

Can Measurement Error Explain the Weakness of Productivity Growth in the Canadian Construction Industry?

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ABSTRACT

According to Statistics Canada productivity estimates, the rate of growth of real output per hour in the construction industry in Canada over the 1981-2006 period was 0.53 per cent per year, one-third of the business sector average. This article examines evidence for and against the hypothesis that measurement error explains this below average productivity performance. The article finds that the use of input cost indexes to adjust nominal output to obtain real output, instead of the more appropriate use of output price indexes, for certain sub-industries of the construction sector represents the most likely source of measurement error. This procedure may result in a downward bias to labour productivity growth in the construction sector of up to 0.44 percentage points per year. It is thus likely that measurement error explains some, but not all, of the gap in labour productivity growth between the construction industry and the business sector.

ACCORDING TO STATISTICS CANADA productivity estimates, the rate of growth of real output per hour in the construction industry in Canada over the 1981-2006 period was 0.53 per cent per year, about one-third of the business sector average of 1.46 per cent. Construction industry practitioners have expressed scepticism over the Statistics Canada figures. Similar concerns about the reliability of official con-

struction productivity estimates have been raised in other OECD countries. A number of studies have found significant productivity gains for many tasks in the construction industry, a result which appears inconsistent with the weak aggregate productivity gains in the industry recorded by Statistics Canada.

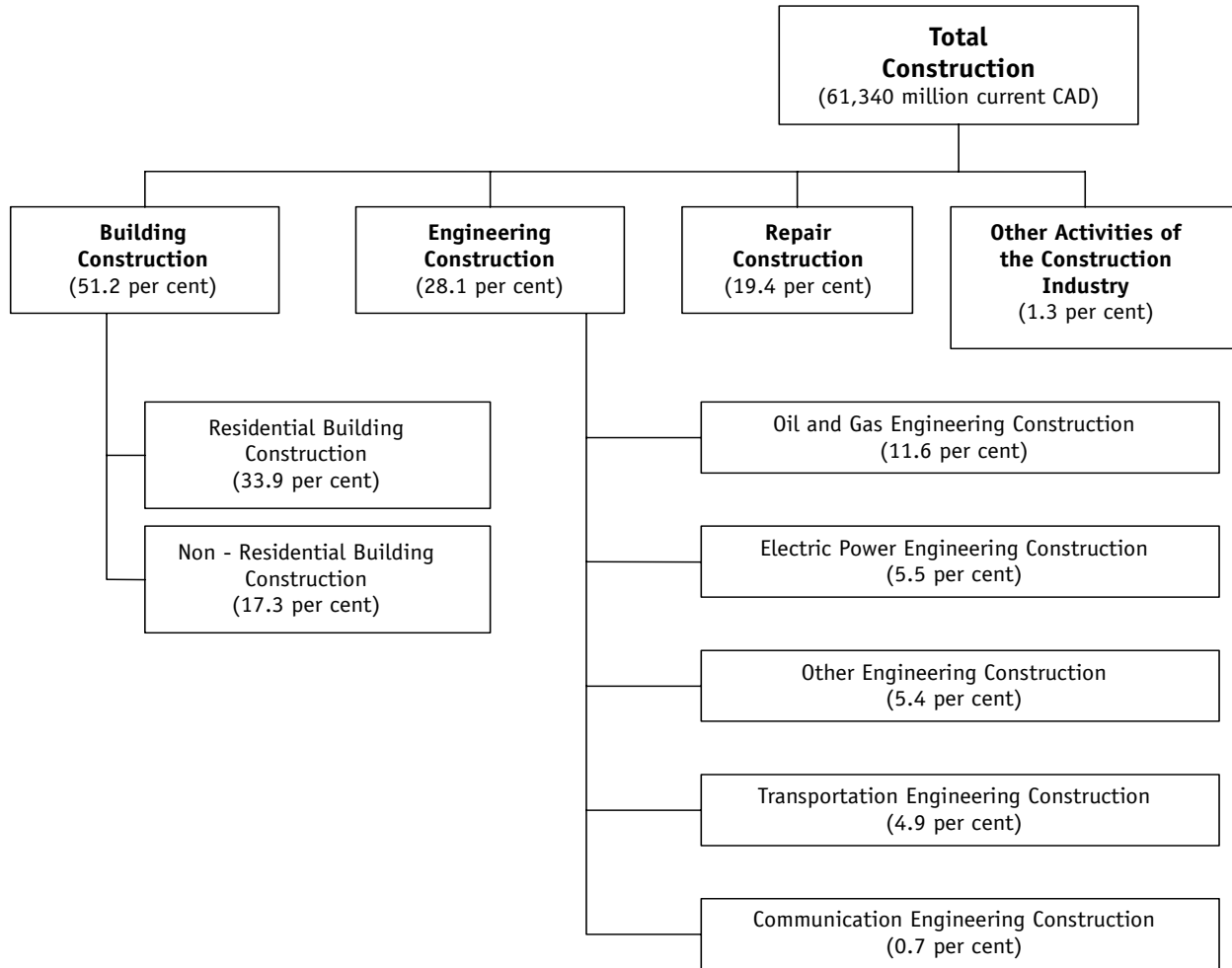
The objective of this article is to assess the reliability of the official Statistics Canada pro-

1 The author is an economist in the Fiscal Policy Division at Finance Canada. This article is an abridged version of a much longer report (Harrison, 2007) prepared for the Construction Sector Council in early 2006 when the author was employed by the Centre for the Study of Living Standards. The view expressed in this article are those of the author and do not necessarily reflect those of Finance Canada. The report was presented at a meeting of the Construction Sector Council in Kelowna, British Columbia in February 2006 and at the annual meeting of the Canadian Economics Association in Montreal in May 2006. The author would like to thank Jean-François Arsenault and Sharon Qiao for assistance in the preparation of the report; Statistics Canada officials who responded to numerous questions on how construction sector productivity estimates are compiled; the members of the Labour Market Information Committee of the Construction Sector Council who were interviewed for the study; Andrew Sharpe and Pierre Fortin for useful comments; and George Gritzotis and Rosemary Sparks from the Construction Sector Council for support of the project. Email: harrison.peter@fin.gc.ca.

Chart 1

The Organization of the Construction Industry

(share of value added in total construction, current dollars, 2003)



Note: 2003 is the most recent year for nominal output in construction.

ductivity estimates for the construction industry in light of the industry perspective that there have been significant labour productivity gains in the industry. Construction practitioners argue that Statistics Canada is failing to capture productivity gains in the construction industry because of measurement issues.

The article is divided into five sections. The first section discusses the organization of the construction sector in Canada. The second section examines labour productivity trends and levels in the construction sector in Canada since 1961. Section three reviews the evidence supporting the

mismeasurement hypothesis, particularly the issue of whether input-cost based deflators have an upward bias. Section four examines the evidence that does not support the mismeasurement hypothesis. Section five concludes.

The Organization of the Construction Industry in Canada

From the point of view of those who analyze productivity, construction is divided into three main sub-industries: building construction, engineering construction and repair construc-

tion.² Building construction is further subdivided into residential and non-residential building construction, often considered separate industries.

