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The Canadian Productivity Review

Capital Intensity in Canada and the United States, 1987 to 2003

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Abstract

Official data from statistical agencies are not always ideal for cross-country comparisons because of differences in data sources and methodology. Analysts who engage in cross-country comparisons need to carefully choose among alternatives and sometimes adapt data especially for their purposes. This paper develops comparable capital stock estimates to examine the relative capital intensity of Canada and the United States.

To do so, the paper applies common depreciation rates to Canadian and U.S. assets to come up with comparable capital stock estimates by assets and by industry between the two countries. Based on common depreciation rates, it finds that capital intensity is higher in the Canadian business sector than in the U.S. business sector. This is the net result of quite different ratios at the individual asset level. Canada has as higher intensity of engineering infrastructure assets per dollar of gross domestic product produced. Canada has a lower intensity of information and communications technology (ICT) machinery and equipment (M&E). Non-ICT M&E and building assets intensities are more alike in the two countries.

However, these results do not control for the fact that different asset-specific capital intensities between Canada and the United States may be the result of a different industrial structure. When both assets and industry structure are taken into account, the overall picture changes somewhat. Canada's business sector continues to have a higher intensity of engineering infrastructure and about the same intensity of building assets; however, it has a deficit in M&E that goes beyond ICT assets.

Keywords: productivity, investment, Canada–United States differences

Executive summary

This paper examines changes in capital intensity in Canada since 1987 and compares them with those in the United States. Capital–output ratios are used as the metric for comparison.

Capital–output ratios as summary statistics tell us about the nature of the production process. Higher capital output ratios indicate that more capital is being used in production. Changes over time in these ratios have been used to generate conclusions about capital productivity or about the extent to which technological progress is mainly labour enhancing.

When comparing capital intensity across countries, one must grapple with potential differences in methods and data sources. This paper approaches this problem by standardizing one critical set of assumptions so as to produce a more comparable set of estimates. It adopts a common set of depreciation estimates for the two countries and then estimates capital stock using the perpetual inventory technique.

Making use of a comparable set of depreciation rates changes the nature of conclusions about the capital intensity of the two countries. If comparisons of capital intensity are made with the depreciation rates that are used by Statistics Canada in its productivity program and by the Bureau of Economic Analysis in its estimates of capital stock, then the stock of capital as a share of gross domestic product (GDP), or capital intensity, is lower in Canada. However, once we impose common depreciation rates for similar asset classes, Canada's overall capital intensity is higher than that of the United States.

An examination of investment-to-GDP ratios by asset class reveals substantial differences, both in terms of level and trends. Canada's engineering investment-to-GDP ratio is much higher than that of the United States. By contrast, there has been a persistent information and communications technology (ICT) investment-to-GDP ratio gap between Canada and the United States that has increased over time. At an aggregate level, the non-ICT machinery and equipment (M&E) and building assets intensities are more alike in the two countries.

There is always the danger when working with macro data for the entire economy that important differences in the underlying structure of the economy will be missed. Therefore this paper examines the extent to which differences in capital intensity are related to differences in the underlying industry and asset structures of the two countries. It uses a decomposition analysis to examine whether there are substantial differences in the underlying components (both assets and industries) in Canada and the United States.

While Canada has a higher overall capital intensity in the business sector—because it has relatively more engineering assets (pipelines, dams, railways) and less ICT assets—the relative amounts of non-ICT M&E and building assets are more alike in the two countries. This suggests a different aggregate production function that stems from a different industrial composition or from differences in production techniques that are associated with a different economy.

To address this issue, the paper uses a shift-share decomposition analysis to examine whether the higher Canadian capital intensity is the result of differences in asset or industry composition. This analysis shows that Canada's business sector is more capital intensive primarily because of both its industry structure and its focus on engineering assets. Two sectors, the other primary sector (including mining) and utilities, are very intensive in engineering capital in Canada; together, they contributed the preponderance of the intensity effect advantage over the United States.

The industries where engineering assets are concentrated are the core infrastructure industries that provide universal services on which the rest of the economy relies—transportation, communications and energy. These industries are more important in Canada, which may reflect the fact that Canada has a comparative advantage in some natural resource sectors that are associated with these industries and that the Canadian economy is more diverse geographically and requires more of the services of these sectors per unit of GDP produced than does the United States.

The non-ICT M&E capital intensity in the Canadian business sector is 14% higher than in the United States because Canada tends to concentrate more on industries with higher non-ICT M&E capital intensity. When the difference in the industrial structures in the two countries is controlled for, the non-ICT M&E capital intensity is 12% lower in Canada.

The largest capital intensity gap exists in ICT. Canada's ICT capital intensity has been persistently lower than that of the United States since at least 1987. The gap was fairly widespread across industries in 2003, with differences in industrial structure not playing a significant role. The ICT intensity gap was particularly large in construction; transportation, warehousing and utilities; and in the finance, insurance, real estate and rental and leasing sector.

This paper also examines the relative capital intensity of the non-business sector (government, health and education) in the two countries. Capital intensity here is quite similar—at least when it comes to the use of buildings and engineering infrastructure—but it is extremely different when it comes to expenditures on M&E. The latter arises in part because of military equipment spending in the United States. Inclusion of this component in comparisons of the total economy makes it appear that Canada is deficient overall in M&E, even though this is not the case for the business sector.

1 Introduction

The central role of capital and labour in explaining the process of economic growth has never been in doubt; the debate has centered rather on how capital and labour, separately or in combination, contribute to economic growth. Having internationally comparable measures of capital and labour allows researchers to examine the underlying economic process and to choose the analytical model that best fits the empirical evidence. Furthermore, once the specific model is chosen, a detailed study of the data can reveal areas where one country may be underperforming others, thereby allowing for the identification of potential policy prescriptions that will improve economic performance. However, in the absence of accurate and internationally comparable capital and labour data, suggestions for improvements in productivity are problematic.

Much work has recently been done in producing comparable estimates of labour inputs for both Canada and the United States. Recent work by Baldwin et al. (2005) has found that headline labour inputs for Canada and the United States are not comparable. When the necessary adjustments are made to improve the comparability between the two measures, the level of hours worked in the United States increases considerably. As a result, Baldwin et al. (2005) find that the magnitude of the labour productivity level gap between Canada and the United States is smaller than widely believed.

While much work has been done to improve the comparability of capital stocks between the two countries, measurement issues still remain, as capital stocks can vary based on the underlying assumptions of service lives and asset-specific decay patterns. Blades (1983) pointed to the need to be cautious about different assumptions being employed across countries as to the length of life of capital assets. Baldwin and Gorecki (1986) pointed out the need to use similar methodologies when comparing Canadian and U.S. capital stocks[1]—a message that seems to have been forgotten in the ensuing years.[2]

While differences in methodology may not impact greatly on estimates of growth in multifactor productivity (MFP), they can have a significant impact on comparisons of levels of productivity and levels of capital intensity. The objective of this study is to apply common depreciation rates to both Canadian and U.S. assets in order to produce more comparable capital stock estimates between the two countries. These estimates of capital stocks are then used to compare capital intensities across industries and asset types between the two countries. An accompanying paper (Baldwin, Gu and Yan 2007) examines the level of MFP in Canada and the United States when both comparable labour and capital data are used.

The following section briefly discusses methods and data sources used for capital stock estimates for the business sector in Canada and the United States. Section 3 presents the decomposition methodology used in this study and Section 4 presents results. Section 5 concludes.

1. For a study of Canadian-U.S. productivity levels, they estimate Canadian and U.S. capital stock in the manufacturing sector using similar assumptions about length of life and discard patterns (see Baldwin and Gorecki 1986: 109–118).
2. For a recent exception, see Schreyer (2005).

2 Construction of comparable capital stocks

Both Canada and the United States use the perpetual inventory method (PIM) to estimate the capital stock of each asset type by assuming a geometric declining pattern. The capital accumulation equation using PIM is

$$K^i_{j,t} = I^i_{j,t} + (1-\delta_j)K^i_{j,t-1}, \tag{1}$$

where, $I^i_{j,t}$ is investment in asset type j in country i in period t. δ in Equation (1) is the geometric rate at which the efficiency of an asset declines over time.

The implementation of PIM requires estimates of the size and time profile of depreciation rates, gross investment time series and an initial level of capital stock, all of which will be discussed in turn below.

2.1 Estimates of depreciation

For the purposes of this paper, we make use of a geometric form of the depreciation rate—that is, we assume that the value of an asset depreciates at a constant rate per year. The productivity program in Canada derives estimates of the depreciation rate from data on the prices of used assets that are sold during their useful lives and data on the time when each asset is discarded (see Statistics Canada 2007). The United States also makes use of prices on used assets to estimate depreciation rates.

Nevertheless, the sources of the data differ. Statistics Canada receives its data directly from its investment survey that includes both positive prices and zero prices when assets are discarded at the end of their useful life. The United States has developed its data from a number of different sources—mainly trade data. These generally only contain prices of assets that are sold at a positive price. The U.S. method also has to make assumptions about the pattern and intensity of discards of assets at zero values because there is a selection bias problem if depreciation rates are estimated from only positive prices.

Both countries also derive constant geometric depreciation rates using data on the length of life of the asset—where data on used asset prices are not available but an estimate of the length of life is available.

This section discusses how depreciation estimates are commonly derived when estimates are available of the length of life (T). We focus on two specific forms of depreciation: straight-line and geometric. While our analytical interest rests with the latter, straight-line depreciation is a useful starting point, and it is applied extensively in a national accounting framework. In this section, the length of life of an asset is treated as non-stochastic—as known with certainty.

Straight-line patterns assume equal dollar value depreciation at all stages of an asset's lifecycle. Per-period depreciation for a dollar of investment takes the form

$$D = \frac{1}{T} \tag{2}$$

where T is service life. Although the dollar loss for straight-line depreciation is equal from period-to-period, the rate of depreciation—that is, the percent change in asset value from period-to-period—increases progressively over the course of an asset's service life. For a marginal dollar of investment, this rate is

$$\delta_i = \frac{1}{T-(i-1)}, \text{ for all periods } i = 1,...,T. \tag{3}$$

Geometric depreciation represents a conceptual counterpoint to the straight-line case. Geometric profiles hold the rate of depreciation, not the period-to-period dollar amount, fixed over the course of an asset's service life.[3] Geometric profiles are accelerated—with higher dollar depreciation in early periods—giving rise to the convex age-price profile.

Per-period depreciation is defined as

$$D_i = \delta(1-\delta)^{(i-1)} \tag{4}$$

where δ is the constant (age invariant) rate of depreciation.

While the straight-line method can often be found in the accounting literature, the majority of empirical research in the North American productivity literature on asset depreciation has concentrated on the geometric form. In early studies, geometric patterns were often assumed. Evidence that geometric rates are generally appropriate for a wide range of asset types is found in Hulten and Wykoff (1981) and Koumanakos and Hwang (1988).[4]

In practice, geometric rates are analytically expedient for two reasons: (1) they can be estimated indirectly via accounting methods; and, (2) their constant-rate property allows them to be used as a proxy for the replacement rate in standard PIMs of capital stock. We address the first of these points below.

Direct estimates of δ can be derived from information on resale prices or on the length of life of the asset (T). For many years, the latter method was the most common and T was determined from accounting information—often associated with tax laws. In the absence of sufficient price information, geometric rates can be calculated indirectly from estimates of the length of life (T) of an asset derived from the tax code as

3. For an overview of the geometric distribution, see Hastings and Peacock (1975).
4. For a survey of the empirical literature, see Fraumeni (1997); for a discussion of empirical methods, see Jorgenson (1994).

$$\delta = \frac{DBR}{T} \tag{5}$$

where T is taken from the service life of the asset (the length of time over which it provides useful value) and DBR (referred to as the declining-balance rate) is chosen in a way that satisfies a certain concordance with the straight-line method (or any other method). The value of the DBR determines, other things equal, the extent to which asset values erode more rapidly early in the lifecycle (Fraumeni, 1997). Higher values of DBR bring about higher reductions in asset value earlier in service life, giving rise to more convex (i.e., accelerated) depreciation profiles.

Double-declining-balance rates (DDBRs)—which set the value of the DBR to 2—have been extensively used in practice. In their estimates of capital stock, Christensen and Jorgenson (1969) employ DDBRs to estimate rates of economic depreciation. Statistics Canada's productivity program at one time based its estimates of geometric depreciation on a double-declining rate. One advantage of the DDBR is that it provides a 'conceptual bridge' back to the straight-line case, anchoring the midpoints of the depreciation schedules at an equivalent age point. Indeed, the average depreciation rate in the straight-line case will match the constant rate derived from a DBR of 2.

To see this, we can examine a simple measure of central tendency. Defining μ as the midpoint of the geometric curve (the expected life of a dollar invested in an asset), then

$$\mu = \frac{1}{\delta}, \tag{6}$$

from Equation (5), when δ is chosen as *DBR/T*

$$\mu = \frac{T}{DBR} \tag{7}$$

Now $\frac{T}{2}$ also represents the midpoint of the linear depreciation schedule (the point at which a dollar is half-way depreciated) of an asset whose length of life is *T*. Thus, if the DBR in the geometric formula is set equal to 2, the linear depreciation world, often used by accountants, can be brought into congruency with a geometric world—so that an average dollar in the geometric world lasts the same amount of time as it takes a dollar to lose half its length of life, which is just the expected life of a dollar invested in an asset in the straight-line world.

