Productivity Trends in the Construction Sector in Canada: A Case of Lagging Technical Progress

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Official Statistics Canada data show that real output per hour in the construction sector in Canada in 2000 was well below levels achieved in the early 1980s. Given the importance of the construction sector in the economy, this negative productivity growth has dampened Canada's aggregate productivity performance. The objective of this article is to offer an explanation for the lagging productivity growth in the construction sector. The article is divided into three parts. Part one provides an overview of the construction sector, looking at its importance in the overall economy and in output and employment trends. Part two looks at productivity trends within the construction sector while part three examines possible explanations for lagging productivity growth in the sector.

The Construction Sector: An Overview

Relative importance of the sector and its components

The construction sector's importance in the Canadian economy has been declining over time. In 2000, the construction sector accounted for 5.4 per cent of real output ($1992), down from 9.9 per cent in 1961 (Chart 1). Construction accounted for 6.5 per cent of nominal GDP in 1997, down from 9.8 per cent in 1961. In terms of employment, 6.6 per cent of all workers were in the sector in 2000, down from 9.3 per cent in 1961.

The construction sector can be divided into four major industries or components: residential construction, non-residential building construction, engineering construction, and finally repair construction. In 1997, the most recent year for which industry data are currently available, residential construction was the largest component of the construction sector, accounting for 33.9 per cent of real output ($1992), followed by engineering construction (28.5 per cent), non-residential building construction (20.0 per cent), and repair construction (17.6 per cent). The employment shares were similar: 33.7 per cent, 24.0 per cent, 20.4 per cent, and 21.9 per cent respectively.

Characteristics of the construction sector

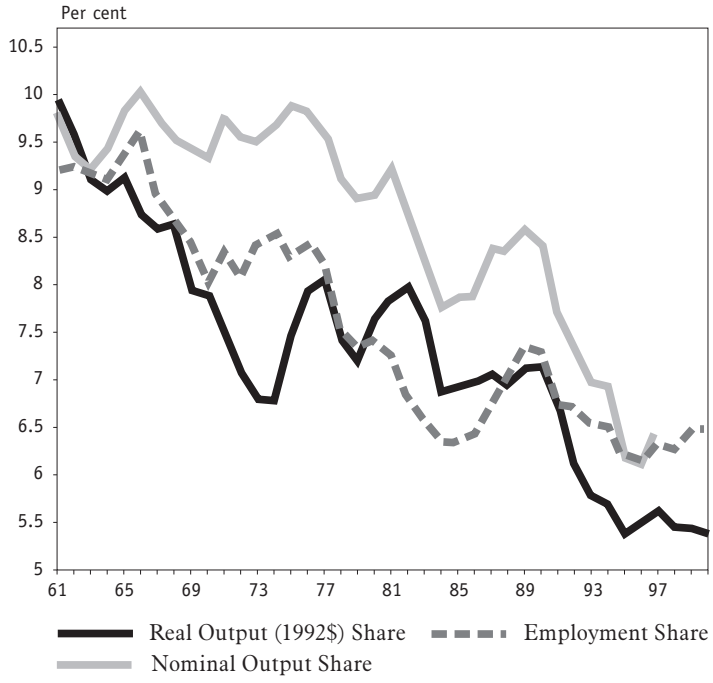
The construction sector is distinct from other goods-producing industries in a number of ways, with important implications for productivity

growth (CMHC, 1989:2). In particular, the sector is characterized by: its geographical dispersion; the heterogeneous nature of output; on-site construction; a high degree of regulation, particularly by municipal authorities; ease of entry, resulting in many small firms operating in a competitive environment; and the cyclical nature of activity.

Output growth

The pace of growth in the construction sector has been lagging that of the total economy or business sector for the past four decades (Appendix Table 1). Over the 1961-2000 period, the average annual rate of growth in the construction sector was 2.2 per cent, only 58 per cent the rate of advance of the business sector cent (3.9 per cent). The construction sector did particularly poorly in the 1990s, with the level of output in 2000 still below that of 1989.

Chart 1
Trends in Output and Employment in the Construction Sector, 1961-2000
Construction as a per cent of Total Economy



Source: Labour Force Survey, National Accounts, Aggregate Productivity Measures, Statistics Canada.

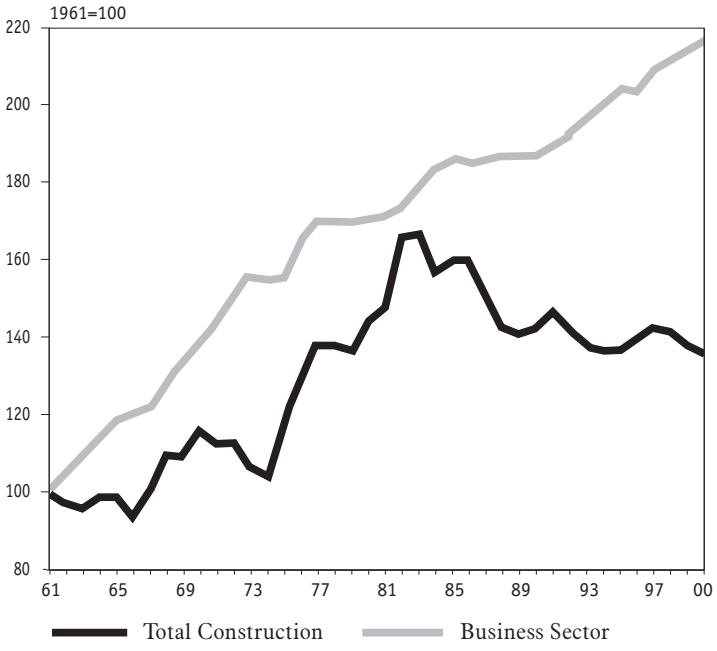
Table 1
Labour Productivity Trends in Canada by Sector, 1961-2000
Average annual rate of change in output per hour

	1961-2000	1961-1973	1973-1981	1981-1989	1989-2000	1989-1995	1995-2000
Business sector	2.0	3.7	1.2	1.1	1.4	1.5	1.2[1]
Agriculture	4.4	5.9	3.6	1.8	5.2	4.3	6.3
Fishing and trapping	-0.2	2.7	-0.5	-3.0	-0.9	-1.4	-0.3
Logging and forestry	2.2	4.0	1.8	3.4	-0.2	-2.0	2.0
Mining, quarrying and oil well	1.6	6.1	-5.9	3.0	1.6	3.4	-0.6
Manufacturing	2.9	4.2	2.0	2.3	2.0	3.0	0.9
Construction	0.8	0.5	4.1	-0.6	-0.3	-0.5	-0.2
Transportation and storage	2.4	5.1	0.0	2.2	1.6	1.8	1.3
Communication and other utility industries	3.4	5.8	3.1	1.6	2.3	1.4	3.5
Wholesale trade	2.5	2.3	1.7	4.4	1.9	1.2	2.8
Retail trade	2.1	3.6	1.5	1.0	1.8	0.4	3.5

Source: Aggregate Productivity Measures, Statistics Canada, May 22, 2001.