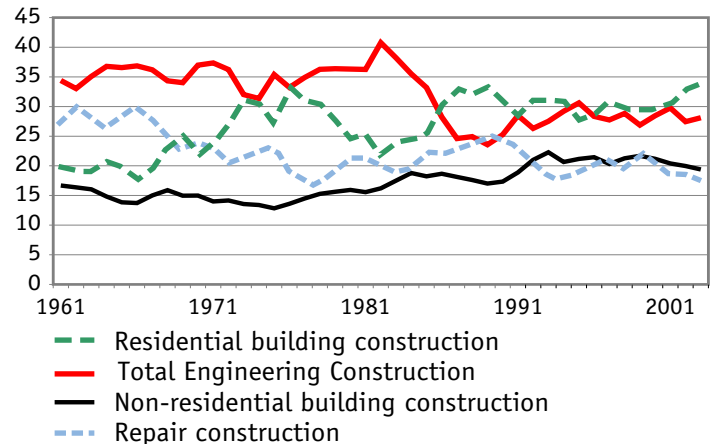
The sub-industries within the construction industry are not of equal size in terms of the value added they generate (Appendix Table 1). Based on data from 2003, the latest year for which current dollar output data are available, residential construction was by far the largest sub-industry with 33.9 per cent of total value added. Non-residential building accounted for 17.3 per cent of value added. Together residential and non-residential building construction thus accounted for slightly more than half of total value added in the construction industry (51.2 per cent).

Engineering construction accounted for 28.1 per cent total value added in the construction industry. Within engineering construction, oil and gas engineering construction was the most important component at 11.6 per cent of construction value added. Electric power engineering (5.5 per cent), other engineering (5.4 per cent), transportation engineering (4.9 per cent), and communication construction (0.7 per cent) were the other components.

Repair construction constituted 19.4 per cent of construction industry value added. Other activities of the construction industry accounted for only 1.3 per cent of value added in 2003.

While looking at a snapshot of the composition of the construction industry in one year is informative, it does not provide a complete picture, since over time there have been important changes in the relative importance of different sub-industries (Chart 2). Interestingly, the high

Chart 2
Shares of Total Output, Construction Industry, Canada
(current dollars, per cent, 1961-2003)



Source: Statistics Canada: CANSIM Table 379-0023.

relative importance of residential construction is only a recent trend. Between 1961 and 1986 engineering construction was the most important sub-industry.³ Non-residential building construction has shown a fairly steady downward trend over the entire period. Repair construction has shown a slightly increasing trend.

Productivity Trends in the Construction Sector in Canada

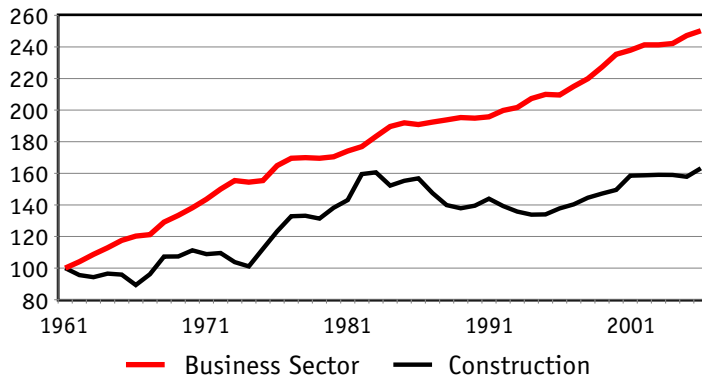
Overall productivity trends

Based on Statistics Canada estimates, the productivity performance of the construction industry in Canada since 1961 has been relatively poor in comparison with that of the business sector as a whole. Output per hour in the construction industry in 2006 was 63 per cent higher than it was in 1961, equivalent to an aver-

² The fourth sub-industry, "Other Activities of the Construction Industry" is heterogeneous and very small (Chart 1), so it will not be included in this analysis.

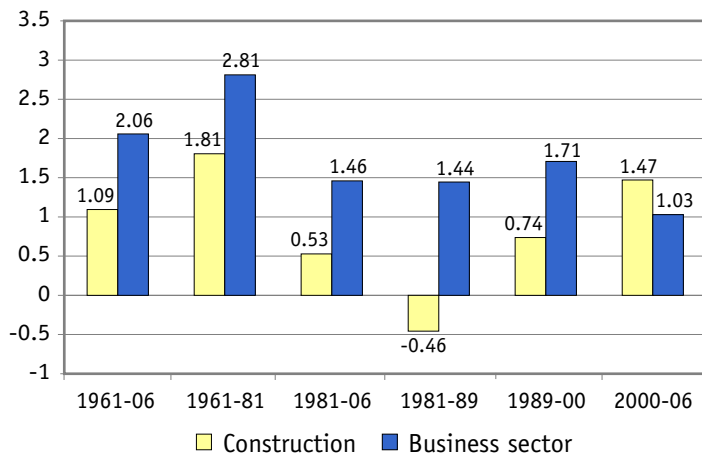
³ Within engineering construction there have been significant shifts in the relative size of the sub-industries. The importance of oil and gas construction has waxed and waned with the state of the wider energy sector, with peaks in 1971, 1982, and a recent increase beginning in the early 1990s. Electric power engineering construction has also changed in importance peaking in the late 1960s, late 1970s, and early 1990s. Transportation engineering construction has gradually declined in relative importance since a peak in the mid-1960s. Both communications engineering and other engineering construction have exhibited long-run downward trends.

Chart 3
Index of Labour Productivity (output per hour),
Construction Industry and Business Sector,
Canada, 1961-2006



Source: Calculated by CSL from Statistics Canada Productivity Measures.

Chart 4
Labour Productivity (output per hour) Growth Trends,
Construction Industry and Business Sector,
Canada, 1961-2006



Source: Calculated by CSL from Statistics Canada Productivity Measures.

age annual rate of increase of 1.09 per cent (Chart 3 and Chart 4).⁴ This was only less than one half the rate of increase of the business sector, which saw productivity advance 150 per cent

between 1961 and 2006, or 2.06 per cent per year. Since 1981, output per hour in the construction sector has only advanced at a 0.53 per cent average annual rate, one-third that of the 1.46 per cent rate in the business sector.

The construction industry experienced extremely strong labour productivity performance between 1974 and 1983, with output per hour up 59 per cent. Since then productivity growth in the construction sector has been disappointing, up only 1.7 per cent or 0.1 per cent per year. Indeed, virtually all of the productivity growth in the construction industry in the period from 1961 to 2006 took place during the brief 1974-1983 period. While business sector productivity has grown more or less continuously between 1961 and 2006, the construction sector suffered absolute declines in productivity between 1961 and 1966, 1970 and 1974, and 1983-1994 periods. Productivity growth picked up after 1995, advancing at a robust pace to 3 per cent per year until 2001. It then stagnated over the 2001-2005 period, before picking up in 2006, when, according to preliminary estimates, it rose a robust 3.5 per cent.

Productivity trends by construction sub-industry

The productivity growth of the non-residential construction greatly outperformed that of the other sub-industries over the 1961-2001 period⁵ (Chart 5), advancing at a 2 per cent compound annual rate. Productivity in residential construction and repair construction grew at less than half that rate (0.54 and 0.52 per cent per year respectively). Productivity growth in engineering construction advanced an even weaker 0.4 per cent for the 1961-1997 period.⁶

4 There are currently no official Statistics Canada pre-1997 estimates of labour productivity for the construction sector based on the North American Industry Classification System (NAICS). These estimates will be released later in 2007. This article uses estimates for the 1961-1997 period based on the Standard Industrial Classification (SIC) (and NAICS-based estimates for the 1997-2006 period). Construction productivity growth rates for the pre-1997 period may change significantly with the release of NAICS-based estimates.