When the rate of depreciation is calculated indirectly by Equation (5), an estimate of *T* is also required. When the estimate of T is based on *ex ante* expectations of service life, the depreciation rate can be described as *ex ante*. In Canada, service life estimates can be derived from the expectations of businesses regarding an asset's useful life. The Investment and Capital Stock Division captures in its annual investment survey the expected length of life on all new investments that are reported to Statistics Canada.

There has been considerable debate over whether the assumptions embodied in the calculation of geometric rates are empirically appropriate. Some researchers have questioned whether the high losses in asset value that are often observed early in asset life are consistent with constant, geometric rates. It should be stressed that constant rates do not, in and of themselves, preclude highly accelerated depreciation profiles; rather, the issue is simply whether these rates are, on net, sensible representations of the change in asset value in every period. A key aspect of this debate centres on choosing, by estimation or otherwise, an appropriate value for the DBR. Even if constant-rate, geometric age-price profiles are empirically justified, the choice of particular values for DBR and T is still at issue. If T is chosen from the tax code, the estimate thereof may differ from actual lives if the tax code does not use accurate length of lives—as it may deliberately do if it is trying to stimulate investment. For this reason, Statistics Canada derives a value of T from its investment survey. Admittedly, firms are required, in advance, to predict how long an asset may last—and may err in a systematic way. But the estimates of T derived in this matter can and have been checked against the evidence on discards and found to accord closely with the latter (Statistics Canada 2007).

Recent estimates of geometric depreciation used by the Bureau of Economic Analysis make use of a lower value for the declining-balance rate for many individual assets (DBR=1.65 for machinery and equipment [M&E] and 0.91 for structures). Based on the empirical research of Hulten and Wykoff (1981), these values will, other things being equal, produce lower rates of geometric depreciation than the double-declining case for the same value of T. But they need not do so if they are chosen along with T so as to produce correct values of the depreciation rate that are derived from used asset prices.

The basis for the Hulten-Wykoff estimates of the DBR warrant some discussion here. In a study for the Office of Tax Analysis of the Department of the Treasury, the authors generate direct estimates of geometric depreciation for those assets for which they had used asset price data, and then base estimates of δ for other assets (for assets for which no price information was available) on the geometric accounting method described by Equation (5), using arbitrary estimates of T that are essentially developed from the tax code. That is, they estimate DBR in the first stage for all assets where they have a direct estimate of δ and T and then apply this DBR in the second stage to those assets where they only have an estimate of T. This two-stage procedure enabled the authors to produce a set of depreciation estimates for asset classes used by the U.S. National Income and Product Accounts.

The first stage of this process yielded average DBR values of 1.65 for M&E and 0.91 for structures—average DBR values based on asset categories for which price information was directly available.[5] In cases where no price information on other assets was available, the authors then combined these estimates of the DBR with asset-specific information on tax-code service

5. As Hulten and Wykoff (1981: 94) note, the asset categories for which they were able to calculate depreciation rates directly from price information represent a substantial share of total National Income and Product Accounts investment expenditures—42% of investment in non-residential structures and 55% of investment in producers' durable equipment.

life T to produce indirect estimates of δ.[6] The estimates of DBR so produced were only meant to be useful for filling in their data set, not to be used for alternate estimates of T, such as those which Statistics Canada's survey produces from direct questions to firms on the expected length of life of assets.

The productivity program at Statistics Canada also follows a variant of this technique.[7] It estimates δ directly from used asset and discard data for those assets where there are an adequate number of observations and a value of the DBR from these assets that produces the estimated δ from the *ex ante* length of life *T* that is yielded by its survey. The resulting estimates of DBR (2.1 for M&E and 2.3 for structures) are then applied to other asset classes where only information on asset life is available (mainly structures). While the DBR that is produced by these two methods differs, it should be noted that the differences are the result primarily of differences in the length of life that is used in the second stage and are not necessarily meaningful. Indeed, Statistics Canada (2007) shows that the depreciation rates for M&E in the two countries are essentially the same, despite the differences in the DBRs that are derived in this way.

For a comparison of Canadian and U.S. capital stocks, we can use several different methods. These are outlined in Table 1 as Methods 1, 2 and 3.

Method 1 takes the U.S. DBRs and applies them to the Canadian length-of-life data that are derived from the Canadian investment survey. As argued above, this is inappropriate for our purposes. These values were chosen in the U.S. studies so as to equate the estimated depreciation rates to the *T*'s that are estimated from a wide variety of ad hoc sources in the United States. (Fraumeni 1997, Bureau of Economic Analysis 2003). Since Canadian *ex ante T*'s are derived from the Annual Investment Survey from the Investment and Capital Stock Division, the U.S. DBRs do not generate the correct depreciation rates that are estimated from those assets that have an adequate quantity of data to directly estimate depreciation rates.

Method 2 makes use of the technique that essentially produces the depreciation rates that are derived directly and indirectly in each country. It employs used asset price data to derive depreciation rates directly for those assets for which used asset price data exist, then derives the DBRs for these assets using estimates of *T* and then applies these estimated DBRs to other assets where only estimates of *T* are available.

Method 3 is directly equivalent to Method 2. It uses the average DBRs that are obtained in Method 2.

6. For a useful discussion of the Hulten-Wykoff methodology, see Fraumeni (1997).
7. We refer here to the capital stock estimates that are derived specifically for the productivity program at Statistics Canada. Other capital stock estimates are produced that serve other purposes in Statistics Canada. The Investment and Capital Stock Division produces capital stock estimates using a straight line method, a hyperbolic and a geometric method because various users have requested these alternatives. Prior to 2000, the geometric truncated model was produced using a double-declining balance rate. More recently, it adopted the U.S. declining-balance rates for its geometric series at the request of some users. The productivity group derives its own estimates of capital stock because of different requirements.

When we use either Method 2 or Method 3, we are employing the respective depreciation rates that are imbedded in the two official statistical systems. There are reasons to be cautious about adopting this approach, which allows the rates to differ across the two countries. While the estimates of the depreciation rates in Canada and the United States are about the same for M&E, the rates of depreciation on structures are higher in Canada than in the United States (see Table 2).[8]

These cross-country differences in depreciation rates probably derive from differences in the quality of the data. The Canadian data have been collected in a systematic way from a survey that provides data on both used asset prices and discard patterns since 1987. The U.S. data are collected from a variety of sources, some of which are dated, and direct data on discards are rarely available.

For purposes of comparisons of growth rates across countries, slight differences in depreciation rates are not very important—at least not for the technique that is used in both countries that employs the internal rate of return. Statistics Canada (2007) reports that the differences in the depreciation rates that are produced by slightly different econometric techniques has only a minor effect on estimated rates of multifactor productivity (MFP) growth.

But for cross-country estimates of MFP levels, differences may be more important. We therefore chose to construct capital stocks for both Canada and the United States using one set of depreciation rates for purposes of comparability. For the majority of the results reported herein, we use the rates that have been derived from the Canadian data for both Canadian and U.S. capital stock. But we also make use of the U.S. rates to ask whether there is much of a difference between the two. We find these differences are minor.

8. The Bureau of Economic Analysis (BEA) depreciation rates in the table are implicit geometric depreciation rates. For those assets (such as computers and software) whose implicit depreciation rates changed over time, we take the average over the 1987-to-2002 period as the approximation to the BEA depreciation rates.

Table 1
Depreciation patterns and methods used in Canada and the United States

		Canada	United States
Method 1		Derive geometric rates from DBR/T[2] formula	Derive geometric rates from DBR/T formula
	Assumed DBRs[1]	1.65—machinery and equipment 0.9—structures	1.65—machinery and equipment 0.9—structures
	Service lives	Derived from *ex ante* estimates from investment survey	Derived from tax records and other sources
Method 2			
	Step 1 (for assets with used asset prices and discard information)	Estimate geometric depreciation rate directly and then estimate DBR using length of life T for these assets	Estimate geometric depreciation rate directly and then estimate DBR using length of life T for these assets
	Step 2 (for assets without used asset prices)	Estimate geometric rate from implicit DBR derived in Step 1 for similar assets and estimate of expected length of life from investment survey	Estimate geometric rate from implicit DBR derived in Step 1 for similar assets and estimate of expected length of life from various ad hoc sources
Method 3		Derive geometric rates from DBR/T formula	Derive geometric rates from DBR/T formula
	Assumed DBRs	2.1—machinery and equipment 2.3—structures	1.65—machinery and equipment 0.9—structures
	Service lives	Derived from *ex ante* estimates from investment survey	Taken from various tax and other sources in the United States

1. Declining-balance rates.
2. T stands the for service life of an asset.
Notes: Canadian and U.S. results are both based on the infinitely lived geometric model. Results shown are from authors' calculations.
Sources: Statistics Canada; and Bureau of Economic Analysis.

Table 2
Bureau of Economic Analysis and Statistics Canada (productivity accounts) depreciation rates by asset type

Asset code	Canada asset type	Implicit Bureau of Economic Analysis depreciation rate	Statistics Canada depreciation rate	Asset class[1]
1	Office furniture, furnishing and fixtures	0.29	0.24	Non-ICT M&E[2]
2	Non-office furniture, furnishings and fixtures	0.14	0.21	Non-ICT M&E
3	Motors, generators and transformers	0.14	0.13	Non-ICT M&E
4	Computer-assisted process equipment	0.16	0.17	Non-ICT M&E
5	Non-computer-assisted process equipment	0.16	0.16	Non-ICT M&E
6	Communication equipment	0.14	0.22	ICT M&E
7	Tractors and heavy construction equipment	0.16	0.17	Non-ICT M&E
8	Computers, hardware and word processors	0.50	0.47	ICT M&E
9	Trucks, truck tractors, truck trailers and parts	0.22	0.23	Non-ICT M&E
10	Automobiles and major replacement parts	0.22	0.28	Non-ICT M&E
11	Other machinery and equipment	0.18	0.20	Non-ICT M&E
12	Electrical equipment and scientific devices	0.16	0.22	Non-ICT M&E
13	Other transportation equipment	0.07	0.10	Non-ICT M&E
14	Pollution abatement and control equipment	0.07	0.15	Non-ICT M&E
15	Software	0.49	0.55	ICT M&E
16	Plants for manufacturing	0.03	0.09	Buildings
17	Farm building, garages and warehouses	0.03	0.08	Buildings
18	Office buildings	0.03	0.06	Buildings
19	Shopping centres and accommodations	0.03	0.07	Buildings
20	Passenger terminals, warehouses	0.03	0.07	Buildings
21	Other buildings	0.03	0.06	Buildings
22	Institutional building construction	0.02	0.06	Buildings
23	Transportation engineering construction	0.02	0.07	Engineering
24	Electric power engineering construction	0.02	0.06	Engineering
25	Communication engineering construction	0.02	0.12	Engineering
26	Downstream oil and gas engineering facilities	0.07	0.07	Engineering
27	Upstream oil and gas engineering facilities	0.07	0.13	Engineering
28	Other engineering construction	0.02	0.08	Engineering

1. The four asset classes used in this paper.
2. Non-information and communications technology machinery and equipment.
Sources: Statistics Canada, 2007, *Depreciation Rates for the Productivity Accounts*; and Bureau of Economic Analysis, 2003, *Fixed Assets and Consumer Durable Goods in the United States, 1925-97*.

2.2 Investment data

The underlying data used in generating the estimates of capital stocks in Canada are derived from investment data based on the North American Industry Classification System (NAICS) that is used in the MFP program of Statistics Canada (Baldwin, Gu and Yan 2007). These data contain investment in current dollars and chain Fisher volume indices over the 1926-to-2003 period for the 28 assets listed in Table 2.[9]

The main data source for estimating capital stock in the United States is investment data by industry based on NAICS over the 1901-to-2005 period.[10] These data are obtained from the Bureau of Economic Analysis (BEA) and contain investment for 47 assets. The investment data for the U.S. government sector can only be divided into three assets—M&E, building structures and engineering structures.[11]

For this paper, we divide our assets into four groups—engineering assets, buildings, non-information and communications technology (ICT) M&E, and ICT M&E. Engineering assets provide the foundation capital for railways, utilities, oil and gas, and pipelines. Buildings house manufacturing plants, commercial offices, hotels, and retail and wholesale facilities. ICT M&E is defined here as including computers, telecommunications equipment and software. Non-ICT M&E is the remainder—some of which is also highly sophisticated and embodies computer automation.

2.3 Initial capital stocks

The level of capital stock is sensitive to the depreciation profiles and depreciation rates that are used to estimate it.[12] To develop comparable measures of capital stock, we have used geometric depreciation profiles and depreciation rates for Canada and the United States as explained in Table 1. The depreciation rates in the table are derived from Statistics Canada research that estimates depreciation profiles for a diverse set of assets that employs used asset prices derived from a Statistics Canada survey (Statistics Canada 2007). The resulting depreciation rates are on

9. The data for 1926 to 1960 contain investment for three assets (machinery and equipment, building structures and engineering structures). To obtain investment for the 28 assets over the 1926-to-1960 period, we assume that the share of investment by asset type over that period is the same as the one averaged over 1961, 1962 and 1963.
10. See Lally (2004) for a discussion of the data.
11. We make use of current dollar and constant dollar estimates from Statistics Canada and from the Bureau of Economic Analysis and do not impose a similar deflator for computers as is done in Schreyer (2005) for his comparison of North America and Europe since the latter is less likely to use hedonics for computers than is North America. However, both Canada and the United States use hedonics to estimate the price deflator for computers, and any differences between the two countries are therefore felt to reflect legitimate differences in market pricing behaviour.
12. Growth rates may also be sensitive to these differences. For the effect on growth rates of capital in Canada using alternative assumptions on depreciation, see Gellatly, Tanguay and Yan (2002).

average the same as those used by the BEA for M&E. They are slightly higher for buildings and engineering construction.[13]

To estimate capital stock, we also need to choose an initial value of capital stock. For Canada, capital stock is estimated using the historical investment from 1926 to 2003. For the United States, capital stock is estimated using historical investment from 1901 to 2005. An initial capital stock in 1926 is chosen for Canada and in 1901 for the United States. That actual value chosen has little effect on capital stock estimates for the 1987-to-2003 period that is used in this paper.