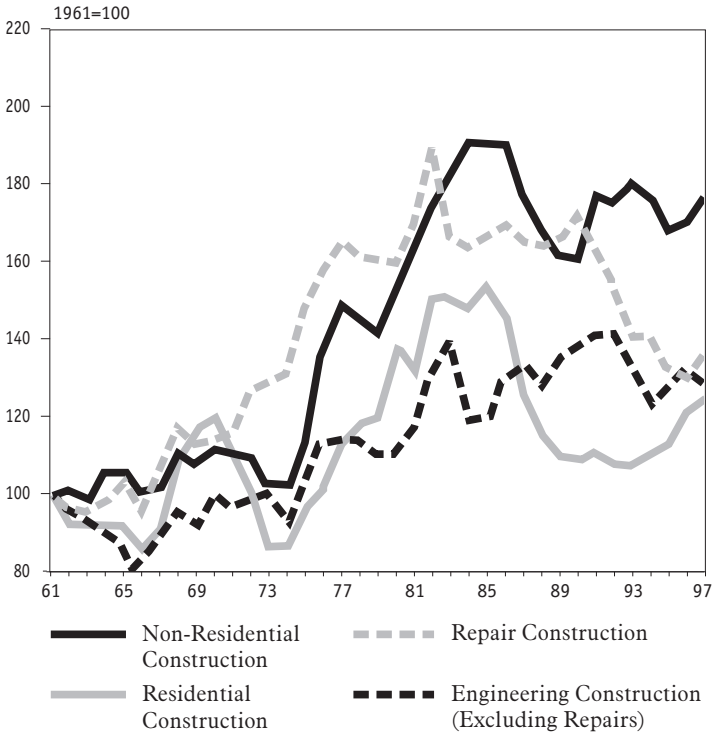
1 Since the May 22 release Statistics Canada has updated the business sector series for the 1987-2000 period to reflect methodological changes introduced into the national accounts released May 31, 2001. Output per hour growth has risen to 1.7 per cent per year from 1.2 per cent for the 1995-2000 period, but was virtually unchanged for the 1987-1995 period. The series for other industry sectors have not yet been updated.

Chart 2
Output per Hour in the Business and Construction Sectors, 1961-2000



Source: Aggregate Productivity Measures, May 2001, Statistics Canada.

Chart 3
Output per Hour Trends in the Construction Sector by Industry, 1961-1997



Source: Aggregate Productivity Measures, May 2001, Statistics Canada.

All four components of the construction sector experienced below-average output growth over the 1961-97 period. Residential construction enjoyed the strongest growth, with real output advancing 3.0 per cent per year, followed by non-residential building construction (2.3 per cent), engineering construction (1.9 per cent), and repair construction (1.3 per cent). In the 1990s, non-residential building construction was particularly hard hit (-3.0 per cent per year).

Employment growth

Employment growth in the construction sector was also well below the economy-wide average. Over the 1961-2000 period, it grew at a weak 1.3 per cent average annual rate, slightly above half the business sector average of 2.2 per cent (Appendix Table 1). Again employment growth was particularly weak in the 1990s, with the employment level in 2000 (966 thousand) barely above that of 1989 (955 thousand).

One component of the construction sector did enjoy above-average employment growth. Residential construction saw the number of jobs increase at a 2.3 per cent average annual rate over the 1961-97 period. The three other construction industries had very weak employment growth over the period: 1.1 per cent in engineering construction, 0.7 per cent in non-residential building construction, and 0.4 per cent in repair construction. In the 1990s (1989-97), employment plummeted in both residential construction and non-residential building construction (-1.9 and -4.0 per cent per year respectively).

The stagnation in the construction sector since 1989 has been due to a number of cyclical and structural factors. They include the high interest rates in the late 1980s and early 1990s which had a negative impact on interest-rate sensitive housing and business investment spending. The weak economy produced large

deficits and in response governments cut spending on public infrastructure and social housing, with a negative effect on the construction sector. Structural factors accounting for slower construction growth include: the slower rate of population growth which reduced growth in potential housing demand; the reduced need for continued rapid rates of growth in public infrastructure spending in the 1980s and 1990s following the completion of the major investments in roads, schools, hospitals, airports, etc. in the 1950s, 1960s, and 1970s; and the shift in employment from goods-producing to service-producing activities, which require less workspace per worker.

Productivity Trends in the Construction Sector

Labour productivity

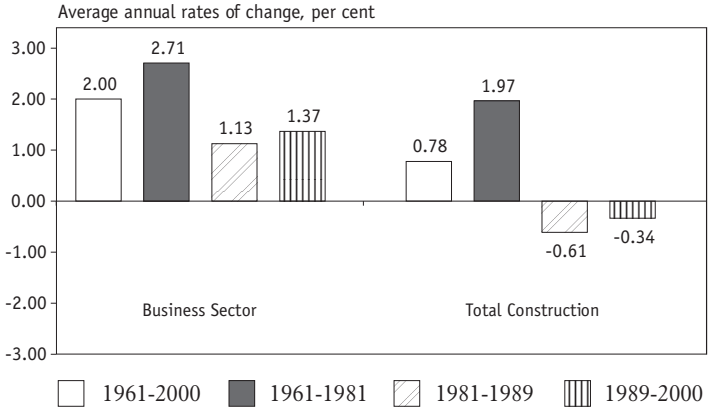
Chart 2 compares output per hour trends in the business and construction sectors in Canada from 1961 to 2000.[1] Over the 39 year period, the construction sector experienced less than one half the average annual rate of increase in output per hour of the business sector — 0.8 per cent versus 2.0 per cent.[2] Business sector productivity grew at a more or less continuous pace, but construction sector productivity exhibited very different patterns in three distinct periods. From 1961 to 1974 output per hour in the construction sector stagnated. Productivity growth then surged from 1974 to 1983 advancing at a very robust 5.3 per cent average annual rate. Since 1983, productivity in the construction sector has fallen 1.1 per cent per year.

Over the 1961-2000 period, Table 1 shows that for the 10 industries (service industries are excluded) for which Statistics Canada officially publishes productivity estimates, the construction sector had the second slowest rate of increase in output per hour (only fishing and trapping was worse).

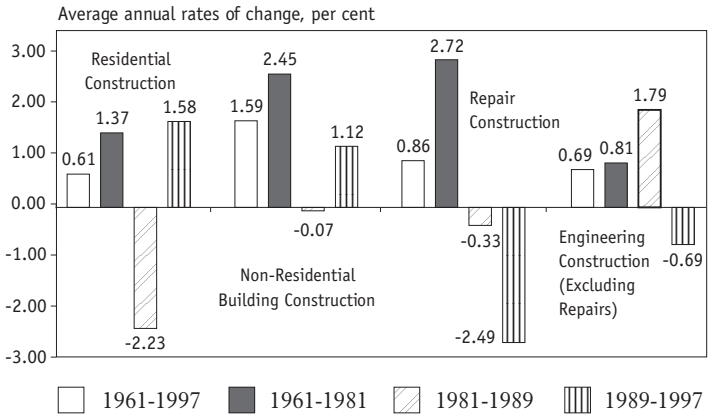
Charts 3 and 4 show output per hour trends in the four construction industries from 1961 to 1997. Non-residential building construction enjoyed by far the best performance over the period, with output per hour advancing 1.6 per cent per year. This was well above the rate of increase of the other three industries: 0.9 per cent for repair construction, 0.7 per cent for engineering construction,[3] and 0.6 per cent for residential construction. Within the period all four construction industries followed the pattern observed for the overall construction sector, namely productivity growth stagnation from 1961 to the mid-1970s,