5 Unfortunately, data at the sub-industry level are not available after 2001, and in the case of engineering construction excluding repairs, after 1997.

There was considerable variation in the productivity growth of the construction sub-industries within the 1961-2001 period, as can be seen in Chart 6.

Productivity levels by industry

Labour productivity levels can be calculated using estimates of hours worked from the Statistics Canada productivity program and gross domestic product at basic prices estimates. Because we are doing cross-industry analysis, we use current dollars data to avoid the distortion due to relative price changes embedded in constant dollars estimates. The comparison focuses on 2003, the most recent year for which current dollar estimates are available.

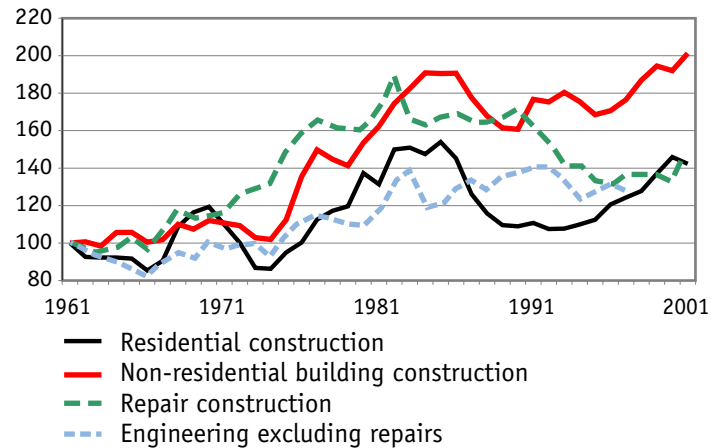
Based on 2003 estimates, labour productivity in Canada averaged \$43.97 per hour. The construction industry at \$33.03 per hour, or 75 per cent of the all industries level, ranked eleventh among the 18 NAICS industries. It ranked fourth among the goods-producing industries, ahead of agriculture (60 per cent) but lagging manufacturing (106 per cent). Because of high levels of capital intensity, the mining, oil and gas sector (443 per cent) and the utilities industry (328 per cent), both have very high levels of labour productivity compared to the industrial average.

Evidence Supporting the Mismeasurement Hypothesis

At least five pieces of evidence suggest that official estimates of productivity growth may underestimate true labour productivity growth in the construction industry in Canada. These are the use of input cost indexes to deflate nominal output, strong construction productivity gains in other countries, significant task-based

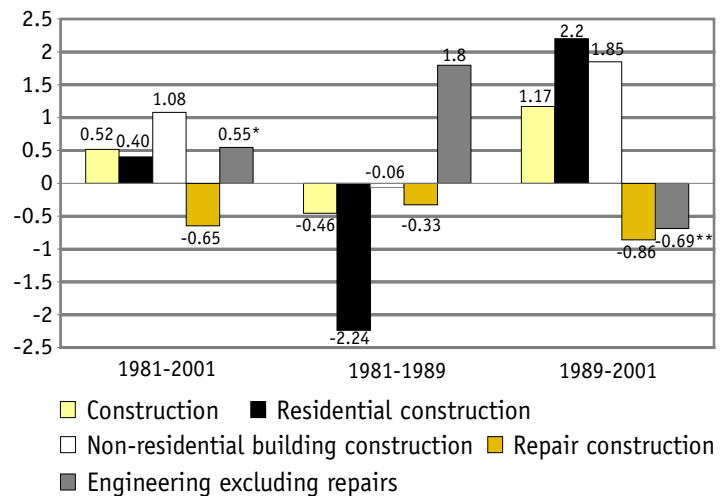
Chart 5
Indexes of Labour Productivity, Construction Sub-industries, 1961-2001

(1961 = 100)



Source: Harrison (2007:Appendix Table 8).

Chart 6
Output per hour Trends, Construction Industry and Component Sub-industries, Canada, 1981-2001



Source: Harrison (2007:Appendix Table 8).

Note: There are four components in construction sector: residential construction, non-residential building construction, repair construction and engineering construction excluding repairs. Data for engineering construction excluding repairs are not available for 1997-2001. * 1981-1997; ** 1989-1997

6 There was very large variation in output per hour growth in the components of the engineering construction sub-industry. Over the 1961-2001 period the communications engineering enjoyed by far the most rapid labour productivity growth (2.6 per cent per year), followed by electric power engineering (1.7 per cent), transportation engineering (1.0 per cent), other engineering (0.7 per cent), and oil and gas engineering (-0.4 per cent).

productivity gains, a possible failure to adjust construction output for quality improvements, and strong growth in the capital-labour ratio in construction.

Use of input cost deflators

The evidence suggests that Statistics Canada is overestimating the increase in the prices (inflation) of output produced by the construction industry, because it is using deflators based on the cost of inputs instead of the price of outputs. This overestimation of the increase in output prices is the strongest evidence that Statistics Canada's estimates of construction labour productivity growth may exhibit downward bias. US researchers have identified a similar problem with US construction productivity statistics. Simply put, the faster prices rise, the more Statistics Canada must adjust downward (deflate) its estimates of output growth and productivity growth. If Statistics Canada overestimates the rise in prices, then it will underestimate real output and productivity growth.⁷

The fundamental difficulty faced by those who attempt to measure the output of the construction industry, in real terms, is the heterogeneous and complex nature of that output; almost every project in construction is unique. Trying to find a uniform measure of the quality of construction projects is exceedingly difficult. Square footage is the most common proxy measure of quality in construction project, but size

alone is an inadequate measure of quality change. For instance, one house might be very large, yet have low quality fittings, while another may be smaller and have better quality fittings. Square footage is not a perfect proxy for quality. Determining what proportion of the increase in the price of a construction project is caused by improved quality, and what proportion is caused by other factors, is difficult, since no two construction projects, especially over time, are exactly the same.

Historically, this difficulty has often led to input-cost based measures of price change being used to deflate construction output. Input cost indexes measure the changing cost of the inputs used in construction projects. However, to generate an accurate measure of real output growth using an input-cost based deflator, two assumptions must hold: both productivity and profit margins must be constant. Essentially, use of an input cost index to deflate output assumes that the price of output moves in step with the price of inputs. Producing more output for a given amount of input is the definition of productivity growth. Even if input prices are rising, output prices may rise more slowly, or even fall, since less input is needed to produce a given amount of output. If productivity growth is taking place, then an input cost index will tend to grow faster than an output price index. If this input cost index is then used to deflate output, the amount of real output will be understated. Furthermore, input cost indexes often use weights for consti-

7 Statistics Canada assigns a rating of moderately reliable to the Fisher volume index of value added in the construction sector and a rating of reliable to labour input. This implies that labour productivity would be rated at least moderately reliable, which may suggest that mismeasurement is not a major problem. See Beckstead, Girard and Harchaoui (2001) who provide a detailed assessment of data quality for Statistics Canada's productivity program at the P level (122 industries), the M level (46 industries) and the S level (16 industries) of industry aggregation. Construction is one industry at all three levels. They assign three rankings (1 for reliable, 2 for moderately reliable, and 3 for unreliable) for Fisher volume indices of aggregation KL, Fisher volume indices for aggregation KLEMS, and inputs costs in current dollars of aggregation KLEMS. In terms of Fisher volume indices of aggregation KL, they assign a rating of reliable to capital, labour, and combined inputs and a rating of moderately reliable to value added and multifactor productivity. In terms of Fisher volume indices of aggregation KLEMS, they assign a rating of reliable to capital, labour, services, combined inputs, and multifactor productivity, a rating of moderately reliable to materials, and a rating of unreliable to energy. In terms of the inputs cost in current dollars of aggregation KLEMS, they assign a rating of reliable to capital, labour, materials, service, total costs of inputs, and a rating of moderately reliable to energy.

uent inputs that remain fixed for long periods of time. Fixed weights do not allow for the inevitable changes in input mix resulting from technological change. Making the assumptions about productivity growth, profit margins, and the relative weights of different inputs in construction, that are required to use input-cost based deflators, can lead to the mismeasurement of productivity growth.