2.4 Other data issues

2.4.1 Coverage of the finance, insurance, real estate and renting and leasing sector

While both Canada and the United States adhere to international standards (the 1993 System of National Accounts) in estimating gross domestic product (GDP), some differences in industrial coverage remain. One major difference is in the finance, insurance, real estate and renting and leasing (FIRE) sector. In the United States this sector includes the rent from rental and owner-occupied residential building. The FIRE sector in the Canadian Productivity Accounts (CPA) includes only the rent from rental residential buildings, but not the imputed rent from owner-occupied dwellings. In order to increase comparability, we have moved the imputed rent of owner-occupied dwellings from the U.S. FIRE sector to the U.S. non-business sector. This means that we have included investment in rental housing in the FIRE sector and included investment in owner-occupied dwellings in the non-business sector.

2.4.2 Definition of the business sector

In this paper, we will examine Canadian-U.S. differences in investment and capital intensities in the total economy and the business sector. The business sector covers the total economy less the non-business sector. The non-business sector in this paper includes the government sector and the health and education sectors. The data for Canada and the United States are both based on NAICS. As such, the government sector (NAICS 91) includes public schools and public hospitals. The private and non-profit schools and hospitals are included in the education and health services sectors of the business sector (NAICS 61 and 62).

It is sometimes argued that a comparison of the business sectors of Canada and the United States is problematic because most health and education activity in Canada is classified as part of the non-business sector (the government sector) since schools and hospitals are generally public in Canada. In contrast, a much smaller portion of health and education in the United States is classified as part of the non-business sector since the United States has a larger share of private and non-profit schools and hospitals. Therefore, for the purpose of comparability between

13. Choosing Bureau of Economic Analysis rates across all categories does not change the results reported here in a material way. What is important is that both Canadian and U.S. capital stock be derived from a similar set of depreciation rates.

Canada and the United States, we have included all health and education activity in the non-business sector.[14]

2.4.3 Valuation of output

The next issue that needs to be addressed is the valuation of output for a Canadian-U.S. comparison of capital intensities. At the total economy level, both Canada and the United States produce estimates of total output (GDP) using similar price concepts—GDP measured at market prices. But this paper will move to the industry level, and here Canadian and U.S. practices differ. Statistics Canada values industry output at basic prices, while the U.S. BEA values industry output at market prices. The difference between the two measures of outputs is taxes and subsidies on products. The difference can be quite large for some industries. Baldwin et al. (2005) report that the value of output at market prices was about 7% higher than the value of output at basic prices in the Canadian business sector in 1999.

To derive comparable measures of output at the industry level for our comparisons of Canada and the United States, we have estimated output at basic prices for the U.S. industries that can be used to compare with the Canadian industry measures that are calculated in basic prices. To derive such a measure, we have subtracted net product taxes from industry output measures that are calculated at market prices. The BEA does not publish net product taxes at the industry level. Instead, it publishes the taxes on production and imports at the industry level, which include both product taxes and property taxes. In this paper, we have estimated taxes on product at the industry level as the difference between the taxes on production and imports and a measure of property taxes at the industry level, which is estimated using the industry distribution of net capital stock and total property taxes published by the BEA. A similar approach is used by the BEA to allocate the total property taxes among industries (Moyer et al. 2004).[15]

Alternatively, we can construct estimates of output at factor cost for the two countries as in Rao, Tang and Wang (2004) or estimates of output at market prices. Such measures are less comparable than the measures adopted here for the purpose of international comparison (Lal 2003). First, GDP at factor costs in the petroleum industries includes gasoline taxes in the United States while it does not in Canada. The use of GDP at factor costs will underestimate the output level in the Canadian petroleum industries relative to that of the United States. Second, GDP at market prices for the U.S. wholesale and retail trade sectors include taxes on all imports, and about 20% of GDP in those industries are product and import taxes in the United States. The use of GDP at market prices will show much lower levels of capital intensity in the Canadian wholesale and retail trade sectors relative to those in the United States.

14. The coverage of business sector industries is not entirely comparable in the two countries. Bureau of Economic Analysis output at the industry level includes the output of non-profit institutions, while the output in Canadian industries excludes the output of non-profit institutions. Both these components are fairly small.
15. Total property taxes are published in the National Income and Product Accounts, Table 3.5.

2.4.4 Investment data

In this paper, we have taken the investment data in the two countries without making major modifications therein. The readers however should be aware that various issues with regards to comparability still remain.

First, it has been pointed out that concepts regarding the measurement of software investment in different countries influence some inter-country comparisons. Basically, the United States makes use of data on wages of software engineers to infer the investment that is being made in own-account software. Canada does the same and follows basically the same methodology.

Second, hedonic price indices are used by the United States for a number of high-tech products, while fewer European countries do the same. But Canada also uses hedonic price indices in most of the same industries and, while these indices differ from U.S. indices, the differences may be generally explained by movements in the Canadian-U.S. exchange rate.

Third, there may be differences in the classification of investments between buildings and engineering construction. Engineering construction is in effect those expenditures that are not easily reported either as M&E or as buildings. A number of industries—especially large projects like electrical generating facilities, dams, railway lines and pipelines—involve the type of civil engineering projects that fall within the ambit referred to as engineering construction. However, at the margin, there is always the possibility that it might be difficult to separate out buildings in some of these projects from the rest of the expenditure and that the practice of respondents to do so might vary across the two countries.

Fourth, it must be recognized that investment data for Canada and the United States are not perfectly comparable at the industry level. Both Canada and the United States collect detailed data on commodities for the economy as a whole. Some of these are classified as investment goods. Canada also has an investment survey that is used to spread the economy-wide totals derived from the commodity totals by industry of ownership of the capital. The BEA has, in the past, spread the total investment of M&E mainly by using occupational data (Haltiwanger 2006). Construction expenditure is obtained directly by industry from a special survey. All of this means that researchers need to be careful when comparing capital stock using fine levels of industry detail.

Fifth, when making a cross-country comparison of investment, one must always keep in mind that the division of expenditures on assets between new investment and repair expenditures may not be the same across countries. Firms buy new assets and repair old ones. While a statistical agency may define investments as those expenditures that extend the life of an asset by more than one year, in practice it may be difficult for a firm to make that distinction. Moreover, for tax reasons, a firm may have the incentive to expense expenditures that could be classified one way or the other. The route that is followed will depend on the vigilance of the tax authorities, and this may differ across countries.

3 Canadian-U.S. comparisons of capital intensity

The construction of comparable estimates of capital stock for Canada and the United States permits us to evaluate the relative importance of investment in the two countries. We do so in two ways. In the first case, we ask how much of gross domestic product (GDP) is devoted to investment of different types over the recent past by examining the investment-to-GDP ratio. Also, since investment when accumulated just equals capital stock, we also examine the capital-to-GDP ratio.

To some, these ratios depict whether there is a 'capital' gap. While we provide these ratios for the interested reader, we offer the following caution in interpreting them. Investment involves foregone consumption. Countries with high investment-to-GDP ratios are in that stage of development where sacrifices may simply reflect the need for large up-front expenditures to provide the infrastructure needed for future production. Therefore, high investment-to-GDP ratios need to be interpreted within context. For example, expenditures on oil exploration are investments for future production and there may be a very long hiatus between the exploration and finding of reserves and their production—as Newfoundland and Labrador has discovered.

The same caveats apply to capital-to-GDP ratios. It should be recognized that the inverse of this ratio is simply a partial capital-to-productivity ratio—telling us how much output an economy obtains per unit of capital. The higher this ratio is, the more efficient an economy is in terms of transforming capital into output. But the inverse of this ratio is also used to assess the importance of capital in an economy—since the higher the capital-to-GDP ratio is, the higher is the share going to capital; and the share going to capital depends on the type of production function, the factor price ratio in the country and the type of technical change taking place.

Finally, it should be noted that the cross-country ratio of capital to GDP can also depend on industry composition if production functions vary across industries. Some industries may require much larger capital inputs than others. For example, utilities, communications and transportation systems are heavy consumers of capital. And these infrastructure industries may be more important in countries with large resource bases or that are geographically spread out with a low population density. Mineral and oil exploration require large amounts of capital. Differences in industry composition, therefore, may be the cause of differences in capital intensity across countries.

For this reason, we also examine the extent to which differences in capital intensity come from differences in industrial structure in the two countries.

3.1 Decomposition method

This section presents the methodology used in decomposing industry and asset sources of the capital intensity difference between Canada and the United States.

3.1.1 Industry contributions to the Canadian-U.S. capital intensity difference

In order to decompose differences in capital intensity between the two countries into components, we make use of logarithmic transformations.[16]

The log difference in capital–output ratio between Canada and the United States is defined as

$$\ln(K/Y)^C - \ln(K/Y)^U = \ln(K^C/K^U) - \ln(Y^C/Y^U)\,. \qquad (8)$$

This equation indicates that the log difference in capital–output ratios in Canada and the United States is equal to the log difference in capital stock minus the log difference in output in the two countries. The method for measuring the difference in capital or output between two countries is similar to the one for measuring the changes in capital or output over time within a country. The difference between logarithms of capital for Canada and the United States is calculated as

$$\ln\left[\frac{K^C}{K^U}\right] = \sum_j \bar{v}_{K,J} \ln\left(\frac{K_j^C}{K_j^U}\right), \qquad (9)$$

where

$$\bar{v}_{K,J} = \frac{1}{2}(v_{K,j}^C + v_{K,j}^U)$$

$$v_{K,j}^i = \frac{P_{K,j}^{\ i} K_j^i}{\sum_j P_{K,j}^{\ i} K_j^i}, \quad i = C,U.$$

K^i denotes capital in country i; i indexes country and equals C for Canada and U for the United States; K_j^i is capital stock of industry *j* in country i; $P_{K,j}^i$ is acquisition price of capital for industry *j* in country i.

Similarly, the difference between logarithms of output for Canada and the United States is calculated as

$$\ln\left[\frac{Y^C}{Y^U}\right] = \sum_j \bar{v}_{Y,j} \ln\left(\frac{Y_j^C}{Y_j^U}\right), \qquad (10)$$

where,

$$\bar{v}_{Y,j} = \frac{1}{2}(v_{Y,j}^C + v_{Y,j}^U)$$

$$v_{Y,j}^i = \frac{P_{Y,j}^{\ i} Y_j^i}{\sum_j P_{Y,j}^{\ i} Y_j^i}, \quad i = C,U.$$

16. These logarithmic transformations allow us to create categories that are additive and exhaustive.

Substituting Equations (9) and (10) in Equation (8), we have the decomposition of the aggregate capital-output difference into the contributions of individual industries.

$$\ln(K/Y)^C - \ln(K/Y)^U = \sum_j \bar{v}_{K,j} \ln\left(\frac{K_j^C}{K_j^U}\right) - \sum_j \bar{v}_{Y,j} \ln\left(\frac{Y_j^C}{Y_j^U}\right)$$
$$= \sum_j 0.5(\bar{v}_{K,j} + \bar{v}_{Y,j})\left(\ln\left(\frac{K_j^C}{Y_j^C}\right) - \ln\left(\frac{K_j^U}{Y_j^U}\right)\right) + \sum_j 0.5(\bar{v}_{K,j} - \bar{v}_{Y,j})\left(\ln\left(\frac{K_j^C}{K_j^U}\right) + \ln\left(\frac{Y_j^C}{Y_j^U}\right)\right) \quad (11)$$

Equation (11) shows that the aggregate capital intensity level difference can be decomposed into two components: the intensity component and the structure component. The first term captures industry capital intensity level differences between Canada and the United States. The second term reflects differences in industry output composition between Canada and the United States. This term is presented as a sum across all industries in order to show industry structure effects.

While the logarithmic transformations have the desirable property that they can be decomposed exactly and allow the relative importance of each component to be estimated, they have to be re-estimated to provide estimates of the percentage gap between Canada and the United States by taking antilogs. When this is done, the direct decomposition presented above is no longer exact. There is a residual that we choose not to allocate to any particular category—and which we denote in the attached tables as the residual contribution. When the percentage gap in capital intensity is small, so too is this residual.

3.1.2 Asset contributions to the Canadian-U.S. capital intensity difference

We can also decompose the overall difference in capital–output ratios in Canada and the United States into contributions stemming from individual assets. The decomposition formula is

$$\ln(K/Y)^C - \ln(K/Y)^U = \sum_a \bar{v}_{K,a} \ln\left(\frac{K_a^C}{K_a^U}\right) - \ln\left(\frac{Y^C}{Y^U}\right)$$
$$= \sum_a \bar{v}_{K,a}\left(\ln\left(\frac{K_a^C}{Y^C}\right) - \ln\left(\frac{K_a^U}{Y^U}\right)\right), \quad (12)$$

where *a* denotes asset type. The equation decomposes the overall capital intensity gap into the contributions of individual assets.[17]

17. The sum of the contribution of individual assets is approximately equal to the overall capital intensity gap if the capital intensity gap is small.

4 Results

In this study, we compare capital intensity, defined as the ratio of capital stock to gross domestic product (GDP), between Canada and the United States. We make no comparisons of capital or GDP across countries; rather we compare each within countries, using the respective currencies of each country and then the ratios across the two countries. If we wished to go further, we would have to derive purchasing power parities of capital stock. Since we do not do so, the reader should be aware that part of the difference in capital intensity revealed here may be due to relative price differences between investment goods and products in general in the two economies.

