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An Analysis of Some Construction Price Index Methodologies

By Rasool Mohammadian & Stan Seymour

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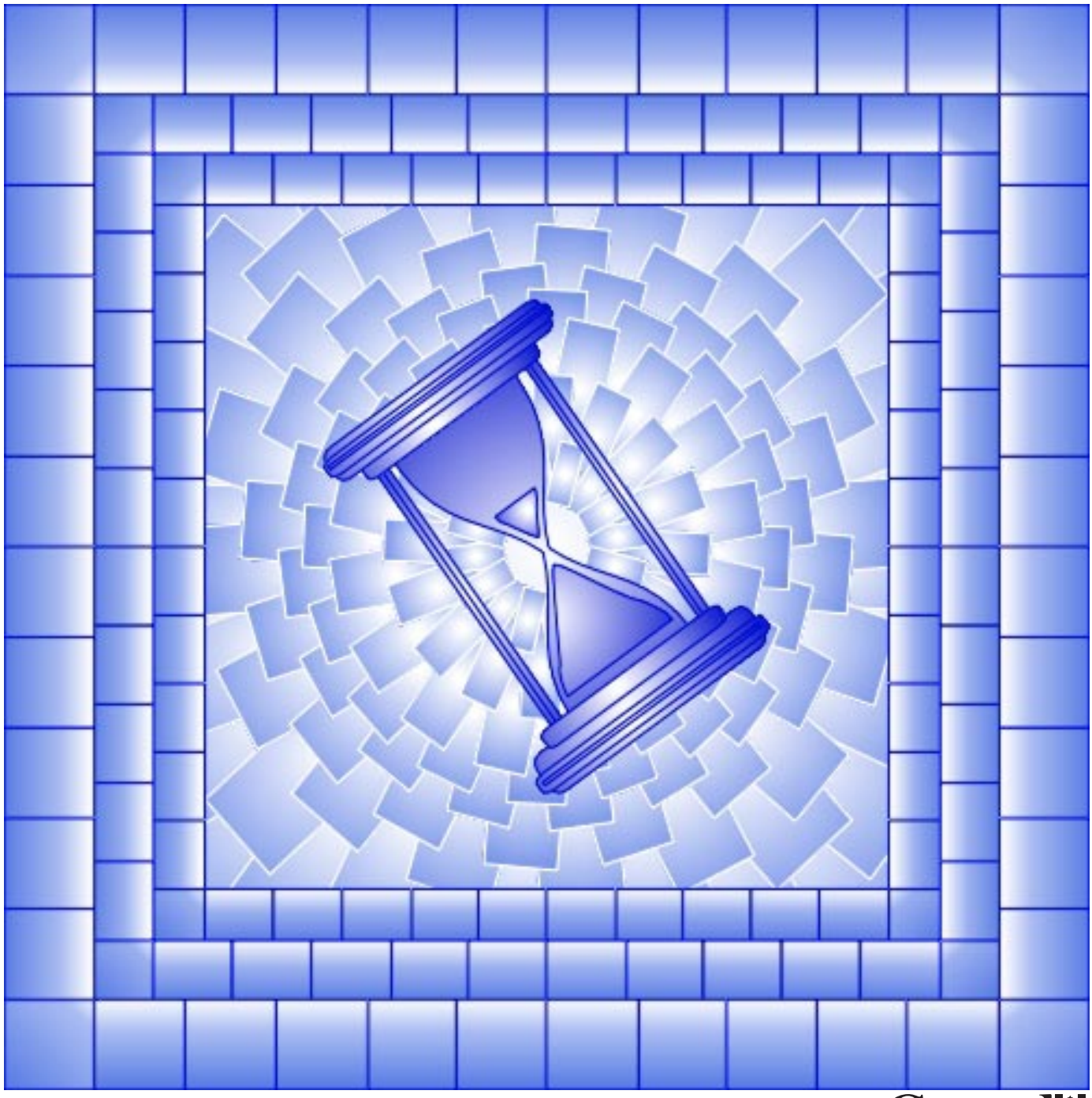

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Abstract

Price indexes are an essential tool for the analysis of real output in the construction industry and for relative performance and productivity measures. They provide a succinct picture of the past and a useful framework for forecasting future developments. Government requires such price indexes as part of the information used in the development of its policies including support programs to provincial governments. These indexes are also used in construction contracts to adjust for cost fluctuations and inflation. It is however, a difficult task to obtain satisfactory indexes reflecting 'pure' price changes for construction. The units built are nonstandard and heterogeneous with large variations in quality, size, design and construction techniques. Consequently, there are many different types of indexes developed from information recorded in the construction industry.