Two key questions that this article seeks to answer are to what extent is Statistics Canada relying on input cost indexes to deflate construction output, and is the use of such input cost indexes resulting in underestimation of real output growth, and therefore productivity growth, in the Canadian construction industry.

Statistics Canada uses both output price indexes and input cost indexes to deflate construction output.⁸ A particular type of price index used by Statistics Canada is called a model price index. A model price index avoids the problem of output heterogeneity by holding constant over time a detailed specification for a structure or different components of a structure. On a regular basis, construction firms or informed individuals, such as cost-engineers or contractors, are asked to estimate the selling price of the model or components of the model. In this way, the pure price change can be observed, while quality is held constant. Examples of model price indexes developed and used by Statistics Canada in the estimation of construction industry productivity are the “New Housing Price Index,” the “Apartment Building Construction Price Index,” and the “Non-Residential Building Construction Price Index.”⁹

Statistics Canada also widely uses input cost indexes to deflate construction output. There

are several justifications for doing so. First, input cost indexes are often “very simple and the least expensive to construct and maintain” (Mohammadian and Seymour, 1997:2). Input-cost based deflators are usually a weighted average of a wage labour index and a building materials index. Input cost indexes can be created by statistical agencies from records collected from businesses on a regular basis, such as union wage rate agreements or the selling prices of materials used in construction like cement, engineered lumber, or electrical wiring. Second, when no alternative is available, using input cost indexes is better than using no deflator at all. Finally, it is arguable that using input cost indexes could be superior to using a price index, if the price index were only distantly related to the output being deflated. However, none of these justifications reduce the potentially serious error that deflation using input cost indexes can impart to productivity estimates.

All nominal output in the engineering construction industry in Canada is deflated using deflators constructed from input cost indexes. Statistics Canada uses three separate deflators to deflate all of engineering construction, a highway construction deflator, a railway construction deflator, and a deflator for all other output of the engineering construction industry. The Income and Expenditure Accounts Division of Statistics Canada is currently developing separate deflators for each of the components of engineering construction, so that they can be deflated separately, instead of using the aggregate approach. Statistics Canada believes this project will result in a better deflator for engineering construction output.¹⁰ Examples of input cost indexes that are used by Statistics Canada to estimate construction industry productivity are the “Construction Union

8 Hedonic and bid-price indexes are discussed in the unabridged version of this article. However, since they are not particularly relevant for construction analysis in Canada, they are not discussed here.

9 For an extensive discussion of these model price indexes, see the unabridged version of this article (Harrison, 2007).

10 This information is based on conversations with Statistics Canada officials.

Wage Rates Index” and “Industrial Products Price Index.”¹¹

The Construction Union Wage Rate Index has a 40 per cent weight in the deflator used to deflate the alterations and improvements component of residential construction. Indirectly, it is also used to deflate part of repair construction, because repair construction is deflated using an implicit price index based on the alterations and improvements component of residential construction. The Industrial Products Price Index (IPPI) tracks the prices of major commodities sold by manufacturers in Canada. Data are collected using a sample survey of manufacturers and other surveys. Prices are measured “at the factory gate” and, therefore, represent what the manufacturer receives, not the price that is paid by the purchaser. Factory gate prices exclude indirect taxes like sales taxes and tariffs and exclude service costs of transporters, wholesalers and retailers where applicable.

The IPPI is the basis for a residential material price index,¹² which is given a weight of 60 per cent in the deflator used to deflate the alterations and improvements component of residential construction. Indirectly, it is also used to deflate part of repair construction, because repair construction is deflated using an implicit price index based on the deflator for the alterations and improvements component of residential construction.

Appendix 1 shows that approximately 60 per cent¹³ of value added in the construction industry in Canada is deflated using input-cost based deflators for intermediate goods and gross output. Given the known problems with using input-cost based deflators, it seems reasonable to hypothesize that a significant proportion of construction industry value added is being over-

deflated, and, therefore, real output is being underestimated. This section will examine the evidence that is available to support (or refute) this hypothesis.

If input-cost based deflators used in the construction industry impart a downward bias to productivity estimates, we would expect to see a more rapid rate of growth in those deflators when compared with deflators based on output price indexes *ceteris paribus*. The deflators used by Statistics Canada to deflate the nominal value of gross output in the engineering, repair and other construction activities sub-industries are based entirely on input cost indexes. On the other hand, the deflator used to deflate non-residential building construction gross output is almost entirely based on output price indexes.

The implicit deflator for engineering, repair and other construction activities, which is input-cost based, increased much more rapidly, on average at 2.71 per cent annually between 1981 and 2003, than the implicit deflator for non-residential construction, which increased at 1.78 per cent annually (Chart 7). This finding is consistent with the hypothesis that the input-cost based deflators impart downward bias to productivity estimates.

What might be the impact of this bias on the growth rate of productivity in the construction industry? There is a difference of 0.93 percentage points between the average rate of growth of the implicit deflator for engineering, repair and construction activities, which is based almost entirely on input cost indexes, and the implicit deflator for non-residential building construction, which is based almost entirely on output price indexes. Let us assume that the implicit deflator for engineering, repair and other con-

11 For an extensive discussion of these input cost indexes, please refer to the unabridged version of this article.

12 This “residential material price index” which is based on the IPPI should not be confused with Statistics Canada’s Residential and Non-Residential Building Material Price Indexes which were maintained monthly between January 1981 and June 1990, at which point they were terminated.

13 Based on 2003 figures. See Appendix Table 1.

struction activities has risen more quickly than it would have if it were based on output price indexes. Therefore, output in engineering, repair and other construction activities is over-deflated. Then the deflator used to deflate non-residential building construction, which is based almost entirely on the Non-Residential Building Construction Price Index, could be applied to engineering, repair and other construction activities to provide a more accurate measure of productivity growth.