In the remainder of the section, we first present the relative levels of capital intensities in the business sector in Canada and the United States. We then compare the capital intensities in the total economy in the two countries.

4.1 Overall trends in investment and capital intensities in the business sector

While capital is seen to have an important impact on growth rates, there is less agreement on the relative importance of different asset types. The history of technology tends to focus on the evolution of machinery and equipment (M&E). Stories abound about the spinning jenny, the power loom and agricultural equipment that have reinforced the importance that is traditionally given to machinery. The recent high-tech boom has led to an emphasis on high-tech products within this class.

Despite the attention that is paid to M&E, it accounts for no more than 32% of total capital in Canada in 1999 (Table 3). In contrast, buildings account for about 40%. In some situations, the capital they provide is complementary to that of machines. Factories require buildings in which operations are housed. Transportation systems may use trucks, engines and airplanes, but they also require airport terminals and warehousing. In other cases, the building is an undeniable part of the product. Retail requires stores. The travel industry requires hotels and conference centres.

Large amounts of capital are also devoted to engineering construction. In fact, at 29%, its share is almost as large as that of M&E in Canada. These assets underpin the utilities sector, pipelines, railways, airports, communications, and the oil and gas sector.

Canada and the United States differ in terms of the composition of assets. The United States has a higher percentage of assets in M&E. It has about 1 percentage point more in non-information and communications technology (ICT) M&E and some 4 percentage points more in ICT M&E. It also has a greater percentage in buildings. It has considerably less in engineering assets.

Table 3
Share of assets in capital stock, business sector, 2003 (nominal dollars)

	Machinery and equipment	ICT[1] machinery and equipment	Non-ICT machinery and equipment	Engineering	Buildings
	percent				
Canada	31.8	5.6	26.2	29.0	39.2
United States	37.2	9.7	27.5	11.0	51.8

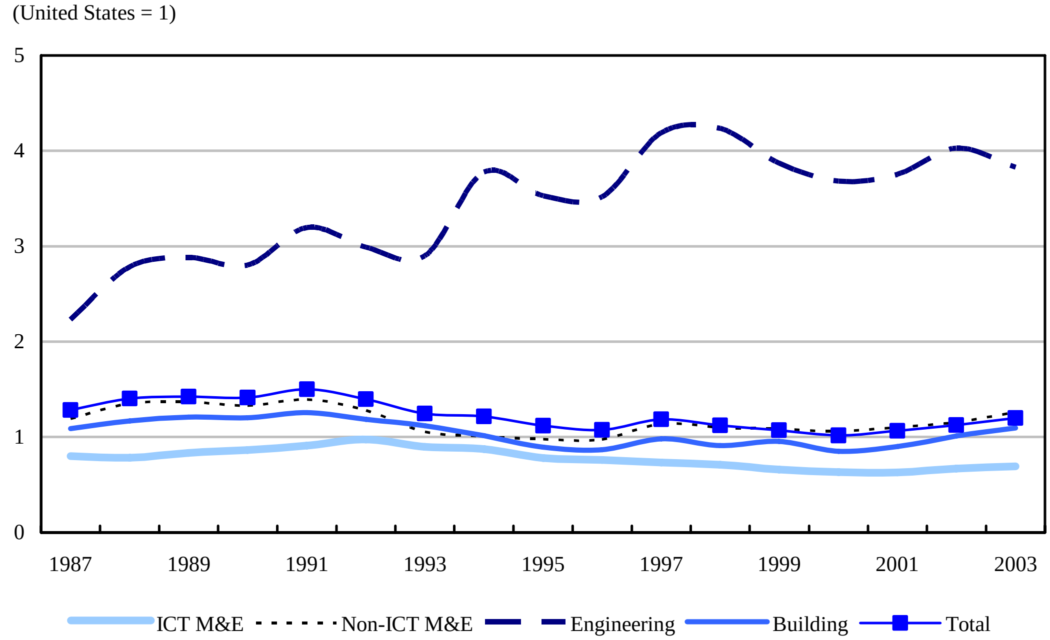
1. Information and communications technology.
Note: Results shown are from authors' calculations.
Sources: Statistics Canada; and Bureau of Economic Analysis.

The investment-to-GDP ratio from 1987 to 2003 for Canada relative to the United States is presented in Figure 1. Canada's total investment-to-GDP ratio is higher than the U.S. ratio from 1987 to 2003.[18] Over that period, total investment-to-GDP ratio in Canada is about 20% higher than the ratio in the United States. It has declined slightly over the period studied: from 1.5 to 1.2 when measured in 1997 dollars, but from only 1.3 to 1.2 when measured in current dollars (Figure B.1).

An examination of investment-to-GDP ratios by asset class reveals substantial differences both in terms of level and trends. Canada's engineering investment-to-GDP ratio is more than twice that of the United States for the period from 1987 to 2003 and has been growing relatively larger over time.[19] The building investment–GDP ratio in Canada is about the same as that in the United States and has remained relatively stable over time. Canada's investment in non-ICT M&E as a proportion of GDP is also higher than that of the United States, but it has fluctuated over time. At the same time, there has been a persistent ICT M&E investment-to-GDP ratio gap between Canada and the United States that has increased over time.

18. Figures in current dollars are in Appendix B. These figures are not qualitatively different from those presented in the main text, which are based on 1997 dollars.
19. Baldwin and Gorecki (1986) report that in manufacturing, the Canadian-U.S. ratio of machinery and equipment was relatively stable from 1961 to 1979, but the Canadian-U.S. ratio for structures and engineering increased in relative terms.

Figure 1
Canadian business sector investment-to-gross domestic product ratio relative to the U.S. ratio, by asset class, 1987 to 2003 (1997 dollars)

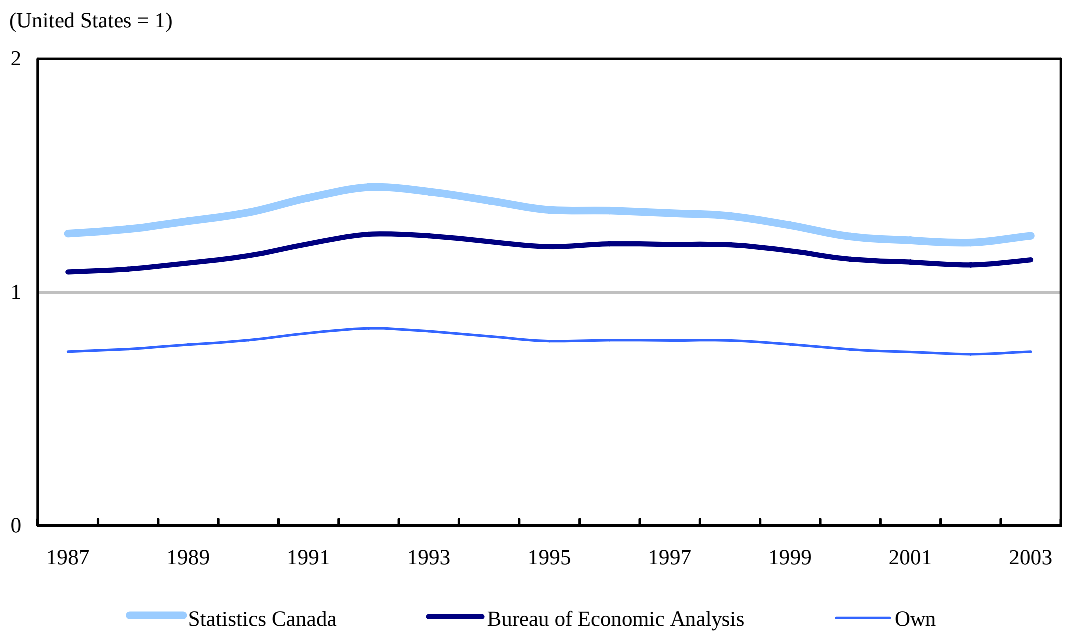


Notes: ICT M&E stands for information and communications technology machinery and equipment. Results shown are from authors' calculations.
Sources: Statistics Canada; and Bureau of Economic Analysis.

As previously discussed, capital stocks in both countries are derived as the accumulation of past investments that are summed using the perpetual inventory method. However, if different service lives and different depreciation rates are used to compare Canada with the United States, estimates of the relative level and trend in capital intensity may be incorrect. Thus, previous comparisons of capital intensity between Canada and the United States using unadjusted depreciation rates may partly reflect the different methodologies. U.S. depreciation rates that are used by the Bureau of Economic Analysis (BEA) are sometimes lower than those used in the Canadian productivity program, particularly in engineering structures and building structures. As a result, the use of these numbers results in a lower Canadian capital-to-GDP ratio than that of the United States. In Figure 2, the line labelled "Own" depicts the course of the total capital-to-GDP ratio if we employ the capital stock estimates for Canada from the Canadian Productivity Accounts (CPA) and capital stock estimates for the United States from the BEA. Figure 2 also contains the capital–output ratios using common depreciation rates (either Canadian or U.S. rates) to produce capital stocks for both countries. Using common rates raises Canada's relative capital intensity (Figure 2). We first apply BEA depreciation rates to the Canadian stock and compare the capital intensities of the two countries. Based on common BEA depreciation rates, Canada's relative capital intensity becomes higher than that based on each country's own depreciation rates.

To undertake a sensitivity analysis of this finding, we also apply Statistics Canada's depreciation rates used in its productivity program to BEA capital stocks. Interestingly, Canada's relative capital intensity rises further with Statistics Canada's depreciation rates.[20] Thus, the magnitude of the difference between Canada's capital intensity and the U.S. intensity is also sensitive to the choice between BEA and Statistics Canada depreciation rates. But at least in the latter part of the 1990s, there is not much difference between the two curves—and the difference is probably not statistically significant. That is, both of these estimates show that the capital–GDP ratio in the business sector is higher in Canada than in the United States. Equally important, the trend in the two countries is virtually the same over the time period under study. The capital stock estimates based on the CPA depreciation rates show that the capital-to-GDP ratio in the Canadian business sector is about 30% higher than that in the United States over the 1987-to-2003 period (Table 4). The results based on the BEA depreciation rates show that the capital-to-GDP ratio in the Canadian business sector is about 20% higher.

Figure 2
Canadian business sector capital-to-gross domestic product ratio relative to the U.S. ratio, 1987 to 2003 (1997 dollars)



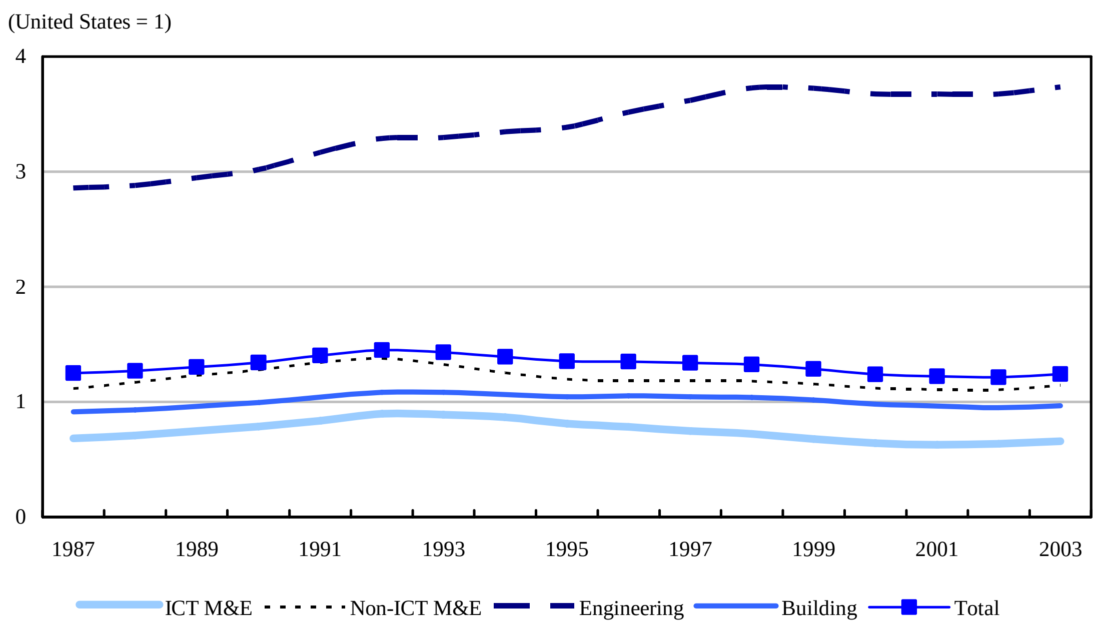
Note: Results shown are from authors' calculations.
Sources: Statistics Canada; and Bureau of Economic Analysis.

20. These results apply to all asset types in both 1997 and current dollars. The difference in the intensities arising from the use of the two depreciation rates reflects the large increase in Canadian investment on buildings and engineering relative to the United States during the 1980s. This will be weighted more heavily in the net capital stock calculation because of the relatively higher Statistics Canada's depreciation rates for these investments. For comparison, see Figure 3 and Appendix Figure D.1. The use of the lower U.S. depreciation rate for engineering and buildings reduces Canadian capital in these areas.