This paper summarizes the various ways in which construction price indexes can be compiled, and examines and compares the performance of some of the indexes currently produced at Statistics Canada. It is hoped that the comparisons would permit an assessment of the various types of construction indexes examined for specific applications.

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1.0 Introduction

The construction industry in this country is a microcosm of the Canadian economic system, accounting for a substantial percentage of total national income and employment. According to 1993 data, the construction industry in Canada accounts for approximately 13% of the Gross Domestic Product (GDP) and close to 6% of the total employed labour force (Catalogue No. 64-201). As a result, indexes that provide estimates of temporal changes in construction prices, have in recent years become important tools used in the interpretation of current economic conditions. These indexes are of particular use to government agencies undertaking economic analyses and others who are concerned about the impact of price changes on capital expenditures. Statistics Canada, for example, prepares estimates of the contribution of the construction industries to national expenditure, real output and capital stock using such indexes. Revaluation of expenditure, output and new order figures for construction work is essential for the analysis of real development in the industry and for assessing the development of the economy generally. Other agencies such as the Department of Finance, Canada Mortgage and Housing Corporation (CMHC), the Bank of Canada, contractors associations and labour unions associated with the construction industry have similar needs for such statistics.

In the private sector, producers and purchasers of construction projects, contractors, suppliers and manufacturers of construction products, designers, quantity surveyors, cost estimators and budget managers, all encounter situations in which price indexes could be of considerable value. Some particular purposes in which construction price indexes would serve as inputs are summarized below:

a) to update previously costed projects
b) to assess company or job performance, vis-a-vis output, productivity and profits
c) to make adjustments to project cost for escalation and for changes in location
d) to restate invested capital and to estimate present day reproduction value of property
e) to forecast financial requirements for proposed projects and real rates of return on investment.

There is now a wide range of construction indexes available to the industry, however, a comprehensive knowledge of limitations of each index type and of basic differences in their calculation methods is essential to their proper application. The following sections present an account of some important procedures that are currently employed at Statistics Canada and other statistical agencies in compiling price indexes for construction. The strengths and weaknesses of each method are discussed and suggestions are made about their potential applications.

2.0 Available Construction Price Indexes

The construction industry in Canada is very broad and highly diversified with considerable variations in operating patterns from region to region and from one type of construction to another. This makes it difficult to derive generalized indexes that would be applicable to the industry as a whole. As a result, several different approaches to index number construction are used depending on the purpose for which the index is required. At Statistics Canada, the following types of construction price indexes are currently produced or are under consideration:

i) Input Cost Index, relating to cost to contractors and own-account purchasers

ii) Output Price Index, relating to contractors' selling prices of construction products:

   a) Model Price Index
   b) Hedonic Price Index
   c) Bid/Unit Price Index

iii) Implicit Price Index, relating to investments in construction.

The methodology used in the compilation of each index type will be discussed in the following sections.

3.0 Input Cost Index

The heterogeneous character of structures and difficulties in measuring the impact of productivity changes arising from technological developments make the collection of price information and compilation of price indexes for construction projects a challenging task. As a result, substitute indexes based on prices of a representative selection of basic inputs into construction, i.e., materials and labour, are frequently used to estimate the price movements of the composite or final construction products and expenditures. Input cost indexes are generally applied to the construction phase of the projects and are primarily provided for the assessment of price fluctuations on contracts, where there is an escalation clause to take account of the effect of inflation on contractors' costs. A number of indexes of this type are now regularly published in the technical press and unit cost books for different types of construction work. However, the adequacy of the statistical procedures used in the derivation of these indexes, their sources for prices and the consistent use of these sources to obtain comparably specified observations, may not always be known and therefore they should be used with caution.

It is important to realize that the input cost index measures the change in the cost of resources to a contractor and it does not measure the change in the price that the client must pay. These indexes are often used when the appropriate price index is not readily available. As measures of price changes of selected inputs, the use of these indexes in measuring movements of output prices would result in inaccuracies, because they take no account of changing technologies and other important elements that affect output prices such as the variations in productivity and the contractor's overhead and profit

margins. In addition, the weightings used in compiling the input cost index are usually held fixed over a considerable period of time and until a subsequent revision of the index.