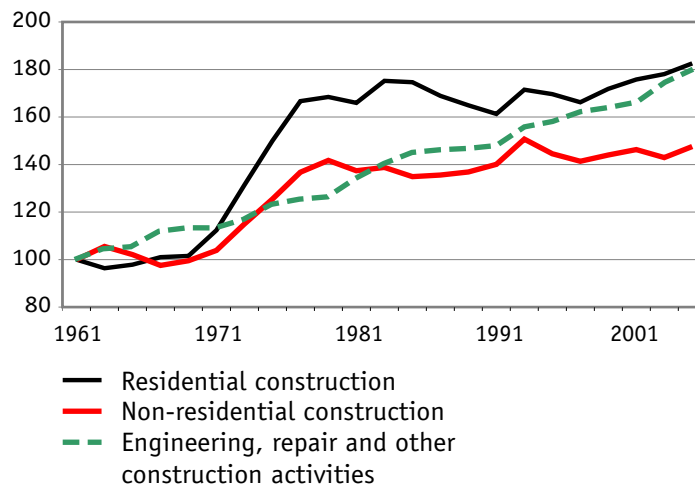
Let us conduct a brief experiment to see the impact of a change in the use of deflators. First, we calculate the implicit deflator for total construction as a weighted average of the deflators and output weights of the main component sub-industries (Equation (1)):

$$\begin{aligned}
 & (1) \text{ Total construction implicit deflator (1981-2003) (2003} \\
 & \quad \text{output weights)} \\
 & = \\
 & \quad (\text{Output weight of residential construction}) * (\text{implicit} \\
 & \quad \text{deflator growth rate for residential construction}) \\
 & + \\
 & \quad (\text{Output weight of non-residential building construc-} \\
 & \quad \text{tion}) * (\text{implicit deflator growth rate for non-residential} \\
 & \quad \text{building construction}) \\
 & + \\
 & \quad (\text{Output weight of engineering, repair and other con-} \\
 & \quad \text{struction activities}) * (\text{implicit deflator growth rate for} \\
 & \quad \text{engineering, repair and other construction activities}) \\
 & = (0.3387) * (2.77) + (0.1732) * (1.78) + (0.4750) * (2.71) \\
 & = 2.53
 \end{aligned}$$

Therefore, we will assume that the growth rate of the implicit deflator for total construction is 2.53 per cent per year. If we now replace the implicit deflator growth rate for engineering, repair and other construction activities with that of non-residential building construction, and recalculate equation (1) we obtain

$$\begin{aligned}
 & (2) \text{ Total construction implicit deflator (1981-2003) (2003} \\
 & \quad \text{output weights)} \\
 & = (0.3387) * (2.77) + (0.1732) * (1.78) + (0.4750) * (1.78) \\
 & = 2.09
 \end{aligned}$$

Chart 7
Implicit Deflators for Residential, Non-Residential and Engineering and Repair Construction, 1981-2003



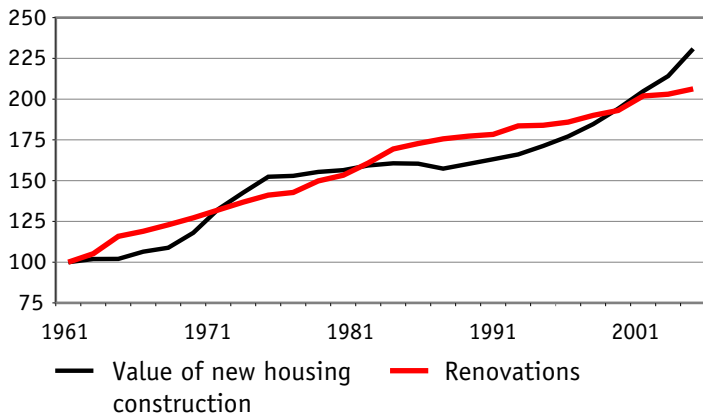
Compound Annual Growth Rates: 1981-2003 (per cent)

Residential Construction	2.77
Non-Residential Construction	1.78
Engineering, repair and other construction activities	2.71

Source: Statistics Canada CANSIM Tables 379-0023 and 379-0017.

Equation (2) shows that a 0.44 percentage-point decrease in the average growth rate for the overall construction deflator would result from a downward adjustment to the implicit deflator for engineering, repair and other construction activities. How would this adjustment impact productivity growth rates? The growth rate of productivity in the overall business sector between 1981 and 2006 was 1.46 per cent. The productivity growth rate in the construction industry was 0.53 per cent. The difference between the two was 0.93 percentage points. As an upper bound estimate of possible over-deflation of construction industry output, 0.44 points (47 percent) of this gap could be explained. If this situation were true, then construction industry productivity growth would have averaged 0.97 per cent per year rather than 0.53 per cent.

Chart 8
Implicit Deflators for the Value of New Housing
Construction and the for Renovations, 1981-2006, Canada



What, however, is to be made of the 2.77 per cent annual growth rate in the implicit deflator for residential construction. Given that approximately two-thirds of value added in residential construction is deflated using output price indexes, why has the implicit deflator shown more rapid growth than the input-cost based deflator used in engineering, repair and other construction activities? Could it be that the input-cost based deflator used to deflate the renovations component of residential construction is biased upward? The evidence suggests that this is not the case (Chart 8). In fact the implicit deflator for the value of new housing rose slightly more rapidly, at 3.40 per cent per year, than the implicit deflator for renovations, which rose at 2.94 per cent per year.

There are two observations that can be made about the relative paths taken by the output-price and input-cost based deflators. The first note is that in both the case of the implicit deflator for renovations (Chart 8) and the implicit deflator for engineering, repair and other construction activities (Chart 7), the growth pattern tended to be less variable than the growth paths of the deflators based on output prices. This phenomenon is the result of input costs generally being more stable than output prices. Indeed, input cost indexes tend almost never to

fall. The second point of note is that the implicit deflators for residential and non-residential building construction increased greatly between 1985 and 1990, and then only increased slightly between 1990 and 2003 (Chart 8). At the same time, the implicit deflator for engineering, repair and other construction activities steadily increased throughout the 1980s and 1990s.

While there is some evidence that input-cost based deflators are overstating the rise in real value added in the construction industry in Canada, the evidence available is conflicting. While the implicit deflator for engineering, repair and other construction activities, based on input cost indexes, grew significantly faster than the output-price based implicit deflator for non-residential building construction, the input-cost based implicit deflator for renovations grew slightly less rapidly than implicit deflator for new housing, which is based almost entirely on output price indexes.

In Canada, deflators used in the construction industry that are based on the costs of inputs (e.g. concrete, labour, wood products) have generally increased faster than those based on output prices (e.g. houses warehouses, roads). For example, the input cost indexes used to deflate nominal output in engineering and repair construction, advanced at a 2.71 per cent average annual rate over the 1981-2003 period. In contrast, the output-price based deflator used to deflate the nominal output of non-residential building construction advanced at only a 1.78 per cent average annual rate, a difference of 0.93 percentage points. Given that engineering and repair construction represent about 48 per cent of total construction GDP, this in turn would increase output per hour growth in the overall construction industry by 0.44 percentage points per year, from around 0.53 per cent to 0.97 per cent. Thus an upper bound estimate on the role of measurement error in construction productivity growth would be 0.44 percentage points, which accumulates to a significant number over

such a long period. This estimate of the measurement error assumes that changes in output prices for engineering and repaid construction can be reasonably proxied by changes in output prices in non-residential building construction. The paper does not argue that these assumptions are valid. Therefore, the estimate of the upper-bound of measurement error should be seen a suggestive and of an order of magnitude only.