Since Canada's capital structure is different from that of the United States, it is important to note the pattern of capital–GDP ratios at the asset level. Canada's relative capital intensity trends by asset class are shown in Figure 3.[21] Canada's engineering capital intensity has been growing faster than that of the United States and Canada's engineering capital intensity, which was three times as high as that of the United States in 1987, reached almost four times that of the United States in 2003. Canada's capital intensity in non-ICT M&E is slightly higher than that of the United States.[22] Canada's building capital matched fairly closely to that of the United States. On the other hand, there has been a persistent ICT M&E capital intensity gap between Canada and the United States.

These differences suggest that there are structural differences between the two countries. The Canadian economy focuses either more on those industries where engineering infrastructure is important or it has a much different capital structure in its industries that leads it to focus more on infrastructure and less on ICT. For buildings, Canada employs a similar relative amount of capital per dollar of GDP.

Figure 3
Canadian business sector capital-to-gross domestic product ratio relative to the U.S. ratio, by asset class, 1987 to 2003 (1997 dollars)



Notes: ICT M&E stands for information and communications technology machinery and equipment. Results shown are from authors' calculations.
Sources: Statistics Canada; and Bureau of Economic Analysis.

21. These results are based on capital stock estimates using Statistics Canada's depreciation rates. Results based on Bureau of Economic Analysis depreciation rates are not qualitatively different; they are presented in Appendix C.
22. The results from using the Canadian Productivity Accounts depreciation rates show that the non-information and communications technology (ICT) machinery and equipment (M&E) capital intensity is about 20% higher in Canada, while the results based on the Bureau of Economic Analysis depreciation rates show that non-ICT M&E capital intensity is similar in the two countries (Table 4).

Table 4
Average relative Canadian-U.S. levels of investment and capital intensities, by asset class, business sector, 1987 to 2003 (1997 dollars)

	Investment-to-gross domestic product ratio	Capital-to-gross domestic product ratio		
		Statistics Canada depreciation	Bureau of Economic Analysis depreciation	Own depreciation
	United States =1			
ICT[1] machinery and equipment	0.78	0.75	0.74	0.61
Non-ICT machinery and equipment	1.17	1.20	0.96	0.86
Engineering	3.42	3.38	2.33	1.38
Building	1.04	1.01	0.95	0.58
Total	1.23	1.32	1.17	0.78

1. Information and communications technology.
Note: Results shown are from authors' calculations.
Sources: Statistics Canada; and Bureau of Economic Analysis.

4.2 Decomposition of the Canadian-U.S. total capital intensity gap in the business sector

This section examines whether the differences in the capital–output ratio come from differences in intensity or from differences in the structure of the two economies. Since structure can be defined in several ways, the section approaches the question in stages. It starts by examining differences in capital structure and then differences by industry.

In the first instance, we ask how much of the difference in capital intensity comes from the difference in the intensity of specific assets as opposed to the fact that the two economies use assets in different proportions—either because of industry differences or because of different production technologies.

Table 5 presents the decomposition of the Canadian-U.S. total capital intensity gap in 2003, based on four asset types using Equation (12). In 2003, Canada's total capital intensity was 24% higher than the U.S. intensity. Canada's superior position was due to a higher capital intensity, which contributed 29 percentage points. An asset-by-asset comparison reveals that engineering capital contributed 30 percentage points to Canada's advantage. However, this was partially offset by Canada's lower capital intensity in ICT and building capital. In sum, the capital intensity of the engineering component contributed more than 100% to Canada's relatively higher capital intensity.

Differences in capital intensity may also arise because of differences in industrial structure—because Canada has a larger percentage of its assets in industries that naturally have a lower/higher capital–GDP ratio. The results of a decomposition exercise using industries are presented in Table 6.

Table 5
Decomposition of Canadian-U.S. aggregate capital intensity gap, by asset class, based on Statistics Canada depreciation rates, business sector, 2003 (1997 dollars)

	K/Y[1] Canada	K/Y United States	Gap[2]	Ki/K[3] Canada	Ki/K United States	Gap	Asset composition	Intensity (contribution)
	(1)	(2)	(3)	(4)	(5)	(6)=(4)-(5)	(7)=(3)-(8)	(8)
	ratio		percent					
Total	1.29	1.04	24.2	100.0	100.0	0.0	-4.9	29.1
ICT M&E[4]	0.11	0.16	-34.1	5.6	9.7	-4.1		-3.1
Non-ICT M&E	0.35	0.30	14.4	26.2	27.5	-1.3		3.7
Engineering	0.37	0.10	273.5	29.0	11.0	18.0		30.1
Building	0.47	0.49	-3.3	39.2	51.8	-12.7		-1.5

1. Capital–gross domestic product ratio.
2. Gap is measured as the percent difference between Canada and the United States.
3. Share of an asset in total capital stock.
4. Information and communications technology machinery and equipment.
Note: Results shown are from authors' calculations.
Sources: Statistics Canada; and Bureau of Economic Analysis.

Table 6
Decomposition of Canadian-U.S. aggregate capital intensity gap, by industry, based on Statistics Canada depreciation rates, business sector, 2003 (1997 dollars)

	K/Y[1] Canada	K/Y United States	Gap[2]	Yi/Y[3] Canada	Yi/Y United States	Gap	Industry structure contribution	Intensity contri-bution	Residual contri-bution
	(1)	(2)	(3)	(4)	(5)	(6)=(4)-(5)	(7)	(8)	(9)=(3)-(7)-(8)
	ratio		percent						
Agriculture	2.21	1.44	53.8	1.8	1.3	0.5		0.9	
Forestry, fishing, hunting and mining	3.37	3.54	-4.9	9.5	2.2	7.3		-0.4	
Construction	0.34	0.41	-16.9	7.4	6.5	0.8		-0.8	
Manufacturing	0.71	0.62	14.8	21.8	17.6	4.1		2.2	
Wholesale trade	0.29	0.51	-41.8	7.1	6.6	0.5		-2.5	
Retail trade	0.52	0.62	-14.9	7.5	8.1	-0.5		-1.0	
Transportation, warehousing and utilities	2.75	1.78	54.4	9.4	6.6	2.8		5.3	
Information	1.25	1.14	9.6	4.6	6.1	-1.5		0.5	
Finance, insurance, real estate and rental and leasing	2.53	2.01	26.2	15.1	20.3	-5.2		6.3	
Professional and business services	0.25	0.46	-45.3	9.4	16.4	-7.1		-4.9	
Other services	0.74	0.91	-18.8	6.4	8.2	-1.7		-1.3	
Total business sector	1.29	1.04	24.2	100.0	100.0	0.0	19.5	4.4	0.3

1. Capital–gross domestic product ratio.
2. Gap is measured as the percent difference between Canada and the United States.
3. Share of an industry in gross domestic product.
Note: Results shown are from authors' calculations.
Sources: Statistics Canada; and Bureau of Economic Analysis.

Canada's industry structure relative to that of the United States was favourable to Canada, contributing 20 percentage points to Canada's relatively higher capital intensity. That is, Canada had a larger share of output in those sectors that were generally more capital intensive, such as the utilities and mining sectors. In addition, higher capital intensity in some sectors increased Canada's structural advantage by some 4 percentage points. The largest industry contributors to Canada's relatively higher capital intensity were utilities, finance and manufacturing. The intensity effects stemming from aforementioned industries were partially offset by Canada's relatively lower capital intensity in business services, other services, wholesale and retail trade.

In summary, Canada's higher capital intensity was primarily the result of a greater focus on industries that have a high capital intensity—particularly infrastructure. However, this decomposition of the aggregate capital–output ratio hides potentially important differences by asset type between the two countries. The next section investigates this possibility.

Table 7
Decomposition of Canadian-U.S. information and communications technology capital intensity gap, by industry, based on Statistics Canada depreciation rates, business sector, 2003 (1997 dollars)

	K/Y[1] Canada	K/Y United States	Gap[2]	Yi/Y[3] Canada	Yi/Y United States	Gap	Industry structure contribution	Intensity contribution	Residual contribution
	(1)	(2)	(3)	(4)	(5)	(6)=(4)-(5)	(7)	(8)	(9)=(3)-(7)-(8)
	ratio		percent						
Agriculture	0.01	0.02	-26.3	1.8	1.3	0.5		-0.3	
Forestry, fishing, hunting and mining	0.02	0.06	-68.1	9.5	2.2	7.3		-3.8	
Construction	0.02	0.07	-78.2	7.4	6.5	0.8		-6.3	
Manufacturing	0.04	0.07	-40.6	21.8	17.6	4.1		-7.3	
Wholesale trade	0.08	0.13	-39.2	7.1	6.6	0.5		-3.0	
Retail trade	0.06	0.06	-6.3	7.5	8.1	-0.5		-0.4	
Transportation, warehousing and utilities	0.12	0.28	-58.6	9.4	6.6	2.8		-8.0	
Information	0.66	0.58	14.4	4.6	6.1	-1.5		2.6	
Finance, insurance, real estate and rental and leasing	0.14	0.19	-27.6	15.1	20.3	-5.2		-5.5	
Professional and business services	0.16	0.20	-23.8	9.4	16.4	-7.1		-3.7	
Other services	0.07	0.05	52.4	6.4	8.2	-1.7		2.1	
Total business sector	0.11	0.16	-34.1	100.0	100.0	0.0	-6.8	-33.4	6.1

1. Capital–gross domestic product ratio.
2. Gap is measured as the percent difference between Canada and the United States.
3. Share of an industry in gross domestic product.
Note: Results shown are from authors' calculations.
Sources: Statistics Canada; and Bureau of Economic Analysis.

Table 8
Decomposition of Canadian-U.S. non-information and communications technology machinery and equipment capital intensity gap, by industry, based on Statistics Canada depreciation rates, business sector, 2003 (1997 dollars)

	K/Y[1] Canada	K/Y United States	Gap[2]	Yi/Y[3] Canada	Yi/Y United States	Gap	Industry structure contri-bution	Intensity contri-bution	Residual contri-bution
	(1)	(2)	(3)	(4)	(5)	(6)=(4)-(5)	(7)	(8)	(9)=(3)-(7)-(8)
	ratio		percent						
Agriculture	1.04	0.94	10.7	1.8	1.3	0.5		0.4	
Forestry, fishing, hunting and mining	0.44	0.72	-38.9	9.5	2.2	7.3		-2.8	
Construction	0.26	0.29	-12.4	7.4	6.5	0.8		-0.8	
Manufacturing	0.44	0.36	23.0	21.8	17.6	4.1		4.9	
Wholesale trade	0.10	0.29	-66.2	7.1	6.6	0.5		-6.0	
Retail trade	0.15	0.15	3.0	7.5	8.1	-0.5		0.2	
Transportation, warehousing and utilities	0.75	0.71	5.7	9.4	6.6	2.8		0.7	
Information	0.02	0.12	-84.8	4.6	6.1	-1.5		-6.2	
Finance, insurance, real estate and rental and leasing	0.50	0.33	53.8	15.1	20.3	-5.2		8.6	
Professional and business services	0.05	0.11	-59.4	9.4	16.4	-7.1		-7.0	
Other services	0.13	0.26	-49.7	6.4	8.2	-1.7		-3.9	
Total business sector	0.35	0.30	14.4	100.0	100.0	0.0	30.5	-11.9	-4.2

1. Capital–gross domestic product ratio.
2. Gap is measured as the percent difference between Canada and the United States.
3. Share of an industry in gross domestic product.
Note: Results shown are from authors' calculations.
Sources: Statistics Canada; and Bureau of Economic Analysis.

4.3 Decomposition of the Canadian-U.S. capital intensity gap by asset type in the business sector

The total capital stock-to-GDP ratios mask significant differences across asset types. Canada's relative capital intensity is lower than that of the United States in ICT M&E, it is higher in engineering structure and non-ICT M&E, and it is similar in buildings. In this section, we examine the contribution of industries to the capital intensity differences for each asset class.

The largest capital intensity gap exists in ICT. Canada's ICT capital intensity was about 34% below the U.S. intensity in 2003. Differences in industrial structure between the two countries contributed about 7 percentage points to the gap while the intensity component contributed 33 percentage points to the gap (Table 7). The largest contributions of lower ICT capital intensity were in construction; manufacturing; transportation, warehousing and utilities; and finance, insurance, real estate and rental and leasing (FIRE). However, the ICT capital intensity gap was fairly widespread across industries, with the exception of information and other services sectors.

The non-ICT M&E capital intensity in the Canadian business sector is 14% higher than in the United States (Table 8). But Canada tends to concentrate more in industries that have higher non-ICT M&E capital intensity and, if industrial structure is taken into account, the non-ICT M&E capital intensity is lower in Canada. The lower non-ICT M&E capital intensity at the industry level in Canada reduced the aggregate non-ICT capital intensity by 12 percentage points. Higher non-ICT M&E capital intensity existed in manufacturing and finance. This was offset by lower non-ICT M&E capital intensity in information and professional and business services—two of the most dynamic service sectors. However, the structural difference between the two countries increased Canada's relative capital intensity by 31 percentage points.

The capital intensity in building structures is similar in the Canadian and U.S. business sectors (Table 9). This is a result of a small intensity effect and a small structural effect. Canada's relative capital intensity in building is lower in forestry, fishing, hunting and mining; manufacturing; retail trade; and professional and business services. It is higher in agriculture; construction; transportation, warehousing and utilities; and the FIRE sector.