In spite of the drawbacks outlined above, the input cost index is suitable for identifying trends in resource costs and it is particularly useful for evaluating cost fluctuations in contracts which allow the reimbursement of changes in cost to the contractor that occur during the contract period. These indexes are often very simple and least expensive to construct and maintain.

4.0 Output Price Index

This type of index provide estimates of construction price changes at the transaction or output level and depending on the requirements and the availability of data they are derived as one of the following categories:

4.1 Model Price Index

One methodology used to derive output indexes is referred to as the 'Model Pricing' technique which uses estimates from contractors, subcontractors, cost engineers and other available sources. These estimates are used to measure average selling price changes of the final or actual contract unit prices for a fixed basket of representative items of work-in-place of the construction projects. The respondents provide prevailing market prices of the materials in place. In this approach, specific projects representative of various categories of construction are selected as 'models' and construction firms are surveyed and asked to estimate the cost of constructing each project. The respondents may be asked to price an entire project or the project may be divided into components, with each respondent estimating only the price of a particular component. In general, the disaggregated or component approach is used for complex types of structures, while the aggregated approach is applied for simpler products.

At Statistics Canada, the disaggregated approach is used to develop price indexes for non-residential and apartment building construction which are extremely heterogeneous in their materials, size and construction methods. The prototype models selected for the non-residential construction represent contemporary designs of commercial, industrial and institutional buildings, while the model apartment building has been selected with the assistance of CMHC. The construction of each model is divided into five main trade categories: architectural, structural, mechanical, electrical, and the general contractor's overhead and profit. Representative sample items of work-in-place are selected for each category for subsequent repricing. Roughly 200 different items are priced for each building type in each location. Those providing the estimates are asked to state market prices prevailing for the class of work specified in the pricing period. As such, the movement of the indexes is in response to changes in prices of materials, the cost of labour and equipment used and changes in overhead costs and profits. On the other hand, the aggregated approach is applied for the new housing price index to measure the rate of change in the selling price of a constant quality of new houses in selected metropolitan areas. The prices collected for housing models are market asking/selling prices. Model pricing methodology has been described in more detail by the authors in another paper (Mohammadian and Seymour, 1994).

The model pricing index seems especially appropriate for very heterogeneous types of construction which are impossible or difficult to price. As the specifications of each model are held fixed over time, this type of index allows for construction heterogeneity and thus quality change better than the input cost indexes. The resulting index should be more sensitive to changes in market conditions. The methodology also allows development of indexes per building type and trade category.

4.2 Hedonic Price Index

As an intended measure of pure price change over time, construction price indexes should not incorporate those differences in prices that may reflect differences in the quality attributes of the final products. Regression method has been applied in some countries to examine specifically the measurement of quality adjusted price changes for some sectors of the construction industry. By fitting a regression equation to observations on the price and various parameters that describe the nature or physical characteristics of a particular type of projects, for a market at a given time, the characteristics associated with the price of the project type and their relative importance can be identified. If the relevant characteristics are properly identified, the coefficients of the equation can be interpreted as unit prices for the characteristics. These characteristics can then be held constant having the effect of removing price changes resulting from their variations and leaving only variations which are considered to be acceptable for index purposes. This technique has been called the 'hedonic,' 'characteristics,' or 'regression' method.

In the United States, the hedonic method is employed to construct price indexes for single-family houses which are also used as a proxy in deflating a variety of other construction activities (Triplett, 1988). It has been found that eight characteristics, namely; size, number of stories, number of bathrooms, presence or absence of central air conditioning, type of parking facility, type of foundation, geographic location, and metropolitan location account for a significant amount of price variability among houses. Adding additional characteristics such as number of rooms or bedrooms, type of house, type of heating system, have not been found to significantly improve the results because of the high degree of multicollinearity between many of the characteristics. The applications of the hedonic price index method to other construction sectors have been largely unsuccessful (Pieper, 1990).

In general, the estimation of official statistical agency measures of price change through the use of the regression technique is limited in scope as data and resource limitations prevent it from being employed to many types of construction. The method requires large numbers of observations on project costs data with detailed information on project characteristics which is a problem for smaller construction sectors. Although these conditions may be reasonably assumed for the housing units, it is difficult to see other areas in Canada wherein the technique could be applied. The success of this method further depends on the identification and the ability to quantify the set of characteristics which have important influence on the price of the project.

