Transportation: Asphalt and concrete pavements are excavated as well as reinforcing steel and structural metal are used in the concrete construction. This form of market basket might be referred to as a classified one. It is more common for state DOTs to use categorical market baskets, which allow for the inclusion of more goods (and hence more cost components) when computing an HCCI. As a result, a bigger proportion of total expenses may more accurately represent the current state of the market. More than 96% of the overall construction expenses are covered by things included in the bids, according to the documentation submitted by respondents. Items in each category should have some resemblance in terms of characteristics, for example, types of asphalt pavement (hot mix asphalt PG 64-22 and PG 58-28). Concrete and asphalt, for example, might degrade indexes because of the different character of the materials they contain.

As long as certain bid elements comprise a sufficient fraction of the overall building expenditures, such things may be utilized directly without being classified into other categories. It is possible to refer to this method as a "item level market basket" since it will provide the indexing formula with finer-grained data. West Virginia Department of Transportation's Highway Condition Classification Index (HCCI) is comprised of Marshall hot-mix base and wear course stones, Marshall hot-mix base course, class B concrete, reinforcing steel bars, and type 1 guardrail.

Selecting the right construction goods is essential for the HCCI to accurately represent changes in the

construction industry and construction prices. It was stated by ten participants that the HCCI was calculated using more frequently bid goods. There must be two consecutive periods in which each item or item category's quantity and unit price are known. The price and quantity of a product may be omitted from one era if it is rare, the analysis should either remove that product or utilise the prices from previous periods' historical data. Calculating the HCCI using any of these methods requires considerable work. In order to avoid having to cope with missing values, state DOTs employ elements that are often used. The Ohio DOT employs a missing-ness factor they designed and applied to determine whether something occurs often enough to be included in the HCCI computation (Collins and Pritchard 2013). The Ohio Department of Transportation has also used SAS® software to automate the HCCI computation procedure.

There may be an omission of larger, less frequent things if just the most common ones are chosen. Since six states' DOTs take the greater expenses into account even when they are seldom utilised, It is possible to utilise data from prior periods when data for those items is not available for a certain item period. Similarly, the prices of things that are variable might affect the total building expenses. However, if the objects in question aren't very big or infrequent, then incorporating them would only add unnecessary complexity. Only one responder (Tennessee Department of Transportation) considered volatility to be an important element in determining market basket.

### ***Indexing Formula***

The Laspeyres index has long been utilized by state DOTs, but the Fisher index is now the preferred choice. More over half of those polled had used one of Fisher, Lapsers, or Paasche (5). The fact that more state DOTs are use or planning to utilise Fisher index might be attributed to FHWA's 2011 adoption of the metric.

NHCCI was first presented in the FHWA BPI, although the Lapsers index is still being utilised by several state DOTs (4). The Utah Department of Transportation (Utah DOT) calculates two separate indices using Laspeyres and Paasche. In order to compute HCCI, the Louisiana Department of Transportation has built a proprietary polynomial regression.

### ***Third Party Indexes***

Some third-party indices are used by state DOTs to monitor the construction business. The BLS and Engineering News-Records, two third-party sources of HCCIs, are used by the twelve state DOTs (ENR). These HCCIs from other states were given a different weighting in terms of importance to respective states. In terms of third-party HCCI, this is the most prevalent, according to NHCCI statistics (Figure 2). The NHCCI was given an average score of 2.6 out of 5 by the eight

people who took the time to rate its importance to their state's DOT. The CPI (consumer price index) receives 3.5 out of 5 stars from the Bureau of Labor Statistics as the most significant third-party indicator. A five-person team monitors the BLS Consumer Price Index (CPI). According to ENR's Cost Index for Nonresidential Maintenance/Repair Construction, they include BLS PPI, CCI, and RS Means Cost Index (Nonresidential Maintenance/Repair) (BMNR). Building cost indices for 20 US cities are published by Engineering News-Record (ENR) (2013), which is a commercial organization, according to ENR (2013). Although ENR indices are monitored by several state DOTs, their utility in the highway building market has been questioned due to its composition in terms of material. (Weris, Inc. 2013). Since vertical building uses timber, the index does not take asphalt prices into consideration. Some DOTs also keep an eye on HCCIs from other states' DOTs in the area.

According to seven of the participants, third-party indices may be used as an indicator of the overall market circumstances. There are five states that utilize it in comparison with their own internal HCCIs and two that use it to predict building project inflation. To compare changes in an index, state DOTs should utilize percentages rather than exact figures. Tollway Authority of the United States (FHWA) 2014b).

#### Use of HCCIs

Several departments within state DOTs make use of the HCCIs. HCCIs are primarily used by the departments responsible for planning and programming (12 responses). There is relatively little information available to the state DOTs during the early stages of project planning. It's at this point that they use cost estimating approaches like the per lane mile method. They employ HCCIs to account for anticipated inflation and changes in market conditions to enhance their estimations. Another group that uses HCCIs is a contract, design, or consulting firm with 10, 6, 4, or 2 replies.

The HCCIs of state DOTs are used for a variety of reasons. Most responders utilize the HCCIs to predict future contract inflation costs (15 responses). Aside from that, the indices serve as a broad barometer for the building industry (11 responses). An agency's buying power may be measured using an index (10 responses). Aside from the national and regional construction markets, state DOTs employ indices to compare their own construction market to those in neighboring states (5 responses). Among other things, According to one respondent, the market in his state tends to follow recent changes in neighboring states. Based on lags in inflation rates across neighboring states, it is feasible to predict future market conditions. The South Dakota Department of Transportation uses the indexes to calculate the state's gas tax rate. Depending on the state, price adjustment provisions for building contracts may include

gasoline and bituminous indices.

#### CONCLUSIONS

Preliminary cost estimations for planning and budgeting stages are greatly aided by an HCCI (Highway Construction Cost Index). In order to keep tabs on the state and national construction markets, the FHWA and state DOTs compute HCCIs. For the HCCI calculation, there are two ways to generate an itemised list of construction materials: a market basket with categories, and b a market basket at the item level. More people are using the categorised market basket to calculate HCCI because it allows for the inclusion of more items. Since it is a good indexing formula, the Fisher index is often referred to as a "ideal" index by state departments of transportation. The chained Fisher index allows for the addition and removal of items, as well as the adjustment of their weights over time.

In order to calculate HCCI, state DOTs have to manually clean and transform the data that they collect. Data cleansing, transformation, and HCCI calculation must be automated. It is possible to utilise HCCIs to estimate costs, convert current dollars into a constant dollar, and track changes in market circumstances, and the determination of the fuel tax rate, among other uses. However, it has been determined that current applications are limited in comparison to what could be done with them.

To keep an eye on the building industry, state DOTs often keep tabs on third-party indices. Two broad inflation indicators are tracked by state DOTs: Statistics on consumer and producer prices from the Bureau of Labor Statistics (BLS) (CPI). Among the third-party indexes used by state DOTs are the Engineering News-Record (ENR) CCI, RS Means Cost Index, and ENR Building Cost Index.

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