Table 9
Decomposition of Canadian-U.S. building capital intensity gap, by industry, based on Statistics Canada depreciation rates, business sector, 2003 (1997 dollars)

	K/Y[1] Canada	K/Y United States	Gap[2]	Yi/Y[3] Canada	Yi/Y United States	Gap	Industry structure contri-bution	Intensity contri-bution	Residual contri-bution
	(1)	(2)	(3)	(4)	(5)	(6)= (4)-(5)	(7)	(8)	(9)= (3)-(7)-(8)
	ratio		percent						
Agriculture	0.84	0.48	75.2	1.8	1.3	0.5		1.1	
Forestry, fishing, hunting, and mining	0.15	0.38	-61.4	9.5	2.2	7.3		-3.5	
Construction	0.07	0.05	40.7	7.4	6.5	0.8		1.3	
Manufacturing	0.18	0.18	-5.0	21.8	17.6	4.1		-0.7	
Wholesale trade	0.11	0.10	13.0	7.1	6.6	0.5		0.5	
Retail trade	0.31	0.41	-26.1	7.5	8.1	-0.5		-2.1	
Transportation, warehousing and utilities	0.24	0.19	24.9	9.4	6.6	2.8		1.3	
Information	0.18	0.18	-2.4	4.6	6.1	-1.5		-0.1	
Finance, insurance, real estate and rental and leasing	1.90	1.52	25.3	15.1	20.3	-5.2		9.4	
Professional and business services	0.06	0.15	-59.2	9.4	16.4	-7.1		-6.8	
Other services	0.54	0.61	-10.3	6.4	8.2	-1.7		-0.8	
Total business sector	0.47	0.49	-3.3	100.0	100.0	0.0	-2.3	-0.3	-0.7

1. Capital–gross domestic product ratio.
2. Gap is measured as the percent difference between Canada and the United States.
3. Share of an industry in gross domestic product.
Notes: Results shown are from authors' calculations.
Sources: Statistics Canada; and Bureau of Economic Analysis.

Canada's engineering capital intensity was higher than that of the United States by 274% in 2003 (Table 10). Both the industry structural and intensity components were positive, contributing 103 and 70 percentage points, respectively, to Canada's advantage. Once again, industry structure tended to increase Canadian overall capital intensity. The industries with the largest engineering intensity advantages were those in the manufacturing and utilities sectors. Although the total engineering capital intensity was significantly higher in Canada than in the United States, some Canadian industries had a lower intensity contribution compared to the United States, including construction and professional and business services.

Table 10
Decomposition of Canadian-U.S. engineering capital intensity gap, by industry, based on Statistics Canada depreciation rates, business sector, 2003 (1997 dollars)

	K/Y[1] Canada	K/Y United States	Gap[2]	Yi/Y[3] Canada	Yi/Y United States	Gap	Industry structure contri-bution	Intensity contri-bution	Residual contri-bution
	(1)	(2)	(3)	(4)	(5)	(6)=(4)-(5)	(7)	(8)	(9)=(3)-(7)-(8)
	ratio		percent						
Agriculture	0.32	..	..	1.8	1.3	0.5		..	
Forestry, fishing, hunting and mining	2.76	2.36	16.9	9.5	2.2	7.3		4.0	
Construction	0.00	0.00	-81.9	7.4	6.5	0.8		-5.8	
Manufacturing	0.06	0.00	1493.2	21.8	17.6	4.1		35.2	
Wholesale trade	0.01	0.00	1190.5	7.1	6.6	0.5		9.3	
Retail trade	0.01	0.00	396.2	7.5	8.1	-0.5		6.6	
Transportation, warehousing, and utilities	1.65	0.61	171.8	9.4	6.6	2.8		26.8	
Information	0.39	0.26	51.2	4.6	6.1	-1.5		3.3	
Finance, insurance, real estate and rental and leasing	0.01	0.01	-5.0	15.1	20.3	-5.2		-0.5	
Professional and business services	0.01	0.02	-57.3	9.4	16.4	-7.1		-6.0	
Other services	0.00	0.01	-52.2	6.4	8.2	-1.7		-2.8	
Total business sector	0.37	0.10	273.5	100.0	100.0	0.0	103.0	70.2	100.3

.. not available for a specific reference period
1. Capital–gross domestic product ratio.
2. Gap is measured as the percent difference between Canada and the United States.
3. Share of an industry in gross domestic product.
Note: Results shown are from authors' calculations.
Sources: Statistics Canada; and Bureau of Economic Analysis.

The decomposition that has been used in this paper suffers from the problem that it is deterministic and does not facilitate hypothesis testing. This problem has long been recognized in the geography shift-share literature (Patterson 1991, Knudsen and Barff 1991). To permit statistical tests, stochastic linear regression models have been adopted that essentially test for differences in means across categories (Patterson 1991, Rubery 1998, Smith, Fagan and Rubery 1998).

In this spirit, we estimated regressions of the capital intensity of assets on binary variables representing each industry used in the above analysis and a binary variable that represented Canada (Table 11). The coefficients on the binary variable indicate the extent to which Canada suffered from a capital deficit after industry structure is considered—what is comparable to the overall intensity contribution reported in Tables 6 to 10. While the significance of the differences can be tested in this way, it should be recognized that the tests are not very powerful here because the number of industry categories being used is not large. Ultimately, to establish the significance of the differences across the two categories, one needs to take into account the statistical test provided by the data in Table 11, the economic meaningfulness of the size of the differences and the sensitivity of the size of the differences to alternate depreciation assumptions used in constructing the capital stock estimates.

The coefficients from the regression generally accord with those from the share decomposition analysis. Canadian aggregate capital intensity is 3.4% higher. ICT and non-ICT M&E is lower. Buildings are slightly lower. Engineering construction is much higher. It should be noted that there are few statistically significant differences between the two countries—which may be due to the level of industry detail available to us. Only ICT capital intensity is significantly lower in Canada than in the United States.

Table 11
Intensity differences using a decomposition analysis and a fixed effects regression, 2003 (1997 dollars)

	Intensity gap	Intensity contribution	
		Decomposition analysis	Fixed effects weighted regression
Aggregate capital (percent)	24.2	4.4	3.4
T statistic			(0.33)
ICT M&E[1] (percent)	-34.1	-33.4	-28.7
T statistic			(-2.28)
Non-ICT M&E (percent)	14.4	-11.9	-16.6
T statistic			(-1.04)
Building (percent)	-3.3	-0.3	-2.4
T statistic			(-0.18)
Engineering (percent)	273.5	70.2	72.3
T statistic			(1.49)

1. Information and communications technology machinery and equipment.
Note: Results shown are from authors' calculations.
Sources: Statistics Canada; and Bureau of Economic Analysis.

4.4 Relative Canadian-U.S. levels of investment and capital intensities in the total economy

In this section, we examine the relative Canadian-U.S. levels of investment and capital intensity in the total economy. The results are presented in Figure 4, Figure 5 and Table 12. Canada's investment-to-GDP ratio in the total economy is about 10% higher than that of the United States in 2003. This is a result of higher investment intensity in the Canadian business sector and slightly lower investment intensity in the non-business sector.

Canada's investment intensity in the total economy is higher than that of the United States for engineering and building structures. But it is lower for M&E. The lower M&E investment intensity in the Canadian economy is a result of much lower investment intensity in the non-business sector. In the business sector, the investment intensity in M&E is similar in the two countries. To some extent, the much lower capital intensity in M&E in the Canadian non-business sector reflects the fact that military expenditure in the United States is treated as investment.

Table 12
Relative Canadian-U.S. levels of investment and capital intensity, total economy, 2003 (1997 dollars)

	Total economy	Non-business sector	Business sector
	United States=1		
Investment-to-gross domestic product ratio			
Machinery and equipment	0.86	0.49	0.97
Engineering	2.15	0.89	3.83
Building	1.14	1.18	1.09
Total	1.09	0.94	1.20
Capital-to-gross domestic product ratio			
Machinery and equipment	0.87	0.40	0.98
Engineering	2.40	1.34	3.74
Building	1.08	1.17	0.97
Total	1.18	1.10	1.24

Note: Results shown are from authors' calculations.
Sources: Statistics Canada; and Bureau of Economic Analysis.

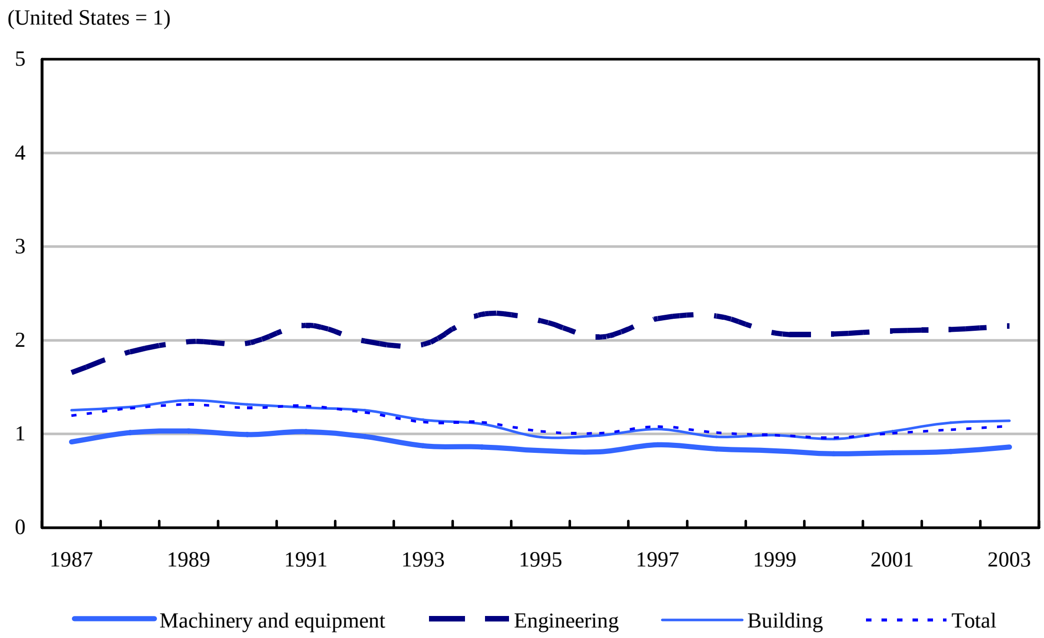
Table 13
Decomposition of Canada-U.S. aggregate capital intensity gap, by asset type, based on Statistics Canada depreciation rates, total economy, 2003 (1997 dollars)

	K/Y[1] Canada	K/Y United States	Gap[2]	Ki/K[3] Canada	Ki/K United States	Gap	Asset composition	Intensity (contribution)
	(1)	(2)	(3)	(4)	(5)	(6)= (4)-(5)	(7)= (3)-(8)	(8)
	ratio		percent					
Total	1.69	1.44	17.6	100.0	100.0	0.0	-1.6	19.1
Machinery and equipment	0.37	0.42	-12.6	19.1	23.5	-4.4		-2.8
Engineering	0.40	0.17	139.9	23.3	12.4	10.9		16.9
Building	0.93	0.86	8.1	57.6	64.2	-6.5		4.9

1. Capital–gross domestic product ratio.
2. Gap is measured as the percent difference between Canada and the United States.
3. Share of an asset in total capital stock.
Note: Results shown are from authors' calculations.
Sources: Statistics Canada; and Bureau of Economic Analysis.

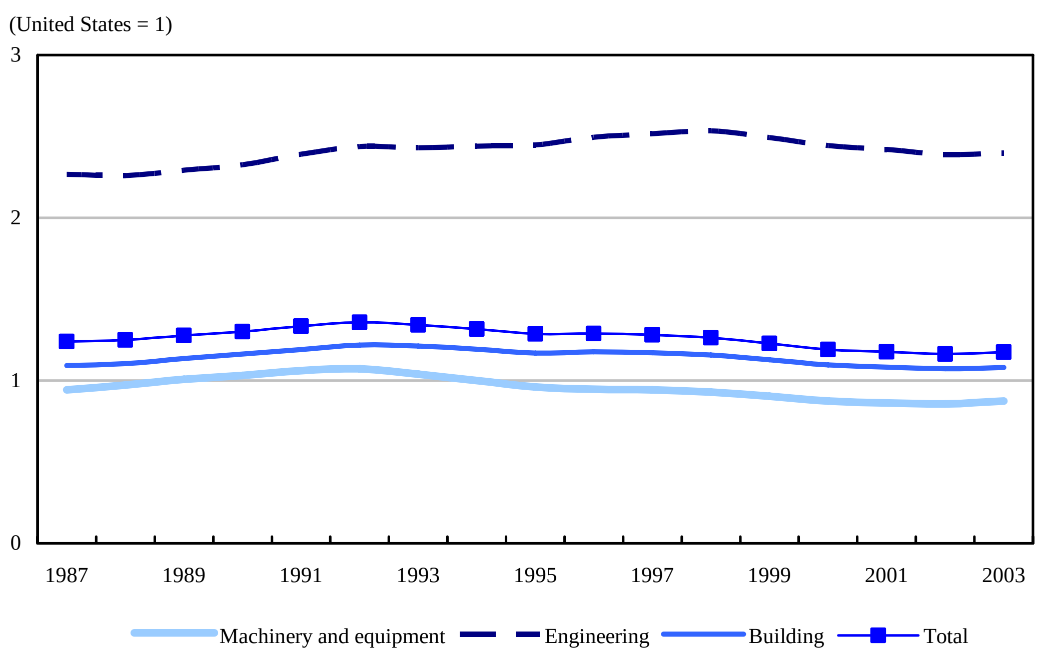
Table 13 presents the decomposition of the Canadian-U.S. capital intensity difference in the total economy in 2003. In that year, Canada's capital intensity in the total economy is 18% higher than the U.S. intensity. Canada's higher capital intensity is due to the higher capital intensity in engineering structures, which contributed 17 percentage points. The higher capital intensity in buildings contributed 5 percentage points. The lower M&E capital intensity in the Canadian economy lowered the overall capital intensity by 3 percentage points.