Chart 4
Output per Hour Trends in the Business and Construction Sectors, selected periods

a) Business Sector and Total Construction

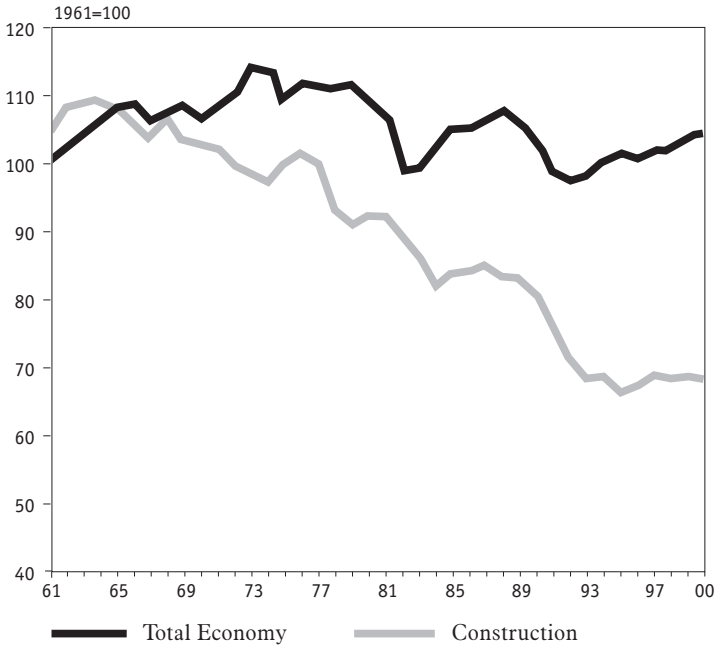


b) Components of Total Construction



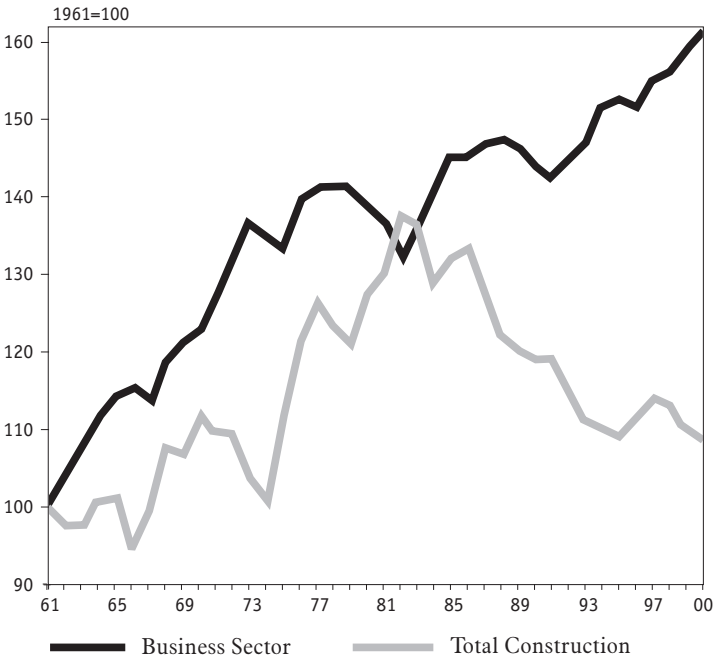
Source: Published and unpublished data from Aggregate Productivity Measures, May 2001, Statistics Canada.

Chart 5
Capital Productivity in the Total Economy and Construction Sector, 1961-2000



Source: Capital Stock Data, Aggregate Productivity Measures, Statistics Canada.

Chart 6
Total Factor Productivity in the Business and Construction Sectors, 1961-2000



Source: Aggregate Productivity Measures, July 2001, Statistics Canada.

then very rapid productivity advance until the first half of the 1980s, followed by absolute declines in productivity levels to the present. This suggests that similar factors were influencing productivity growth across the four industries.

Capital Productivity

Capital productivity is defined as the ratio of output to the capital stock. The most commonly used definition of the capital stock is the net capital stock for the total construction industry, based on the geometric depreciation assumption. For the 1961-2000 period, capital stock in the construction sector grew at an average annual rate of 4.0 per cent per year, compared to an increase of 2.2 per cent in real construction output. Consequently, capital stock productivity fell at a rate of 1.8 percent per year (Chart 5). In contrast, capital productivity was stable in the total economy over the period.

Total factor productivity

Total factor or multifactor productivity growth is defined as the difference between the rate of growth of output and total inputs, defined as the weighted average of the growth rates of capital and labour where the weights are the shares of the factors of production in total value added. Total factor productivity growth represents the growth in output not explained by increases in labour input and capital due to disembodied technical change (i.e. technical change that is not embodied in new capital equipment), measurement error and other factors.[4]

According to data from Statistics Canada's Aggregate Productivity Measures series, multifactor productivity based on value-added (Fisher indices) in the construction sector advanced at a meager 0.2 per cent average annual rate from 1961 to 2000, well below the 1.2 per cent rate of increase for the business sector (Chart 6). Like labour productivity, total factor productivity in the construc-

tion sector stagnated from 1961 to the mid-1970s. It then rose rapidly, peaking in 1982 and has since entered a period of more or less steady decline.

Trends in Explanatory Variables[5]

Capital-labour ratio

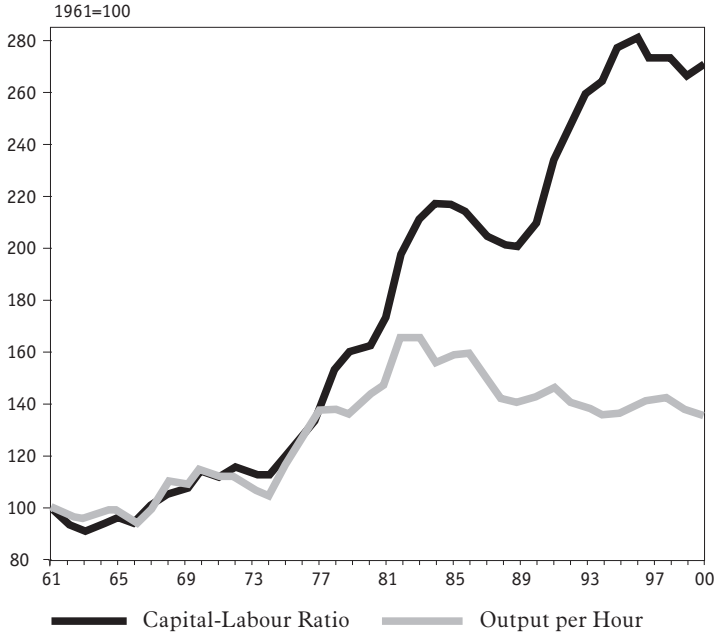
The capital intensity of production, as proxied by the capital-labour ratio is an important driver of labour productivity growth. One might expect that the construction industry would become more productive as more capital stock is employed relative to workers as there are large productivity gains to be had from letting a few machines do the work of many workers.

Chart 7 shows that there has been a strong upward movement (2.6 per cent per year) in the capital-labour ratio in the construction sector over the 1961-2000 period.[6] After exhibiting little growth in the 1960s and first half of the 1970s, the capital-labour ratio advanced rapidly from 1975 to 1984, fell from 1984 to 1990, and regained an upward path to 1996 and then declined slightly. The path of productivity growth in the total construction sector paralleled trends in the capital-labour ratio up to 1983. Since then, the nexus between trends in capital intensity and productivity growth has been broken as the latter has stagnated while the former has increased substantially. This development is perplexing.