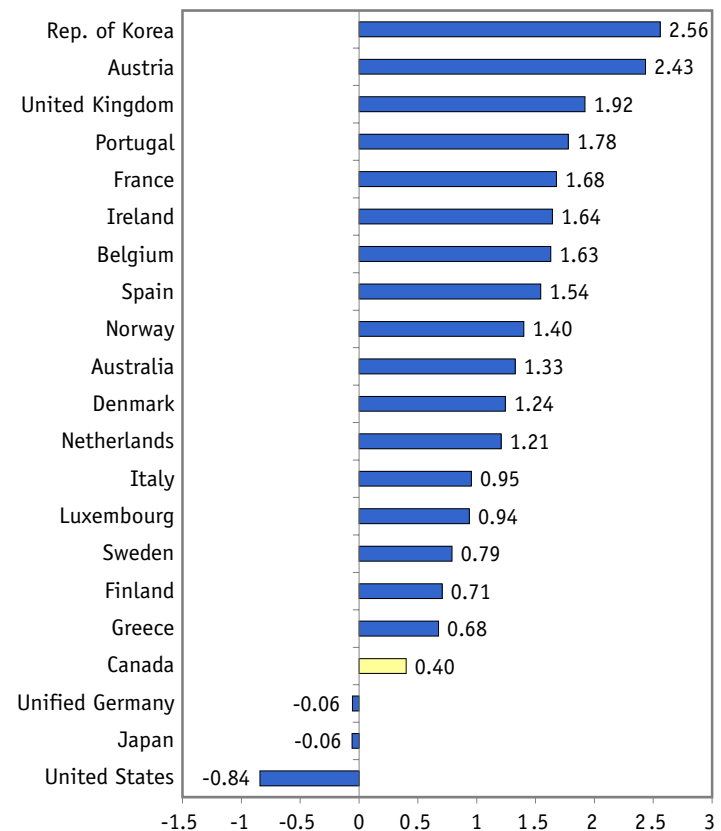
Strong construction productivity gains in other countries¹⁴

It is not inevitable that construction productivity growth be weak. Labour productivity growth in the construction industry in many countries was above 1.5 per cent per year over the 1979-2003 period (Chart 9). The UK construction industry, for example, experienced output per hour growth of 1.9 per cent per year. This situation may suggest that, if properly measured, construction productivity growth can be robust and that Canada's poor productivity performance may reflect mismeasurement. Of course, other factors might also account for faster construction productivity growth in other countries so the use of large differences in productivity performance across countries to support the mismeasurement hypothesis is not conclusive.

Significant task-based productivity gains

Task- or activity-based productivity measurement involves measuring the change over time in the number of hours required to complete a specific task, e.g. installing 10 square metres of ceiling tile. If the number of hours required to perform the task falls, then all else being equal, productivity has improved.

Chart 9
Labour Productivity Growth Rates, Construction Industry, 1979-2003
(per cent)



Source: Harrison (2007:Appendix Table 3).

Note: Average annual growth rates for countries without data available for 2003, such as Japan, Korea and Norway, are calculated for the period 1979-2002.

Construction sector is defined according to the International Standard Industrial Classification (ISIC-rev.3.) category 45.

Both the literature on productivity measurement in the construction industry¹⁵ and the construction practitioners interviewed for this project¹⁶ provided strong evidence that on a task basis there have been significant productivity gains in construction. For example, practitioners cited labour-saving improvements in mate-

14 Data for this section are drawn from the Groningen Growth and Development Centre, 60-Industry Database as of March 2007 and available at <http://www.ggdc.net>. This source is used since the data are classified according to the International Standard Industrial Classification (ISIC), which makes industries comparable across countries.

15 See the unabridged version of this article for an extensive survey of the literature on construction productivity (Harrison, 2007).

rials, like engineered wood flooring over traditional hardwood flooring, and significant improvements in machinery used for hoisting and earth moving. Given the large number of construction tasks that many argue experienced gains, one might have expected that this would have translated into stronger productivity growth at the level of the industry and that the failure of such gains to appear is due to the inability of the statistical system to capture them because of measurement problems.

The counter-argument is that the number of tasks with significant productivity gains may not have been particularly large, and therefore one would not expect a major impact on the overall rate of productivity growth in the construction industry. Moreover, at least one practitioner noted that productivity growth could be slow due to a lack of significant improvement in management and organization coupled with the increasing complexity of projects.

Failure to adjust construction output for quality improvements

It is recognized that price indices should be adjusted to take account of quality improvements, and that such adjustments can lead to much lower price increases and larger real output increases. This has been the case in the computer industry where massive quality improvements in computers have resulted in plummeting quality-adjusted prices and soaring real output. While the quality improvements in the output of the construction industry are certainly much less than in the computer industry, the construction industry practitioners interviewed for this study identified a significant number, such as more energy efficient buildings and lower-maintenance structures. If Statistics Canada has not made sufficient downward

adjustment in construction price indexes to reflect these quality improvements, then real output and productivity may be underestimated.

Strong growth in capital-labour ratio in construction

A key driver of labour productivity is the increase in the capital stock with which each worker works. The rate of growth of the capital-labour ratio in the construction industry in Canada has been strong, averaging 2.57 per cent per year over the 1987-2004 period and above the business sector average. Yet this increased capital intensity of production of the industry has not translated into labour productivity gains, which is surprising and a different result from that found in other industries. This may suggest that measurement error is at play.

Evidence Not Supporting the Mismeasurement Hypothesis

Evidence not supporting the mismeasurement hypothesis includes weak construction productivity growth observed in other countries, rapid productivity growth in earlier periods, large provincial differences in construction productivity growth, the lack of evidence of a failure to capture the underground economy, and the lack of an effect of prework on construction productivity.

Weak construction productivity growth in other countries

It could be the case that labour productivity growth is inherently weaker in construction because of the one-off nature of much construction output. A large number of countries experienced very weak labour productivity growth in the construction industry over the 1979-2003 period (Chart 9). For example, the United States saw an average annual decline of 0.8 per cent in

16 The members of the Labour Market Information Committee of the Construction Sector Council were interviewed in February 2006 to ascertain the views of experienced industry practitioners on construction productivity trends. See the unabridged version of the report (Harrison, 2007) for the results of the survey.

output per hour, and both Japan and Germany experienced slightly negative productivity growth in the construction industry. Of course, measurement problems might account for the dismal construction industry productivity performance in these countries. But to the degree that the statistical systems of these countries are better at capturing true productivity gains than the Canadian statistical system, this situation may be due to the reality that productivity growth in construction is fundamentally slower than in other industries because of the labour-intensive nature of many construction tasks, which are not amenable to mechanization.

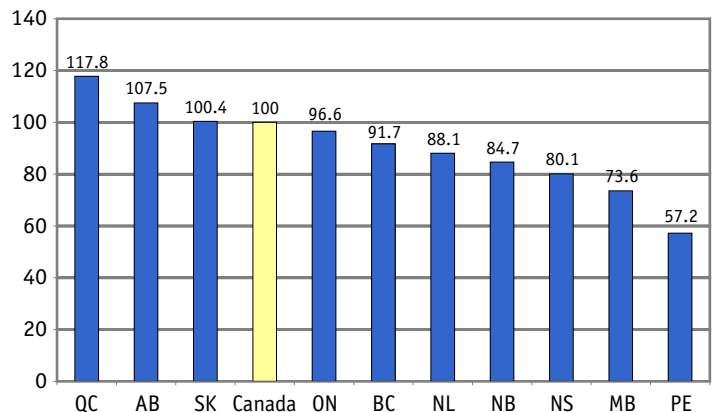
Earlier periods of rapid construction productivity growth in Canada

Labour productivity in the construction industry in Canada advanced at the phenomenal rate of 5 per cent per year between 1974 and 1983. This suggests that our statistical system was fully capable of capturing construction productivity gains in the past, and the fact that since 1983 it has recorded only weak gains suggests that they may just not be there to be recorded. Of course, measurement problems could have been at play in both periods. At the same time, evidence suggests that Statistics Canada did alter its measurement techniques for construction prices in the 1980s and 1990s. While outside the scope of his article, more research is required to determine how changes over time in the measurement techniques used by Statistics Canada have affected productivity estimates for the construction industry.