The difficulties inherent in the hedonic index approach however, do not eliminate the usefulness of the methodology for quality adjusted price measurements of many other products and services. The approach is based on empirical market information and, therefore, offers improvements over the traditional procedures that are based on imputations or average of price movements. It allows more efficient use of the data and by using a computer, statistical tests may be applied and a variety of combinations of characteristics could be tested to evaluate the results systematically.

4.3 Bid/Unit Price Index

In many types of heavy construction projects, contractors often must supply bid prices separately on each item specified in the contract. A price index can then be calculated based on the average of the winning bids on the most important components. This approach is currently used at Statistics Canada in the development of output indexes for provincial highway construction. Contractors' bid prices to provincial governments are used as the basis for preparing indexes showing the change in price for work-in-place of highway construction in Canada. Prices used for these indexes are bid prices for specified items of work such as grading, granular base course, paving, etc., on contracts let by provincial governments for new highway construction. The indexes include the cost of materials, labour, the use of fuel and equipment, taxes, job overhead and profit.

When individual components are not bid on separately, the contract bid price can still be used to form a price index if there is some output measure available such as square feet. Unit price indexes represent changes in prices per square foot, but they are not considered as an appropriate indicator of pure price changes for new construction because price changes as well as non-price changes such as changes in quality and technology are all included as part of the index measurement. It is also believed that the series is biased because the mix of types and price ranges from which the series is derived, is continually changing.

Bid or unit price indexes generally provide the elements required for quick updating of the index for a basis year and they also permit the establishment of temporal indexes per construction type and category. However, the bid or unit price data from contractors cannot be applied to most construction sectors due to the inability to collect sufficient data at a reasonable cost. This approach is more suited to those sectors where there are a large number of contracts for projects of a relatively homogeneous type using similar construction methods. In general, the potential use of bid or unit price data seems somewhat limited due to the lack of homogeneous measures of construction and the problem of matching specifications.

5.0 Implicit Price Index

These indexes are derived from the compilation of the National Accounts. They represent the movements of the ratio of investment in residential and non-residential construction measured in current dollars to investment measured in constant dollars or prices of the base year. Constant dollar estimates are usually made by deflating current dollars by appropriate measures of price movement at a fine level of detail and adding up the results. Current dollars in residential investment include singles, doubles, row and apartment construction, major alterations and improvements, cottages, mobile homes, supplementary costs and commissions from the sale of real estate. Non-residential investment includes engineering construction such as highways, railways, electric utilities, sewage systems and disposal plants, oil and natural gas refineries, as well as non-residential buildings which include commercial, industrial and institutional construction.

For the compilation of implicit indexes, output price indexes which are sensitive to changes in demand levels, productivity and profits are the preferred deflators. But, for both residential and non-

residential construction, input indexes have been used in areas where output price indexes are not available. Where specifically appropriate price indexes are not available, special purpose deflators are prepared. Non-residential capital expenditures, for instance, are deflated by a large number of indexes which include the output price indexes of non-residential construction. However, the implicit indexes reflect not only pure price changes but also the changing expenditure patterns within the major components.

6.0 Comparison of Index Performance

The degree to which an index performs or moves depends on the market factors influencing the components within the index and the weightings applied to these components. In this section, the performance of input cost and output price indexes compiled at Statistics Canada for residential and non-residential construction are compared, over the years 1981 to 1993. The pricing method and the unique features of each index described in previous sections should produce a distinctive performance of the output index as compared to the input cost index.

The comparisons are shown in Charts 1 and 2, where the movement of each index is further superimposed on the corresponding implicit index and the industry activity indicator of contractors' new orders, i.e., building permits at current values. It is seen from these charts that, characteristically, output prices fall or remain constant when the economy is curtailed by recession during the early 1980s and 1990s. Input costs, on the other hand, are shown rising even during the recession and only when the economy has picked up from 1984 onwards, the two indexes move together rather closely. One reason for this is that the output price indexes reflect market prices which are much more volatile than the basic material and labour input costs. These market prices are a function of the local supply-demand situation which imposes constraints on the price setting operation, thereby affecting the profit margins which individual suppliers, distributors, trade contractors and general contractors can build into their bid and also affect total productivity in the industry. The effect of these influences is noticed from the performance of output indexes in Charts 1 and 2, which for both residential and non-residential construction are shown to generally follow the trends observed in the value of the new construction orders. During recessions, contractors normally slash their profit margins to obtain work, but when the volume of orders rises, the output price index does the same, as contractors find orders easy to obtain, increase their prices. This is not however depicted by the input index, particularly during the recession.