Educational attainment

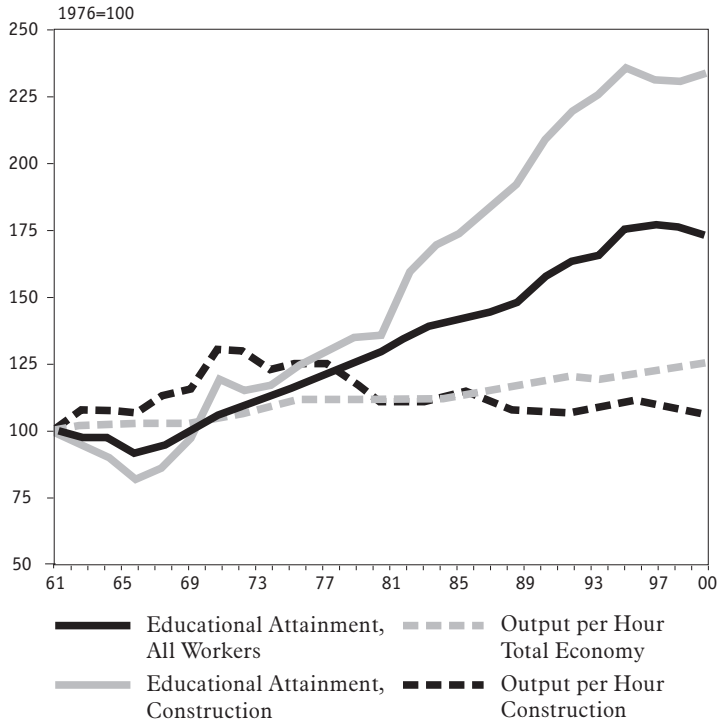
A second key driver of productivity growth is the skills of the workforce. As a general rule the higher the level of skills the higher the productivity and the faster the pace of skills acquisition, the greater the rate of productivity growth. Unfortunately, it is very difficult to ascertain the actual aggregate skills level

Chart 7
Trends in the Capital-Labour Ratio and Labour Productivity in the Construction Sector, 1961-2000



Source: Capital Stock Data, Aggregate Productivity Measures, Statistics Canada.

Chart 8
Trends in Educational Attainment in the Total Economy and Construction Sector, 1976-2000
Per cent of employed persons with a post-secondary certificate or diploma



Source: Labour Force Survey and Aggregate Productivity Measures, Statistics Canada.

Chart 9
Capacity Utilization and Productivity in the Construction Sector, 1961-2000

Source: Capacity Utilization Rates and Aggregate Productivity Measures, Statistics Canada.

of the workforce. Educational attainment is used as a proxy for the skills level.

The level of formal educational attainment in the construction sector is below the national average.[7] In 2000, 43.6 per cent of the workers in the construction sector had a post-secondary certificate, diploma or degree compared to 52.2 per cent in all industries. This situation is accounted for by the small proportion of workers in the construction sector who have a university degree (5.1 per cent compared to 19.7 per cent for all industries). Conversely, an above average proportion of workers in the construction sectors has received a post-secondary certificate or diploma, including apprenticeship certification (38.5 per cent compared to 32.5 per cent for all industries). For most construction occupations, non-university post-secondary educational programs such as apprenticeship training are probably more relevant than university programs.

Like all sectors, the pace of skills upgrading in the construction sector, as proxied by the growth in the proportion of the workforce with a post-secondary certificate or diploma, has been rapid. Between 1976 and 2000, this proportion of workers in the construction sector jumped 22.0 points or 133.3 per cent from 16.5 per cent to 38.5 per cent. In contrast, for all workers, the proportion advanced only 13.7 points or 72.9 per cent from 18.8 per cent to 32.5 per cent.

As Chart 8 shows, there appears to be no relationship between trends in the skills level of the construction sector workforce, as proxied by educational attainment data, and productivity. Productivity growth in construction since the early 1980s has been very weak, despite the massive increase in the educational credentials of the workforce.

Aggregate-demand effects

The rate of capacity utilization is the proportion of the capital stock that is engaged in production and varies with the business cycle. During a recession capacity utilization falls while during an expansion it rises. Chart 9 shows trends in this variable for the total construction sector. The rate of capacity utilization ranged from a low of 76.9 per cent in 1972 to a high of 95.6 per cent in 1989.

From the 87.5 per cent recorded at the 1981 business cycle peak, capacity utilization in the total construction sector fell during the recession of the early 1980s, reaching a trough of 78.6 per cent in 1984. With the expansion of the mid- and late 1980s capacity utilization again picked up, peaking at a record 95.6 per cent in 1989. The weak economic conditions in the first half of the 1990s saw capacity utilization drop to a trough of 76.6 per cent in 1995. With the expansion during the second half of the 1990s, the rate rose, attaining 91.4 per cent in 2000.

Productivity trends exhibit a strong cyclical component. One explanation of this phenome-

non is the existence of lags in the adjustment of employment to changes in output. According to this explanation, productivity behaves in a pro-cyclical manner, falling in recessions as the semi-fixity of labour input results in greater falls in output than employment and rising in the early phase of expansions as output expands faster than employment. A second explanation of the cyclical behaviour of productivity is linked to the effect of the cycle of the financial circumstances and hence behaviour of the firm. According to this explanation, productivity behaves in a counter-cyclical manner, rising in recessions as the fall in profitability forces employers to cut employment more than output, and falling in expansions as the improved profitability allows inefficiencies to develop.

The short-to-medium term productivity performance in the construction sector appears to correspond better to the second explanation than the first. During both the recessions of the early 1980s and 1990s labour productivity rose while during the expansions of the mid and late 1980s and 1990s labour productivity fell. However, capacity utilization does not appear to explain the weak long-term or trend productivity growth in the construction sector.[8]

Industries experiencing strong output growth over long periods tend to enjoy above average productivity growth while industries with weak growth tend to record below average productivity gains. Strong demand for a sector's output and the resulting rapid output growth can foster productivity gains through static and dynamic economies of scale, greater stimulus to innovate to increase production, larger profits to finance investment, learning by doing, and other mechanisms. The construction sector experienced below average growth in the last two decades. This situation, which has reflected both cyclical and structural influences, may not have been a favourable environment for productivity advance.

Measurement errors

Labour productivity growth estimates can be subject to a wide margin of error because of input and output measurement problems. An overestimation of labour input results in an underestimation of labour productivity growth. Equally, an underestimation of real output growth associated with undercoverage of the nominal value of output or incorrect deflators produces an underestimation of labour productivity growth.

Some observers suggest that measurement problems may account for part of the weak measured productivity growth in the construction sector in Canada, a situation that has plagued estimates of construction sector productivity in the United States for many years.[9] Indeed, Allen (1985) estimated that about one half the construction productivity decline in the United States was due to an overdeflation of construction output. Two potential measurement problems are biases in estimates of construction price indexes and undercoverage of the construction sector because of underground activity.

The most important measurement issue for the construction sector is whether the price series used to deflate nominal output are capturing true changes in prices over time and hence giving true movements in real output. This may not be the case if quality changes in construction output are not captured. For example, new homes in recent years have become more fuel efficient because of better insulation and other features. They are also increasingly likely to include landscaping and appliances. It is unclear whether housing prices reflect this quality improvement. Developing accurate structures deflators is very difficult due to the heterogeneity of most structures.