Figure 4
Canadian investment-to-gross domestic product ratio relative to the U.S. ratio, total economy, 1987 to 2003 (1997 dollars)



Note: Results shown are from authors' calculations.
Sources: Statistics Canada; and Bureau of Economic Analysis.

Figure 5
Canadian capital-to-gross domestic product ratio relative to the U.S. ratio, total economy, 1987 to 2003 (1997 dollars)



Note: Results shown are from authors' calculations.
Sources: Statistics Canada; and Bureau of Economic Analysis.

5 Conclusions

When comparing capital intensity across countries, one must grapple with potential differences in methods and data sources. This paper approaches this problem by standardizing one critical set of assumptions so as to produce a more comparable set of estimates. It starts by adopting a common set of depreciation estimates for the two countries and then estimates capital stock using the perpetual inventory technique. While it is possible that capital depreciates at different rates across countries whose economies differ in terms of their competitive characteristics, Canada and the United States are sufficiently similar that differences seem unlikely.

Making use of a comparable set of depreciation rates changes the nature of conclusions about the capital intensity of the two countries. If comparisons of capital intensity are made with the depreciation rates that are used by Statistics Canada in its productivity program and by the Bureau of Economic Analysis in its estimates of capital stock, then the stock of capital as a share of gross domestic product (GDP), or capital intensity, is lower in Canada. However, once we impose common depreciation rates for similar asset classes, Canada's capital intensity is higher than that of the United States. The trend, however, is slightly downward since 1987—though the decline is less when expressed in nominal rather than constant dollars. While capital–GDP ratios for engineering assets increased, they remained basically the same for building assets; information and communications technology (ICT) machinery and equipment (M&E) intensities declined.

Capital–output ratios as summary statistics tell us about the nature of the production process. Higher capital–output ratios indicate that more capital is being used in production. Changes over time in these ratios have been used to generate conclusions about capital productivity or about the extent to which technological progress is mainly labour enhancing.

The data here suggest that at the level of the total business sector, capital intensity is higher in Canada than in the United States. But, at the level of the total economy, it is difficult to discern much of a difference in the overall capital intensity. It declines slightly more when measured in constant 1997 dollars, but is virtually unchanged when measured in current dollars.

There is always the danger when working with macro data for the entire economy that important differences in the underlying structure of the economy will be missed. Our examination of differences in the underlying components (both assets and industries) reveals that this is the case here.

While Canada has a higher overall capital intensity in the business sector—because it has more engineering assets and less ICT assets—the non-ICT M&E and building assets intensities are more alike in the two countries.[23] Setting aside the explanation that this comes from

23. Non-information and communications technology machinery and equipment capital intensity is slightly higher in Canada when using Canadian depreciation rates, but slightly lower when using U.S. depreciation rates. Buildings intensity is about the same when using Canadian depreciation rates, but slightly lower when using U.S. depreciation rates (see Table 4). Since these two estimates bound a value of 1, it is difficult to reject the conclusion that capital intensity for these two assets is essentially the same. These are also the same assets where the statistical tests are least able to reject the null hypothesis that there are no significant differences in capital intensity across Canada and the United States (see Table 11).

classification differences in the two countries, this strongly suggests a different aggregate production function that stems from a different industrial composition or from differences in production techniques that are associated with a different economy.

To address this issue, the paper uses shift-share decomposition analysis to examine whether the higher Canadian capital intensity is the result of differences in asset or industry composition. The decomposition analysis shows that Canada's business sector is more capital intensive, primarily because of its industry structure and because of a focus on engineering assets. Canada has a higher intensity industry by industry in terms of engineering assets and has more industries where the engineering asset–output ratios are higher. Two sectors—the primary sector (including mining) and utilities—are very intensive in engineering capital in Canada; together, they contributed the preponderance of the intensity effect advantage over the United States.

The industries where engineering assets are concentrated are the core infrastructure industries that provide universal services on which the rest of the economy relies—transportation, communications and energy. These industries are more important in Canada—both because Canada has an inherent comparative advantage in some natural resource sectors that are associated with these industries, and because the Canadian economy is more diverse geographically and requires more of the services of these sectors per unit of GDP produced than does the United States.

When industry structure is taken into account for the M&E asset class, most industries of Canada's business sector are less capital intensive than that of the United States. In the case of non-ICT M&E, there is a small deficit of about 12%. The deficit is more pronounced for ICT investments—some 33%. Canada's ICT capital intensity has been persistently lower than that of the United States, at least since 1987. The gap was fairly widespread across industries in 2003. It was particularly large in construction; transportation, warehousing and utilities; and the finance, insurance, real estate, and rental and leasing sector.

Finally, it should be noted that the non-business sectors in the two countries resemble one another when it comes to the use of buildings and engineering infrastructure, but they are extremely different when it comes to expenditures on M&E. The latter arises in part because of military equipment spending in the United States.

For any evaluations of the Canadian economy, one therefore needs to take into account the fact that it is composed of different sectors. It is not a homogeneous entity with a single production function that can be easily estimated from aggregate data. Policy prescriptions in cases like these may want to take into account the extent to which differences in asset composition arise from simple reasons such as those related to inherent comparative advantage, the nature of being a northern country with a lower population density than its southern neighbour and whether public policy-related factors favour the differences in Canadian-U.S. capital configurations.

Appendix A Bureau of Economic Analysis depreciation rates

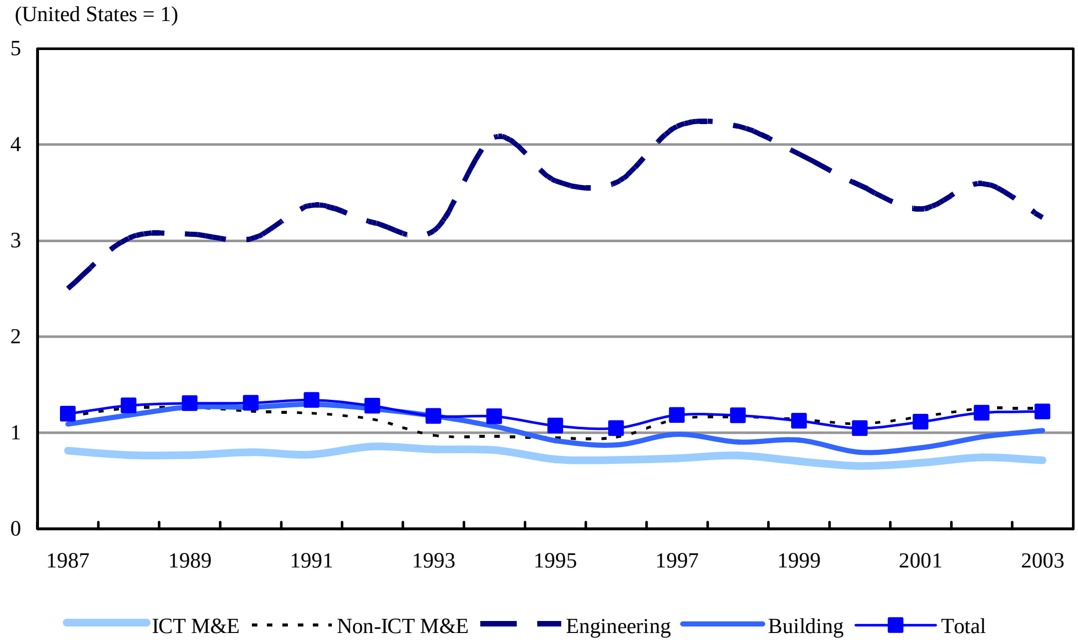
Table A.1
Depreciation rates for estimating U.S. capital stock

	United States National Income and Product Acccount asset type	Depreciation rate	Asset class[1]
1	Computers and peripheral equipment	0.45	ICT M&E[2]
2	Software	0.40	ICT M&E
3	Communications	0.23	ICT M&E
4	Medical equipment and instruments	0.17	Non-ICT M&E
5	Non-medical instruments	0.17	Non-ICT M&E
6	Photocopy and related equipment	0.25	Non-ICT M&E
7	Office and accounting equipment	0.25	Non-ICT M&E
8	Fabricated metal products	0.17	Non-ICT M&E
9	Steam engines	0.09	Non-ICT M&E
10	Internal combustion engines	0.09	Non-ICT M&E
11	Metalworking machinery	0.18	Non-ICT M&E
12	Special industrial machinery	0.18	Non-ICT M&E
13	General industrial equipment	0.18	Non-ICT M&E
14	Electric transmission and distribution	0.09	Non-ICT M&E
15	Light trucks (including utility vehicles)	0.21	Non-ICT M&E
16	Other trucks, buses and truck trailers	0.21	Non-ICT M&E
17	Autos	0.27	Non-ICT M&E
18	Aircraft	0.15	Non-ICT M&E
19	Ships and boats	0.15	Non-ICT M&E
20	Railroad equipment	0.15	Non-ICT M&E
21	Household furniture	0.23	Non-ICT M&E
22	Other furniture	0.23	Non-ICT M&E
23	Agricultural machinery	0.16	Non-ICT M&E
24	Farm tractors	0.16	Non-ICT M&E
25	Construction machinery	0.16	Non-ICT M&E
26	Construction tractors	0.16	Non-ICT M&E
27	Mining and oil field machinery	0.18	Non-ICT M&E
28	Service industry machinery	0.18	Non-ICT M&E
29	Household appliances	0.18	Non-ICT M&E
30	Other electrical	0.18	Non-ICT M&E
31	Other	0.18	Non-ICT M&E
32	Office, including medical buildings	0.13	Building
33	Commercial	0.14	Building
34	Hospitals and special care	0.10	Building
35	Manufacturing	0.07	Building
36	Electric	0.11	Engineering
37	Other power	0.11	Engineering
38	Communication	0.11	Engineering
39	Petroleum and natural gas	0.10	Engineering
40	Mining	0.09	Engineering
41	Religious	0.10	Building
42	Educational	0.10	Building
43	Other buildings	0.09	Building
44	Railroads	0.08	Engineering
45	Farm	0.09	Building
46	Other	0.09	Engineering

1. The four asset classes used in this paper.
2. Information and communications technology machinery and equipment.
Source: Bureau of Economic Analysis, 2003, *Fixed Assets and Consumer Durable Goods in the United States, 1925-97*.

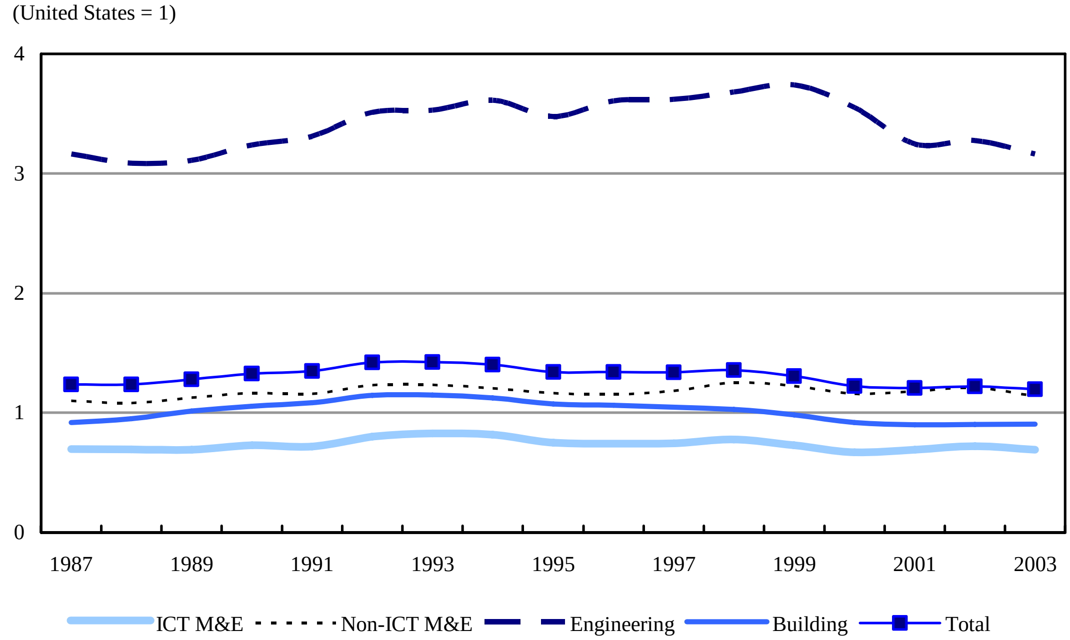
Appendix B Relative Canadian-U.S. levels of capital and investment intensities (nominal dollars)

Figure B.1
Canadian business sector investment-to-gross domestic product ratio relative to the U.S. ratio, by asset class, 1987 to 2003 (nominal dollars)



Notes: ICT M&E stands for information and communications technology machinery and equipment. Results shown are from authors' calculations.
Sources: Statistics Canada; and Bureau of Economic Analysis.