Chart 1. Residential Construction Indexes (1981 = 100) and Value of Building Permits (Current $)

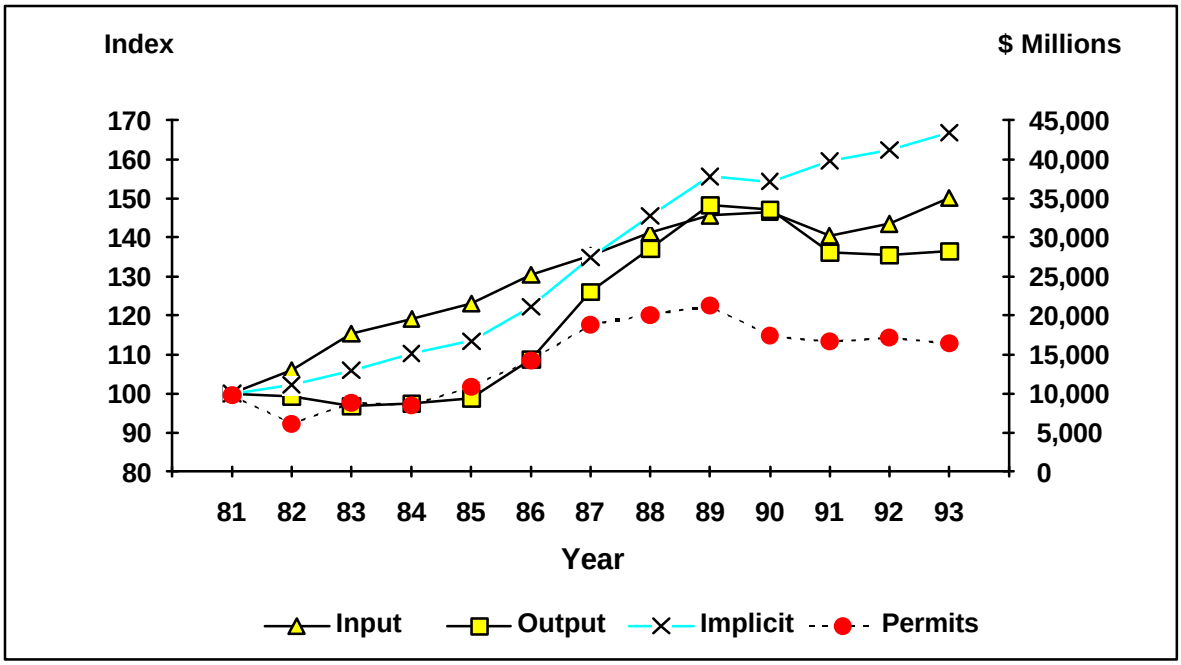
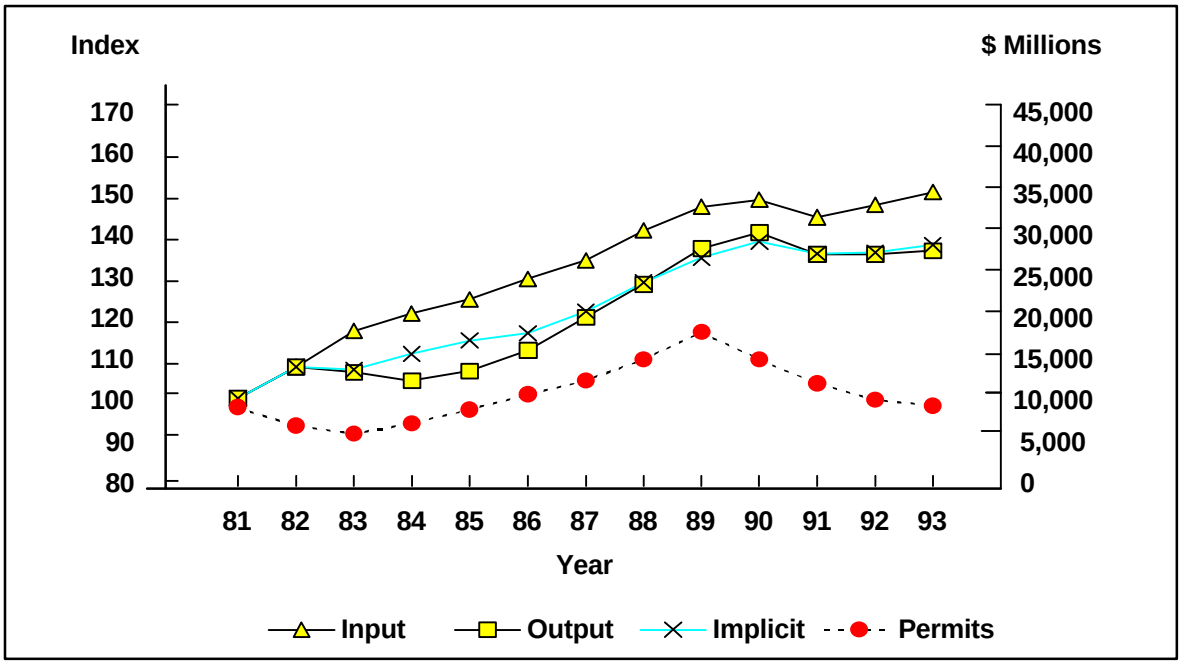