The introduction of the GST in 1991 gave individuals and businesses engaged in construction activities an additional incentive to fail to

report or underreport income. Many observers believe that this situation has fueled the growth of underground activities in the sector, with implications for measured productivity growth. Of course, if both employment and income are underreported in the same proportion, productivity is unaffected. But most observers believe undercoverage is much greater for income than employment, as persons have much greater incentive to underreport their income when filing tax returns than to underreport hours worked when responding to the Labour Force Survey.

If a growing proportion of construction activity is taking place underground and is not reported to the authorities, a growing gap between actual and measured labour productivity growth may develop, assuming labour input is accurately captured. In theory, such a development could explain some of the weak measured productivity performance in the construction sector in Canada in the 1990s.[10]

It is important to note that the estimates of output in the construction sector produced by Statistics Canada are based on more than the income reported to tax authorities. Statistics Canada officials impute income to the sector based on employment data, building supply sales, and other relevant information. From this perspective the growth of the underreporting to the tax authorities will not necessarily lead to an underestimation of the output of the sector. Without further work it is not possible to state with any certainty whether the decline in output per hour in the total construction sector over the last two decades can be accounted in full or in part by measurement problems, but it is likely to have played a role.

Technological change

Technological change is the most important determinant of productivity growth in most sectors and the construction industry is probably no exception. The amount of technological change that takes place in the construction sector according to conventional indicators is very low.[11]

Because of the small amount of R&D undertaken and limited number of patents granted,[12] it appears that no time series on R&D and patents in the construction sector are available for Canada. For this reason, it is not possible to directly measure technological change in the construction sector.[13]

A case can be made that the pace of technological progress is slower than in other sectors because of the labour-intensive nature of many of construction activities, which limits the possibilities of mechanization, that is the substitution of capital for labour. The limited number of patents and R&D expenditures undertaken by the construction sector, noted above, may be taken as evidence that there is limited potential for productivity improvement. Otherwise more resources would be allocated to improving productivity.

Estimates of the number of hours needed to construct a house provide an approximation of labour productivity trends in the residential construction sector over time. A CMHC study (CMHC, 1989:21-22) found that the number of site person-hours needed to build a house in the mid-1940s totaled 2,400. By the mid-1960s the number of hours needed to construct a similar house had fallen to 950, a decrease of 4.5 per cent per year over the 20 year period.[14] Construction time in the mid-1940s was about seven months, due to delays in material supply. By the mid-1960s it had been reduced to eight weeks. The study attributed these large improvements to a number of changes in production methods which significantly reduced on-site labour requirements and to the application by homebuilders of factory-like "stationary assembly line" flow to on-site operations which greatly decreased the length of the production process.

Exhibit 1
Changes in the Mainstream Homebuilding Production Process, Canada, Mid-1940s to Mid-1980s

Process	Mid-1940s Practice	Mid-1960s Practice	Mid-1980s Practice
Excavation	Bulldozer	Backhoe	No change
Basement	Concrete block and site-mixed concrete used with site-built board formwork. Boards then re-used as wall and roof sheathing.	Transit-mixed concrete used with prefabricated formwork.	Little change, but some use of preserved wood foundations.
Wall framing	Platform frame. Some stationary assembly line processes. Little use of power equipment or piece-work sub-trades.	Precut studs, tilt up, stationary assembly line with sequencing of piece-work produced by sub-trades.	Little change
Roof	Laid out and erected by skilled tradesmen.	Engineered, pre-fabricated roof trusses in general use.	Little change
Wall and roof sheathing	Boards	Plywood sheets	Waferboard sheets
Siding	Wood clapboard, brick and stucco	Precoated aluminum and hardboard introduced.	Introduction of vinyl siding.
Plumbing and heating	Site-fitted and installed.	Prefabricated chimneys. Some ductwork sub-assemblies.	All-plastic plumbing. Chimneys and flues prefabricated.
Interiors	Wet-finished with plaster, cured and brush-painted.	Dry-finished with dry-wall and roller-painted.	Little change
Windows/ cabinetry/doors	Fabricated on site.	Prefabricated windows, cabinetry and counter-tops.	Introduction of pre-hung doors and pre-fabricated stair units.

Source: CMHC, 1988:24.

Exhibit 1 outlines the changes in mainstream production methods in the housing industry in Canada in the mid-1940s, mid-1960s, and mid-1980s. Between the mid-1940s and mid-1960s there were major changes in the homebuilding production process in terms of excavation, basement construction, wall framing, roofing, siding, plumbing and heating, interiors, and windows/cabinetry/doors. As Exhibit 2 shows, these changes had significant effects on on-site

Exhibit 2
Reductions in On-Site Labour From Changing Production Methods

Changing This Operation	To This Operation	Fractioned Site Person-hours to:
Framing piece by piece, in balloon construction (still practiced here and there in the mid-1940s)	Platform framing with tilt-up, and using power tools	About a third or less
Constructing windows on site	Installing manufactured windows	A quarter or less
Sheathing walls and floors with boards	With sheet plywoods	A third or less
Forming basements with board formwork and site-mixed concrete	With prefabricated plywood forms and transit-mixed concrete	A third or less
Constructing cabinetry on site	Installing manufactured cabinetry	A quarter or less
Finishing interiors with wet plaster	Drywalling interiors	A third or less
Framing roofs piece by piece, ceiling joists/rafters/collar ties	Framing roofs/ceilings with trusses	A half or less
Brush painting interior, two or three coats	Roller painting, one or two coats	A third or less
Constructing chimneys with brick and flue tile	Installing manufactured flues	A quarter or less
DWV (drain-waste-vent) plumbing in cast iron and galvanized steel	Plastic DWV pipe	About half

Source: CMHC 1989:21.

person-hours. In contrast, between the mid-1960s and mid-1980s there was little further change in many of these areas and the change that did take place was in most cases less fundamental than in the earlier period.

The study found that there has been little if any decrease in the labour requirements to build a standard house since the mid-1960s, nor any reduction in the length of time needed. It did note however that this apparent death of productivity improvement since the mid-1960s is not completely accurate in the sense that the end product is now better. The house of the mid-1980s has markedly improved in its windows, insulation, airtightness and heating efficiency compared to the mid-1960s forerunner, and has better finishes and freedom from maintenance.

Trends in labour requirements for apartment construction were similar to single-family homes. According to the CMHC study (CMHC, 1989:26), the on-site labour hours consumed in constructing walk-up apartments in 1946-47 were about 2,000 per unit. By the peak period of high-rise apartment production in Canada in the mid and late 1960s, better finished and serviced high-rise apartment units were being produced in about 1,000 site hours or less. A number of technological advances in apartment construction in the 1950s and 1960s detailed in the CMHC study were responsible for this reduction in labour requirements. It appears that the pace

of technological progress slowed down considerably after the end of the 1960s.

The above findings on the pace of change in labour requirements in the housing sector are consistent with the findings of this article that there has been little sustained improvement in productivity in the residential construction sector since the late 1960s. They also provide strong support for the view that lack of technical advance in the sector is the key explanation of this situation, just as important changes in production methods account for the rapid productivity growth from the mid-1940s to the mid-1960s. Real output per hour in residential construction in 1997 was only 4.3 per cent above the level achieved 27 years earlier in 1970 (Chart 3 and Appendix Table 2).