Large provincial differences in construction productivity growth

While current dollar GDP per hour worked in the construction industry in 2003 in Canada as a

Chart 10
Labour Productivity by Province as a Percentage of Canada's Labour Productivity in Construction Industry, 2003
 (current dollars)



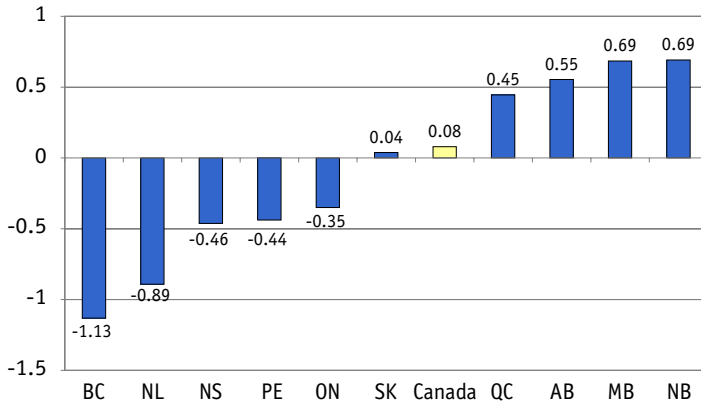
Source: Calculated by CSLS from Statistics Canada CANSIM II table 379-0025 and 383-0010.

whole was \$33.03, this performance masked wide variations in construction productivity levels among provinces (Chart 10).¹⁷ Quebec showed by far the highest productivity with a value of per hour output of \$39.91 (117.8 per cent of the national average), while the lowest productivity was observed in Prince Edward Island, at \$18.89 (57.2 per cent of the national average). Alberta showed the second highest level of productivity, while Manitoba and Nova Scotia had relatively low levels of productivity. The other provinces fell somewhere in between, most approximately between \$28.00 and \$33.00 of output per hour.

Turning to growth rates in constant dollar GDP per hour worked, on a provincial basis, the diversity across provinces is even more pronounced than in levels (Chart 11). In the 1987-2005 period, construction industry productivity in Canada rose at a compound annual rate of 0.08 per cent. Five provinces exhibited negative growth rates over the period, while five showed positive growth rates. The poorest performers

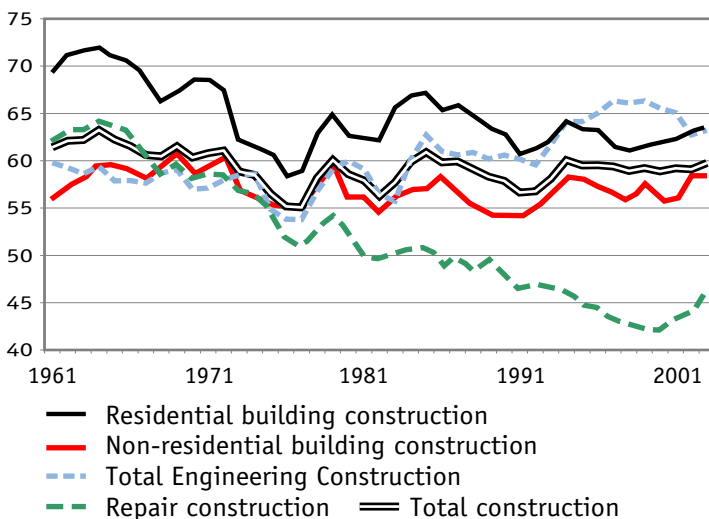
¹⁷ Data on output per hour by province is in terms of value productivity, not in terms of physical productivity, since estimates of purchasing power parity prices for the construction industry across provinces are not available.

Chart 11
Labour Productivity (real GDP per hour) Growth,
1987-2005
(per cent)



Source: CCLS Database: Labour, Capital and Total Factor Productivity by Industry for Canada and the 10 provinces: <http://www.ccls.ca/data.asp>. Tables S1 and S7.

Chart 12
Value of Intermediate Goods as a Proportion of Gross
Output, Major Construction Sub-industries, Canada,
1961-2003
(per cent)



Source: Compiled by the CCLS from Statistics Canada CANSIM Tables 379-0023 and 381-0009.

were British Columbia (-1.13 per cent) and Newfoundland (-0.89 per cent). Nova Scotia (-0.46 per cent), Prince Edward Island (-0.44 per

cent) and Ontario (-0.35 per cent). The highest compound annual growth rate (0.69 per cent) was observed in New Brunswick and Manitoba, with Alberta (0.55 per cent), Quebec (0.45 per cent) and Saskatchewan (0.04 per cent) also showing positive productivity growth.

These differences between provinces suggest that factors other than measurement problems may be at play in explaining construction productivity growth. Of course, both measurement problems and other factors may be at work. Differences across provinces are not inconsistent with measurement problems.

Lack of evidence of a failure to capture the underground economy

It is widely recognized, including by all industry practitioners who we surveyed, that much construction activity is not reported to the taxation authorities. But this does not mean that these transactions are not included, through imputations, in the estimates of nominal output for the construction industry produced by Statistics Canada. Indeed, our detailed analysis of the procedures used by Statistics Canada to estimate the nominal output of the industry suggests that the lion's share of underground activity is accounted for and that nominal output is not underestimated. However, because of the clandestine nature of underground activity, one cannot say with full certainty that this is the case, but is unlikely that underground activity is the cause of mismeasurement.

The possibility of a large-scale underestimation of gross output in the construction industry is thus very small in Canada. This results directly from the method used to estimate gross output in the industry, which relies mainly on demand-side indicators rather than supply-side indicators. While contractors in the construction industry have strong incentives to underreport, consumers' incentives to

do so are much lower. Though it is still possible that there is some underestimation of gross output in the construction, this underestimation, even under a worst-case scenario, cannot account for much of the weakness in the construction sector productivity growth.

The lack of effect of prework on construction productivity

The greater use of prework¹⁸ in the construction industry, while resulting in productivity gains in terms of overall labour requirements for construction projects, has no *a priori* effect on output per hour in the construction industry itself and, therefore, cannot account for mismeasurement of productivity gains. During the interviews with construction industry practitioners, it also became clear that there was considerable uncertainty as to whether prework was taking place in the construction industry or the manufacturing industry. Most respondents believed that prework, regardless of where it was carried out should constitute part of the construction industry.

Another reason why prework is unlikely to be mismeasured is the stability of the ratio of current dollar intermediate goods to gross output. This stability suggests that the relative importance of prework has not been increasing over time in Canada.

Conclusion

This article makes a case that measurement error may account for much of the weakness in labour productivity growth in the construction industry in Canada over the last quarter century. It is argued that the use by Statistics Canada of input cost deflators in the deflation of the nominal value of output in a number of construction sub-industries introduces a significant downward bias into productivity estimates. A ballpark estimate of the upper bound of this bias is 0.44 percentage points per year over the 1981-2006 period. This would raise output per hour growth in the construction industry from 0.53 per cent to 0.97 per cent and would eliminate about one half of the gap in labour productivity growth between the construction industry and the overall business sector. It is important to stress that the estimates should be seen as suggestive and of an order of magnitude only.