Chart 2. Non-residential Construction Indexes (1981 = 100) and Value of Building Permits (Current $)



The continuous upward trend in the input indexes could partly be due to the fact that the base date for the input cost index is many years old, resulting in an index which may be based on outdated estimates of labour and material requirements. Weights currently used to combine material and labour

indexes for the non-residential input indexes are based on a cost analysis of a small number of structures built in the 1960's to establish the relative importance of materials and labour. The weights for the Canada total, as of 1971, are 52.6% for materials and 47.4% for labour. For the residential input indexes the weights are based on a 1969 study by CMHC, and for the Canada total, as of 1971, are 64.1% for materials and 35.9% for labour. The relevance of these weights and the adequacy of the list of commodities included in the cost index basket are therefore dubious as they are based on periods in a remote past. It may be that the balance of resources has changed considerably in the intervening period and this is not represented in the index. Over the longer term, changes in technology may not only make the base 'mix' of resources on a typical project untypical but may also distort its price indexes. Consequently, if cost indexes are to be used for deflation, they should at least have recent weights based on updated material costs and quantities. More importantly though, some commodity substitutions should be introduced to make the index reflect more accurately the current materials being used in the construction of residential and non-residential buildings. It should also be noted that most residential construction is performed by non-union labour, and it would be desirable to evaluate the impact of non-union labour on cost indexes. In addition, labour costs should include the supplementary payments as well because the movement of the supplements may be more marked than the movement of base rates alone.

It is further observed from Charts 1 and 2, that for non-residential construction, the implicit index bears closer relationship to output price movements, whereas for residential construction it follows mostly the trend shown by the input index. In general, the relationship between the implicit movements and the appropriate price movements of its components should be close, being affected mainly by shifts in the relative importance of the components. The divergence of implicit index from output index for the residential sector, may need a more comprehensive review of the indexes used in the formation of implicit deflators for residential construction.

7.0 Choice of Index in Practice

Most index series described in the preceding sections and many other industry statistics, matrices and special aggregations currently developed at Statistics Canada, form a library of database information which is available for dissemination in both hard copy and computerized products. Before applying any type of these indexes, however, it is quite important to recognize their limitations, the differences in their basic derivation methods and their geographic and demographic bases. Indexes based on input components, for example, do not consider factors such as productivity, changes in technology, and competitiveness of contractors. These factors are reflected to some extent in output indexes which are based on project outputs or completed structures. The output type of indexes are nevertheless much more narrow in scope, and it would be difficult to interpret one based on a particular type of product and apply it to another type of work. On the other hand, the input type of indexes are much more general and could therefore be applied to a broader range of construction projects. An index, however, could be used most effectively if it is used only for the purpose that it is intended. In general, the choice of index should be based on the particular application for which the index is needed.

8.0 Conclusion

Reliable estimates of construction price changes would be of considerable value to the industry in planning and control of its operations, activities and organization. The heterogeneity of construction projects, however, combined with their relatively limited occurrence, the lack of standardized documentation in contracts and variability in price rates make it important to develop appropriate indexes for different sectors of the industry. The application of inappropriate indexes can lead to substantial errors in estimates of true changes in prices. This is indicated by our analysis in this paper and the comparison of current output price and input cost indexes for the residential and non-residential construction. It is shown that output price indexes reflect more accurately the true price movements of both the residential and non-residential construction. In comparison, input indexes based on selected materials and union wage rates alone are generally associated with a number of important limitations from the standpoint of providing an accurate picture of price movements necessary for deflation purposes. There are nevertheless specific uses for each index type, and it is recommended that the existing input indexes be improved by substituting new commodities into the mix of materials, and by establishing a more accurate material-labour ratio.

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