The construction repair sector has also experienced literally no productivity growth in the last quarter century, with real output per hour in 1997 below the level achieved in 1975 (Chart 3 and Appendix Table 2). The CMHC study (CMHC, 1989:29) sheds light on this situation by noting that renovation is extremely labour-intensive, with two-thirds of the renovation dollar going to labour versus one-third for single-family house construction; and that there have been no technological breakthroughs in the sector given that materials have to be custom fitted and tradepersons must be able to work with design and materials that are now not commonly used.[15]

Other factors

- The level of average labour productivity in a sector is a weighted average of the productivity levels of the sub-sectors within the sector. It has been suggested that compositional shifts within the construction sector may have affected the sector's overall labour productivity growth rate. However, an inspection of the data provides little evidence of such an effect, mainly because productivity levels in the major components of the construction sector are very similar (Appendix Table 2). In addition, compositional shifts in the construction sector over the last two decades have been relatively small, which suggests a limited impact on overall productivity.
- The rate of wage growth can influence productivity growth through its effect on the pace of capital-labour substitution. Large wage increases can induce employers to use more equipment in the production process, which increases the rate of growth of labour productivity (but not necessarily total factor productivity). From 1981 to 1997 nominal hourly labour compensation advanced at a 3.2 per cent average annual rate in the total construction industry, compared to 4.2 per cent in the business sector. This situation implies that employers in the construction sector had less incentive, ceteris paribus, to substitute capital for labour than in other sectors and hence may account for part of the slower labour productivity growth in this period.
- Labour unions can influence productivity, with the effects both positive and negative and their relative importance a topic of heated debate among researchers. Some argue that workplace rules such as narrow job descriptions negotiated by unions to protect their membership impede flexibility in the workplace and reduce productivity growth. Others point out that unions provide a voice for workers, increasing job satisfaction and reducing turnover, thereby improving productivity growth. There appears to be no obvious relationship. Both union density and productivity increased in the early 1980s and then fell in the mid-1980s. Union density rose in the late 1980s while productivity showed little trend. From this perspective it appears that neither the level nor rate of

change in union density is a significant factor in explaining productivity trends in the construction sector.

- It is sometimes asserted that the construction sector has an older and rapidly aging workforce, and that this situation may have an impact on productivity reflecting differential productivity by age. However, census data on the age structure of workers in the construction sector provide little support for any major role for the demographic structure of the workforce as an explanation of productivity developments in the sector.

Conclusion

The findings of this article are paradoxical. Despite an increased capital-labour ratio and higher levels of educational attainment in the workforce, labour productivity in the construction sector in Canada was lower in absolute terms at the end of the 1990s than in the early 1980s. The construction sector was almost unique among Canadian industries in experiencing such negative productivity developments over the period.

The article has examined a large number of factors that could be responsible for this situation. The major conclusion is that lagging technical progress appears to lie at the root of the construction sector's poor productivity performance. Because of their labour-intensive nature, many construction activities appear not to be amenable to productivity advance, despite increased capital per worker and higher education levels for the workforce. While the construction sector enjoyed productivity gains in the immediate postwar period, with the labour required to build a house falling significantly, these gains have not been repeated in the last two decades. In addition, measurement problems have also probably contributed to the poor measured productivity performance of the construction sector in Canada.

Notes

* This article is an abridged version of a much longer study entitled "Productivity Trends in the Construction Sector in Canada" prepared by the Centre for the Study of Living Standards for Canada Mortgage and Housing Corporation. The full study is available at www.csls.ca/reports. The author would like to thank Jean-Pierre Maynard, Someshwar Rao, Eric Tsang, and Julie Bernier for comments and Jeremy Smith and Yu Zhang for research assistance. Email: csls@csls.ca.

1 Statistics Canada recently released estimates of productivity by industry (*The Daily*, August 24, 2001) showing that in 1996-97 GDP per job in construction averaged $43,500 at the national level. Only two out of nine sectors for which data were released (agriculture, fishing and trapping and low-wage services) had lower productivity levels. The relatively low capital intensity of the construction sector explains, at least in part, why labour productivity levels in the sector are below the national average.

2 Given the below average productivity growth, cost increases have been above average in the construction sector. From 1961 to 1997, unit labour costs increased 5.4 per cent per year in construction, compared to 4.5 per cent in the business sector (Appendix Table 1). The better productivity performance in the non-residential building construction translated into below average unit labour cost increases (4.3 per cent). On the other hand, the much weaker productivity growth in repair construction and residential construction resulted in higher cost increases in these industries (6.7 per cent and 6.0 per cent per year respectively). Paradoxically, since 1981 the relative price of housing has been falling dramatically despite the above average increase in unit labour costs in residential construction. From 1981 to 1997 the price of new houses increased 1.9 per cent per year, compared to 3.8 per cent for the Consumer Price Index. Unit labour costs in the residential construction sector rose 3.8 per cent per year versus 2.9 per cent for the business sector. For a detailed discussion of this situation, see CSLS (2001).

Because construction is not a traded good, the decline in cost competitiveness has not led to increased imports and declining exports. Equally, housing demand, at least in terms of number of units if not square footage, is largely demographically determined. Given the relative price inelasticity of demand for the output of the construction sector, one implication of weak productivity performance is that employment growth is much stronger than it would have been under a regime of faster productivity growth. In other words, employment growth in the construction sector over the last two decades would have been much weaker if productivity growth had tracked the economy-wide average,

as output growth would not have been greatly affected by higher productivity growth.

3 Output per hour growth over the 1961-97 period varied widely within the construction engineering industry, from a high of 2.7 per cent per year in railway and telephone telegraph construction to a low of -0.4 per cent in gas and oil construction facilities construction. It was 1.8 per cent per year in dams and irrigation projects, 0.8 per cent in other engineering construction, and 0.6 per cent in road, highway and airstrip construction (Appendix Table 1).

4 See Lipsey and Carlaw (2000) for a critique of the concept of total factor productivity as currently used by economists. Also see Sargent and Rodriquez (2000).

5 A major barrier to an analysis of the factors determining productivity growth at the industry level in the construction sector is lack of data. The most glaring gap is the lack of capital stock data. At this time Statistics Canada only produces capital stock data for the overall construction sector. This means that it is not possible to include estimates of capital intensity, investment, and capacity utilization in any equation for the different construction industries. A second problem with the capital stock data for the construction industry is that it includes only the capital stock owned by firms classified to this industry and hence excludes capital stock owned by the financial sector and leased to the construction sector. A second gap is the lack of establishment-level data on the residential construction sector as no survey of residential construction firms is conducted. This means that there is limited information on the characteristics of the firms and establishments in the sector.

6 The construction sector is not capital-intensive. In the 1984-88 period, it ranked 44th out of 50 industries in the gross investment intensity of production, 42nd in the machinery and equipment investment intensity of production, 43rd in the gross capital stock intensity of production, and 39th in the machinery and equipment capital stock intensity of production (CSLS, 2001:Appendix Table 45). It is unlikely that this situation changed significantly in the 1990s.

7 According to figures compiled by Industry Canada (CSLS, 2001:Appendix Table 43), in 1986 the sector ranked 47th out of 50 industries in the proportion of knowledge workers (9.9 per cent of the construction workforce), 34th in the proportion of scientists and engineers (2.3 per cent) and 28th in the proportion of workers with post-secondary education (36.5 per cent).