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18 Unfortunately, there appears to be a lack of clarity about the precise definition of prework and of its components: modularization, prefabrication, and preassembly. The term *industrialization* has also been used in reference to pre work, for example Finn (1992), but following Haas *et al.* (2000) this study does not use that term. Therefore, it is worth briefly clarifying what is meant by these terms as used in this study. Following Haas *et al.* (2000), a study completed by the Center for Construction Industry Studies at the University of Texas at Austin, the components of prework are:

Modularization: construction of a complete system away from the job site which is then transported to the site. Modules may be too large to transport in one piece, and, therefore, may need to be broken down into smaller pieces for transport.

Prefabrication: Tatum (1987) defines prefabrication as "a manufacturing process, generally taking place at a specialized facility, in which materials are joined to form a component part of a final installation." Haas *et al.* (2003:3-4) add that prefabrication "normally involves one skill or trade, such as electrical, piping, or rebar" and that "any component that is manufactured offsite and is not a complete system can be considered prefabricated."

Preassembly: Preassembly is a combination of prefabrication and modularization. It involves the assembly of materials and prefabricated components at the jobsite or somewhere else. Preassembly often involves the work of numerous trades and usually only involves part of a system. Preassembled work is installed in a manner similar to the installation of modules (Haas *et al.*, 2000:4).

19 A complete bibliography is included in the unabridged version of this article.

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Appendix 1: Statistics Canada Methodology for Estimation of Construction Value Added

Because of inflation, in order to determine the real change in output, nominal (current-dollar) output must be converted to real (constant-dollar) output by use of a deflator.²⁰ A deflator is a number by which nominal output is divided in order to produce real output. Once deflated, a real output series should measure only the change in the volume of output. Real value added is calculated using what is called the double-deflation methodology. This procedure involves deflating separately the value of gross output and the value of intermediate inputs by appropriate deflators. Real value added is then calculated residually as the difference between the two series.

In the Input-Output tables construction is divided into eight special industry aggregations also known as commodities: Residential; Non-

residential building; Transportation Engineering; Gas and oil engineering; Electric power engineering; Communications engineering; Other engineering; and Repair construction. These commodities are then deflated using deflators developed by the Income and Expenditure Accounts Division of Statistics Canada. (Statistics Canada, 2001a:35) Deflators are constructed to deflate specific series. For example, there are separate deflators for apartment buildings and for shopping malls. The price indexes that are used to construct deflators and the deflators themselves will be examined in detail below. It is in the construction of deflators for output that a potential problem of productivity measurement arises.

Appendix Table 1 summarizes the deflators currently used to deflate different commodities pro-

²⁰ For an extensive discussion of how Statistics Canada calculates nominal output in the construction industry, including an extensive discussion of estimations on the underground economy in construction, please refer to the unabridged version of this article.

Appendix Table 1
Summary of Construction Deflator Methodologies

Commodity/Industry (NAICS/IOIC-based)	Deflation Method	Type of Deflator	Share of total Construction Industry Value Added in 2003, current dollars, (per cent) ²	
Residential Building Construction				
Single dwellings, semi- detached dwellings, and row housing	New Housing Price Index (NHPI)	Output (model) price index	23.77	33.87
Apartments	Apartment Building Construction Price Index (ABCPI)	Output (model) price index		
Alterations and improvements to existing housing (renovations)	Residential building materials index, (60% Industrial Products Price Index, 40% Construction Union Wage Rates Index) ¹	Input cost index	10.10	
Non-Residential Building Construction	Non-Residential Building Construction Price Index (NRBCPI) with an adjustment of 10 per cent for own-account construction	Output (model) price index	17.32	
Transportation Engineering Construction (SIC: Road, highway and airport runway construction)	Highways and roads are deflated by a specific index, airport runway construction is deflated using the aggregate deflator for engineering construction excluding highways and railways	Input cost index	4.90	
Oil and Gas Engineering Construction (SIC: Gas and oil facility construction)	Aggregate deflator for engineering construction excluding highways and railways	Input cost index	11.61	
Electric Power Engineering Construction (SIC: Dams and irrigation projects)	Aggregate deflator for engineering construction excluding highways and railways	Input cost index	5.48	
Communications Engineering Construction (SIC: Railway and telecommunications construction)	Railways are deflated by a specific input cost index, telecommunications construction is deflated using the aggregate deflator for engineering construction excluding highways and railways	Input cost index	0.75	
Other engineering construction	Aggregate deflator for engineering construction excluding highways and railways	Input cost index	5.38	
Repair Construction	Implicit price index for alterations and improvements component of residential construction	Implicit price index based on input cost index	19.39	

Notes:

- 1 The weighting used in the deflator for Alterations and Improvements to residential structures is derived from the Homeowner Repair and Renovation Survey.
- 2 Shares do not sum to 100 because "Other activities of the construction industry," which account for 1.31 per cent of output do not appear in this table at this time.

Sources: Centre for the Study of Living Standards, based on discussions with Statistics Canada officials and Statistics Canada (2001a:35-36)

duced in the construction industry. In order to generate real value added, the corresponding deflator is used to deflate each of these commodities.

Residential building construction

Residential building construction is subdivided into three principal components for deflation

purposes. The first component includes single-family dwellings, semi-detached dwellings, row houses, and cottages. This component is deflated using the New Housing Price Index. The second major component is apartment building construction, which is deflated using the Apartment Building Construction Price Index. The third

substantial component of residential construction is renovations. Renovations are deflated using a specially constructed wage and materials cost index. The Construction Union Wage Rates Index is given a weight of 40 per cent in the deflator and a special construction materials index is given a weight of 60 per cent. Several other minor components of residential construction are deflated in a variety of ways.

Residential building construction accounted for 33.87 per cent of all construction industry value added in 2003. Within residential construction, 23.77 per cent of total construction value added was derived from single-family dwellings, semi-detached dwellings, row houses, cottages, and apartment building construction, and was deflated using output prices. Alterations and improvements (renovations), deflated using an input-cost based deflator constituted 10.10 per cent of total construction value added.

Non-residential building construction

Non-residential building construction is deflated by the Non-Residential Building Construction Price Index, which is an output-price based deflator based on the model price method. Contracted investment is given a weight of 90 per cent and own-account work a weight of 10 per cent. Own-account construction work is deflated using a fixed-weighted index based on the Survey of Employment, Payroll and Hours (SEPH) for earnings in the construction industry, materials prices based on the Industrial Products Price

Index, and overhead costs based on various prices indexes. Non-residential building construction made up 17.32 per cent of total construction industry value added in 2003.

Engineering construction

Engineering construction is deflated in three components. The first two are highway construction and railway construction. Each is deflated by a specific input-cost-index based deflator. The remaining component of engineering construction is also deflated using a different input-cost-index based deflator. These deflators are based on a composite of wage, materials and overhead costs. The weights accorded to each of the three components were derived from the 1997 Input-Output tables. The wages component is based on the SEPH. These prices are not output prices. The materials component is based on the Industrial Products Price Index. The overhead costs component is based on a mix of average weekly earnings indexes and consumer price indexes. Engineering construction accounted for 28.11 per cent of total construction value added in 2003. Almost all of this output was deflated using input cost indexes.

Repair construction

Repair construction is deflated using the same cost index that is used to deflate residential renovations. Repair construction made up 19.39 per cent of total construction industry value added in 2003.