8 The link between the unemployment rate and productivity is similar to the relationship between capacity utilization and productivity. On the one hand, weak demand conditions, which lead to increased unemployment, can have a negative or pro-cyclical productivity decline due to the presence of overhead labour. There will be a negative relationship between the unemployment rate and productivity even though there is no causation. On the other hand, weak demand that produces higher unemployment may have a positive or countercyclical effect on productivity through greater effort exerted by the employed workers because of fear of layoffs or through a composition effect whereby the less productive workers are the first laid off. In this channel, greater unemployment directly increases productivity so there is a causal relationship. Again the second relationship seems more related to developments over the past two decades. Productivity growth rose during the recessionary early 1980s and 1990s when unemployment increased. Equally productivity growth was flat or in decline during periods when the unemployment rate was in decline.

9 Labour productivity growth in the construction sector in the United States has been negative since 1973. Real value added per hour fell 1.5 per cent per year in the 1973-79 period, 0.6 per cent in 1979-87, and 0.3 per cent in 1987-98 (CSLS, 2001: Appendix Table 80).

10 According to the CHBA (2000), since the introduction of the GST in 1991, the underground share of total housing activity has increased significantly. A study for the Ontario Construction Secretariat (O'Grady *et al.*, 1998) found a large underground economy in the construction sector. It estimated that underground construction employment in Ontario averaged between 58,000 and 79,000 annually between 1995 and 1997, with most of the underground work in the residential renovations sector. According to the study, in Ontario 53 per cent of all employment in repair construction and 44 per cent in alterations and improvements was underground. For new housing the figure was 12 per cent and for non-residential construction 10 per cent. Unfortunately, no time series information is available so one does not know if the relative importance of underground activity has increased over time.

11 For example, in the 1984-88 period the construction industry (CSLS, 2001:Appendix Table 42) ranked dead last (43 out of 43) in terms of R&D intensity and was second to last (ahead of retail trade) in both R&D personnel per worker and professional R&D personnel per worker. In terms of patent activity, the construction industry ranked below average on most indicators in the 1984-88 period (CSLS, 2001:Appendix Table 44). It ranked 38th out of 55 industries in terms of total patents used per unit of output and 32nd in total patents granted per unit of output. It did better in the absolute number of patents given the large relative size of the sector, ranking 9th in total patents used, 28th in total patents granted, and 16th in externally used patents.

12 A key characteristic of the construction sector is that it benefits from technological change in other sectors. Technological advances in construction materials and construction tools and equipment generated by these industries in the manufacturing sector boost productivity in the construction sector, but this innovative activity is not registered in the construction sector.

13 One of the first attempts to chronicle innovation activity in the construction industry has been made by the Science, Innovation and Electronic Information Division (Statistics Canada, 2001). The report found that in 1999 only 16 per cent of construction businesses considered investing in research and development important, and only 14 per cent

considered patenting important. E-mail was the most widely used new technology, with only 38 per cent of businesses using it now and another 25 per cent planning to use it within two years. The most widely used sources of information about innovation were suppliers, trade journals, and clients, rather than government programs. The report provided no historical data so it is not possible to compare current innovative effort and use of advanced technologies in the construction sector with past trends.

14 The person-hours eliminated were not simply transferred to a factory. In almost every case, the factory production of the materials consumed fewer hours.

15 The following quotation sums up well the state of residential renovation:

"For many renovation firms, most jobs are one-off, surprise-ridden, barely planned and never truly repeatable. In the mid-1980s, as in the mid-1940s, no pattern or discernible stage of evolution, no real changes or hints of change, no technological breakthroughs, presents itself. Indeed, there may be reversals: a need in the mid-1980s and beyond for the once-traditional materials, skills and techniques that were part of the fabric of house construction/renovation in the mid-1940s, instead of some of the newer materials and procedures used for new housing production in the mid-1980s." (CMHC, 1989:29)

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Appendix Table 1
Productivity Trends in the Construction Sector and its Components, 1961-2000, Average Annual Growth Rates

	Real GDP	Number of Jobs	Average Hours	Hours Worked	Real GDP per Hour	Hourly Labour Compensation	Total Labour Compensation	Unit Labour Cost
Business Sector								
1961-1981	4.73	2.64	-0.65	1.97	2.71	8.75	10.90	5.87
1981-1989	3.18	1.97	0.04	2.02	1.13	5.52	7.63	4.35
1989-1997	2.06	0.79	-0.12	0.67	1.38	2.83	3.53	1.44
1989-2000	2.74	1.40	-0.04	1.36	1.37	2.97	4.37	1.58
1961-2000	3.85	2.15	-0.33	1.81	2.00	6.43	8.35	4.33
1961-1997	3.78	2.08	-0.38	1.69	2.06	6.69	8.50	4.53
1981-1997	2.61	1.38	-0.04	1.34	1.25	4.17	5.56	2.88
Total Construction								
1961-1981	3.69	1.79	-0.09	1.70	1.97	9.09	10.94	6.99
1981-1989	1.84	1.93	0.53	2.48	-0.61	4.23	6.81	4.87
1989-1997	-1.09	-1.11	-0.12	-1.23	0.14	2.07	0.81	1.94
1989-2000	-0.08	0.11	0.14	0.25	-0.34	2.24	2.49	2.58
1961-2000	2.23	1.34	0.10	1.45	0.78	6.12	7.65	5.29
1961-1997	2.20	1.17	0.04	1.21	0.98	6.41	7.69	5.38
1981-1997	0.36	0.40	0.20	0.61	-0.24	3.15	3.77	3.39
Residential Construction								
1961-1981	4.36	3.07	-0.13	2.95	1.37	9.23	12.48	7.76
1981-1989	3.25	4.74	0.82	5.60	-2.23	4.63	10.51	7.00
1989-1997	-0.60	-1.93	-0.21	-2.14	1.58	1.52	0.14	0.75
1961-1997	2.99	2.30	0.06	2.37	0.61	6.64	9.18	5.99
1981-1997	1.31	1.35	0.31	1.66	-0.35	3.47	5.19	3.82
Non-Residential Building Construction								
1961-1981	3.84	1.47	-0.12	1.35	2.45	8.38	9.85	5.79
1981-1989	3.97	3.49	0.53	4.04	-0.07	4.20	8.41	4.27
1989-1997	-3.04	-3.97	-0.14	-4.11	1.12	1.94	-2.25	0.81
1961-1997	2.30	0.68	0.02	0.70	1.59	5.99	6.73	4.33
1981-1997	0.41	-0.31	0.19	-0.12	0.53	3.07	2.94	2.53
Repair Construction								
1961-1981	2.16	-0.56	0.02	-0.54	2.72	11.35	10.75	8.41
1981-1989	2.59	2.77	0.16	2.93	-0.33	4.34	7.40	4.68
1989-1997	-1.96	0.67	-0.13	0.54	-2.49	1.86	2.41	4.46
1961-1997	1.32	0.44	0.02	0.46	0.86	7.60	8.10	6.68
1981-1997	0.29	1.71	0.02	1.73	-1.42	3.09	4.87	4.57
Engineering Construction (Excluding Repairs)								
1961-1981	3.54	2.84	-0.13	2.70	0.81	7.98	10.90	7.11
1981-1989	-1.24	-3.74	0.78	-2.98	1.79	4.48	1.37	2.64
1989-1997	0.84	1.65	-0.11	1.54	-0.69	1.81	3.38	2.52
1961-1997	1.86	1.08	0.08	1.16	0.69	5.80	7.02	5.07
1981-1997	-0.21	-1.08	0.33	-0.75	0.55	3.14	2.37	2.58

Note: The growth rate of the Number of Jobs plus the growth rate of Average Hours gives the growth rate of Hours Worked. The growth rate of Hours Worked plus the growth rate of Hourly Compensation gives the growth rate of Total Compensation. The growth rate of Real GDP subtract the growth rate of Hours Worked gives the growth rate of Real GDP per Hour. The growth rate of Total Compensation subtract the growth rate of Real GDP gives the growth rate of Unit Labour Cost.

Source: Published and unpublished data from Aggregate Productivity Measures, May 28, 2001, Statistics Canada.

Appendix Table 2
Levels of Output Per Hour in the Construction Sector by Industry, 1961-2000
(1992 $)

	Total Construction	Total Excluding Residential	Residential Construction	Non-Residential Bldg. Const.	Other Const.	Repair Const.	Engineering Excluding Repairs	Road, Highway & Airstrip Const.	Gas & Oil Facility Const.	Dams & Irrigation Projects	Railway & Telephone Telegraph Const.	Other Engineering Const.	Construction, Other Activities
	(1)	(2)	A	B	C	D	E	F	G	H	I	J	K
1961	16.89	16.13	19.59	13.45	17.32	14.20	20.72	17.97	27.43	22.59	12.30	20.91	16.47
1962	16.14	15.57	18.14	13.54	16.56	13.71	19.82	16.89	27.69	21.54	11.96	20.28	16.67
1963	15.92	15.31	18.07	13.24	16.27	13.51	19.23	15.86	26.43	21.03	11.61	19.82	19.63
1964	16.30	15.72	18.07	14.21	16.38	13.90	18.75	15.23	25.64	21.30	11.80	19.25	17.72
1965	16.20	15.65	17.97	14.22	16.36	14.71	17.82	13.99	24.31	20.19	10.81	18.40	19.68
1966	15.08	14.66	16.72	13.51	15.25	13.55	16.72	13.00	22.18	19.21	9.97	17.50	19.41
1967	16.24	15.83	17.74	13.69	16.92	15.05	18.64	15.26	21.55	21.40	11.81	20.17	21.68
1968	18.13	17.17	21.29	14.80	18.29	16.68	19.80	16.17	21.77	22.78	12.18	21.02	23.55
1969	18.14	16.62	22.80	14.45	17.63	16.04	19.03	15.71	20.34	22.94	11.59	19.22	25.18
1970	18.79	17.58	23.38	15.07	18.77	16.18	20.81	17.23	21.37	25.51	13.31	21.07	25.44
1971	18.39	17.43	21.49	14.89	18.61	16.47	20.00	16.51	21.66	24.89	13.48	18.98	28.65
1972	18.51	18.08	19.61	14.70	19.56	18.00	20.55	17.75	21.33	27.81	11.73	18.62	30.70
1973	17.54	17.80	16.99	13.84	19.77	18.34	20.76	17.05	21.72	26.90	13.37	19.12	32.07
1974	17.07	17.15	16.90	13.71	18.97	18.67	19.18	13.72	19.14	25.90	14.22	18.25	34.49
1975	18.95	19.08	18.62	15.13	21.27	21.05	21.41	15.22	19.91	30.38	15.79	19.50	35.10
1976	20.83	21.49	19.65	18.23	22.93	22.46	23.24	18.04	21.96	28.89	17.55	22.26	38.41
1977	22.44	22.64	22.04	20.14	23.63	23.46	23.74	17.85	22.89	32.84	17.76	20.83	38.48
1978	22.49	22.26	22.97	19.47	23.32	22.89	23.59	18.13	20.22	36.29	15.60	20.58	31.62
1979	22.19	21.66	23.43	19.00	22.83	22.82	22.83	16.88	19.58	36.55	14.78	19.61	31.73
1980	23.34	22.10	26.91	20.65	22.75	22.72	22.76	17.56	18.27	38.51	18.19	19.39	34.06
1981	24.16	23.56	25.73	21.83	24.33	24.28	24.36	16.21	25.32	36.13	21.33	19.26	39.50
1982	26.94	26.12	29.38	23.47	27.18	26.92	27.32	18.34	27.45	44.04	22.65	21.70	41.30
1983	27.13	26.21	29.57	24.54	26.84	23.67	28.90	18.25	28.50	53.99	20.28	22.14	40.97
1984	25.71	24.56	28.89	25.67	24.14	23.22	24.76	17.14	25.41	41.62	21.67	20.09	40.66
1985	26.22	24.78	30.16	25.62	24.40	23.66	24.91	19.66	24.60	44.86	20.98	20.40	41.16
1986	26.48	25.56	28.44	25.64	25.52	24.05	26.73	20.77	27.48	47.35	20.85	22.22	38.53
1987	24.91	25.03	24.71	23.89	25.67	23.47	27.73	23.80	27.33	45.04	21.20	23.20	39.39
1988	23.63	24.12	22.70	22.58	25.03	23.29	26.55	22.33	27.98	38.76	20.66	22.64	34.26
1989	23.29	24.29	21.47	21.72	25.96	23.65	28.09	23.27	28.82	40.27	23.71	23.54	31.89
1990	23.56	24.69	21.34	21.62	26.61	24.41	28.52	24.04	28.73	37.73	24.29	24.30	37.01
1991	24.31	25.54	21.70	23.77	26.44	23.10	29.20	25.78	25.38	38.62	27.17	26.65	35.41
1992	23.53	24.86	21.06	23.58	25.44	21.78	29.13	24.30	24.36	39.62	26.90	26.40	36.29
1993	22.94	23.91	21.10	24.27	23.78	20.00	27.53	24.03	23.58	38.16	27.86	24.37	35.87
1994	22.60	23.14	21.53	23.61	22.97	19.93	25.51	22.61	21.77	36.24	30.66	23.96	38.28
1995	22.63	22.90	22.03	22.66	22.99	18.85	26.40	21.78	23.87	37.14	35.17	25.95	35.01
1996	23.27	23.12	23.62	22.95	23.18	18.55	27.37	21.58	25.03	42.92	38.61	25.01	34.88
1997	23.71	23.40	24.35	23.74	23.25	19.33	26.58	22.17	23.51	43.00	32.10	27.74	35.11
1998	23.62												
1999	22.99												
2000	22.61												
						Average annual growth rates							
61-97	0.95	1.04	0.61	1.59	0.82	0.86	0.69	0.58	-0.43	1.80	2.70	0.79	2.12
61-81	1.81	1.91	1.37	2.45	1.71	2.72	0.81	-0.52	-0.40	2.37	2.79	-0.41	4.47
81-89	-0.46	0.39	-2.24	-0.07	0.81	-0.33	1.79	4.62	1.63	1.37	1.33	2.53	-2.64
89-97	0.22	-0.47	1.58	1.12	-1.37	-2.49	-0.69	-0.61	-2.51	0.82	3.86	2.08	1.21
89-00	-0.27												
95-00	-0.02												

Notes: A+B+C=(1), D+E=C , E=F+G+H+I+J+K, (2)=(1)-A

Source: Published and unpublished data from Aggregate Productivity Measures, May 28, 2001, Statistics Canada.