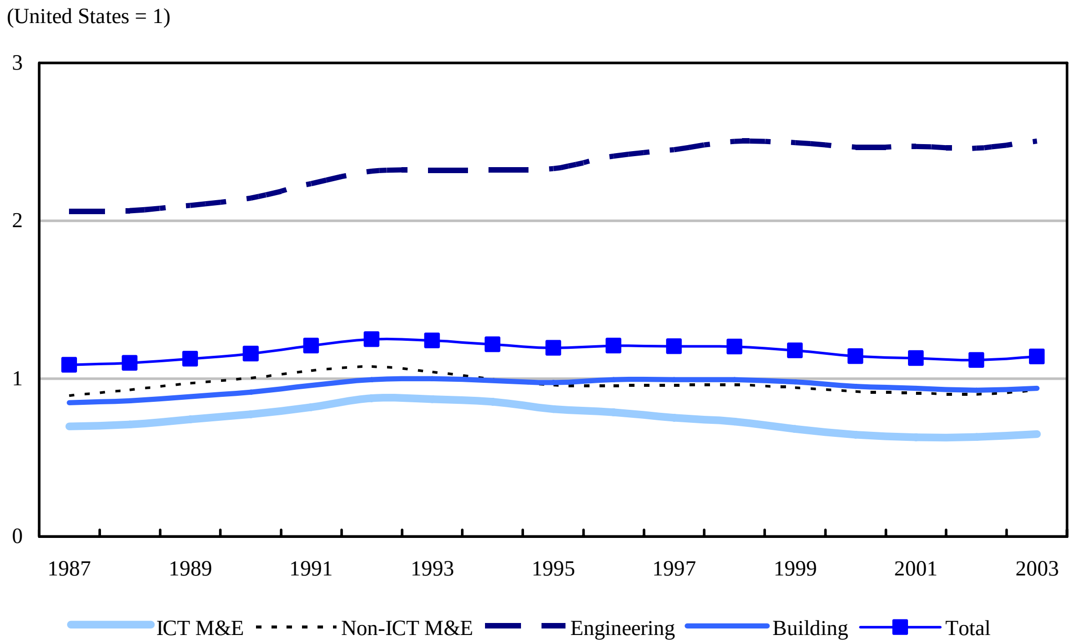
Figure B.2
Canadian business sector capital-to-gross domestic product ratio relative to the U.S. ratio, by asset class, 1987 to 2003 (nominal dollars)



Notes: ICT M&E stands for information and communications technology machinery and equipment. Depreciation rates are taken from the Canadian depreciation rates (productivity accounts) in Table 2. Results shown are from authors' calculations.
Sources: Statistics Canada; and Bureau of Economic Analysis.

Appendix C Results based on Bureau of Economic Analysis depreciation rates

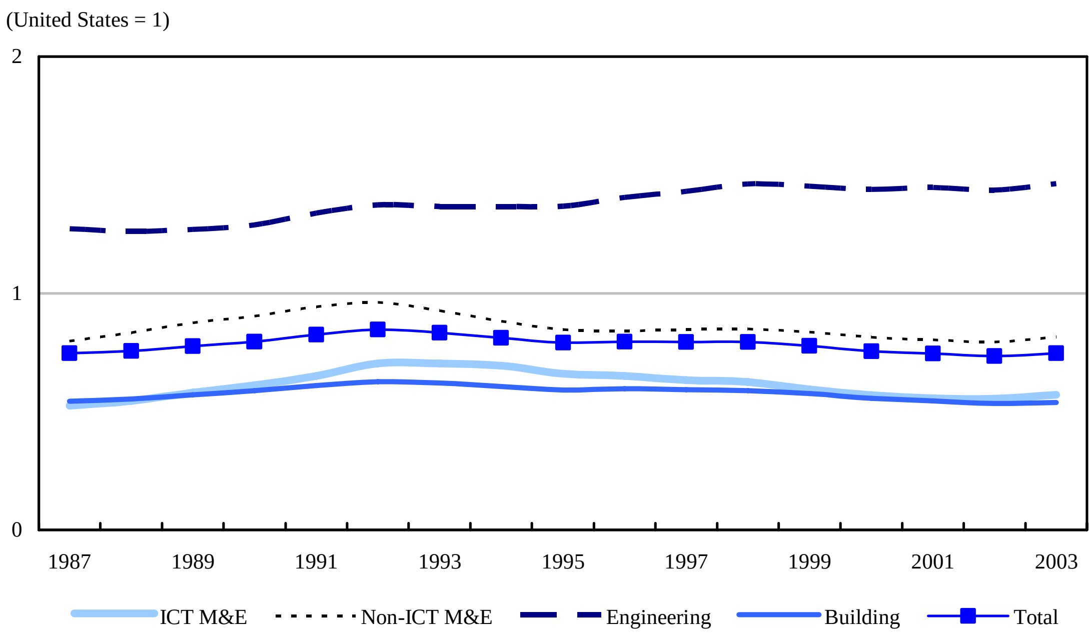
Figure C.1
Canadian total capital-to-gross domestic product ratio relative to the U.S. ratio, by asset class, 1987 to 2003 (1997 dollars)



Notes: ICT M&E stands for information and communications technology machinery and equipment. Results shown are from authors' calculations.
Sources: Statistics Canada; and Bureau of Economic Analysis.

Appendix D Results based on own depreciation rates

Figure D.1
Canadian total capital-to-gross domestic product ratio relative to the U.S. ratio, by asset class, 1987 to 2003 (1997 dollars)



Notes: ICT M&E stands for information and communications technology machinery and equipment. Results shown are from authors' calculations.
Sources: Statistics Canada; and Bureau of Economic Analysis.

Appendix E Results based on Bureau of Economic Analysis depreciation rates

Table E.1
Decomposition of Canadian-U.S. aggregate capital intensity gap, by asset class, based on Bureau of Economic Analysis depreciation rates, business sector, 2003 (1997 dollars)

	K/Y[1] Canada	K/Y United States	Gap[2]	Ki/K[3] Canada	Ki/K United States	Gap	Asset composition	Intensity (contribution)
	(1)	(2)	(3)	(4)	(5)	(6)= (4)-(5)	(7)= (3)-(8)	(8)
	ratio					percent		
Total	1.97	1.73	13.9	100.0	100.0	0.0	-3.6	17.4
ICT M&E[4]	0.12	0.19	-35.1	4.3	6.8	-2.5		-2.4
Non-ICT M&E	0.40	0.43	-7.4	19.3	22.8	-3.4		-1.6
Engineering	0.64	0.25	150.5	32.1	15.7	16.4		24.5
Building	0.82	0.88	-6.2	44.2	54.8	-10.5		-3.1

1. Capital–gross domestic product ratio.
2. Gap is measured as the percent difference between Canada and the United States.
3. Share of an asset in total capital stock.
4. Information and communications technology machinery and equipment.
Note: Results shown are from authors’ calculations.
Sources: Statistics Canada; and Bureau of Economic Analysis.

Table E.2
Decomposition of Canadian-U.S. aggregate capital intensity gap, by industry, based on Bureau of Economic Analysis depreciation rates, business sector, 2003 (1997 dollars)

	K/Y[1] Canada	K/Y United States	Gap[2]	Yi/Y[3] Canada	Yi/Y United States	Gap	Structure contri-bution	Intensity contri-bibution	Residual contri-bution
	(1)	(2)	(3)	(4)	(5)	(6)= (4)-(5)	(7)	(8)	(9)= (3)-(7)-(8)
	ratio		percent						
Agriculture	4.19	2.45	71.4	1.8	1.3	0.5		1.3	
Forestry, fishing, hunting and mining	4.90	5.34	-8.1	9.5	2.2	7.4		-0.7	
Construction	0.42	0.53	-21.4	7.4	6.5	0.8		-1.0	
Manufacturing	1.00	1.12	-11.3	21.8	17.7	4.1		-1.9	
Wholesale trade	0.40	0.69	-42.4	7.1	6.6	0.5		-2.4	
Retail trade	0.78	1.01	-23.5	7.5	8.1	-0.5		-1.6	
Transportation, warehousing and utilities	4.43	3.84	15.4	9.4	6.7	2.7		1.9	
Information	2.20	1.92	14.8	4.6	6.1	-1.6		0.8	
Finance, insurance, real estate and rental and leasing	3.87	3.15	22.8	15.1	20.2	-5.1		5.4	
Professional and business services	0.29	0.65	-55.8	9.4	16.4	-7.1		-6.3	
Other services	1.15	1.55	-25.8	6.4	8.1	-1.7		-1.8	
Total business sector	1.97	1.73	13.9	100.0	100.0	0.0	22.0	-6.4	-1.7

1. Capital–gross domestic product ratio.
2. Gap is measured as the percent difference between Canada and the United States.
3. Share of an industry in gross domestic product.
Note: Results shown are from authors' calculations.
Sources: Statistics Canada; and Bureau of Economic Analysis.

Table E.3
Decomposition of Canadian-U.S. information and communications technology capital intensity gap, by industry, based on Bureau of Economic Analysis depreciation rates, business sector, 2003 (1997 dollars)

	K/Y[1] Canada	K/Y United States	Gap[2]	Yi/Y[3] Canada	Yi/Y United States	Gap	Structure contri-bution	Intensity contri-bution	Residual contri-bution
	(1)	(2)	(3)	(4)	(5)	(6)=(4)-(5)	(7)	(8)	(9)=(3)-(7)-(8)
	ratio		percent						
Agriculture	0.01	0.02	-30.1	1.8	1.3	0.5		-0.3	
Forestry, fishing, hunting and mining	0.02	0.07	-70.3	9.5	2.2	7.4		-4.0	
Construction	0.02	0.08	-81.6	7.4	6.5	0.8		-6.9	
Manufacturing	0.04	0.08	-45.8	21.8	17.7	4.1		-8.4	
Wholesale trade	0.08	0.15	-42.6	7.1	6.6	0.5		-3.3	
Retail trade	0.06	0.07	-13.2	7.5	8.1	-0.5		-0.8	
Transportation, warehousing and utilities	0.12	0.34	-63.0	9.4	6.7	2.7		-9.0	
Information	0.89	0.76	17.0	4.6	6.1	-1.6		3.4	
Finance, insurance, real estate and rental and leasing	0.14	0.20	-26.9	15.1	20.2	-5.1		-5.1	
Professional and business services	0.16	0.22	-29.5	9.4	16.4	-7.1		-4.5	
Other services	0.07	0.05	43.4	6.4	8.1	-1.7		1.8	
Total business sector	0.12	0.19	-35.1	100.0	100.0	0.0	-4.7	-36.9	6.5

1. Capital–gross domestic product ratio.
2. Gap is measured as the percent difference between Canada and the United States.
3. Share of an industry in gross domestic product.
Note: Results shown are from authors' calculations.
Sources: Statistics Canada; and Bureau of Economic Analysis.

Table E.4
Decomposition of Canadian-U.S. non-information and communications technology capital intensity gap, by industry, based on Bureau of Economic Analysis depreciation rates, business sector, 2003 (1997 dollars)

	K/Y[1] Canada	K/Y United States	Gap[2]	Yi/Y[3] Canada	Yi/Y United States	Gap	Structure contri-bution	Intensity contri-bution	Residual contri-bution
	(1)	(2)	(3)	(4)	(5)	(6)= (4)-(5)	(7)	(8)	(9)= (3)-(7)-(8)
	ratio		percent						
Agriculture	1.17	1.17	-0.4	1.8	1.3	0.5		0.0	
Forestry, fishing, hunting and mining	0.49	1.02	-51.9	9.5	2.2	7.4		-4.2	
Construction	0.27	0.34	-21.6	7.4	6.5	0.8		-1.4	
Manufacturing	0.47	0.61	-22.5	21.8	17.7	4.1		-6.0	
Wholesale trade	0.11	0.36	-69.1	7.1	6.6	0.5		-6.3	
Retail trade	0.19	0.19	-2.0	7.5	8.1	-0.5		-0.1	
Transportation, warehousing and utilities	0.91	1.09	-16.8	9.4	6.7	2.7		-2.6	
Information	0.02	0.18	-87.8	4.6	6.1	-1.6		-7.0	
Finance, insurance, real estate and rental and leasing	0.58	0.38	50.7	15.1	20.2	-5.1		7.8	
Professional and business services	0.05	0.15	-64.7	9.4	16.4	-7.1		-8.0	
Other services	0.18	0.33	-46.3	6.4	8.1	-1.7		-3.5	
Total business sector	0.40	0.43	-7.4	100.0	100.0	0.0	28.3	-31.1	-4.6

1. Capital–gross domestic product ratio.
2. Gap is measured as the percent difference between Canada and the United States.
3. Share of an industry in gross domestic product.
Note: Results shown are from authors' calculations.
Sources: Statistics Canada; and Bureau of Economic Analysis.

Table E.5
Decomposition of Canadian-U.S. building capital intensity gap, by industry, based on Bureau of Economic Analysis depreciation rates, business sector, 2003 (1997 dollars)

	K/Y[1] Canada	K/Y United States	Gap[2]	Yi/Y[3] Canada	Yi/Y United States	Gap	Structure contri-bution	Intensity contri-bution	Residual contri-bution
	(1)	(2)	(3)	(4)	(5)	(6)= (4)-(5)	(7)	(8)	(9)= (3)-(7)-(8)
	ratio		percent						
Agriculture	1.98	1.26	57.8	1.8	1.3	0.5		1.1	
Forestry, fishing, hunting and mining	0.33	0.88	-62.6	9.5	2.2	7.4		-3.8	
Construction	0.13	0.11	20.3	7.4	6.5	0.8		0.7	
Manufacturing	0.40	0.43	-7.0	21.8	17.7	4.1		-1.1	
Wholesale trade	0.19	0.19	-0.5	7.1	6.6	0.5		0.0	
Retail trade	0.51	0.76	-32.8	7.5	8.1	-0.5		-2.8	
Transportation, warehousing and utilities	0.39	0.26	48.7	9.4	6.7	2.7		2.3	
Information	0.30	0.29	3.3	4.6	6.1	-1.6		0.1	
Finance, insurance, real estate and rental and leasing	3.16	2.59	21.8	15.1	20.2	-5.1		7.8	
Professional and business services	0.08	0.26	-69.2	9.4	16.4	-7.1		-8.8	
Other services	0.90	1.15	-22.2	6.4	8.1	-1.7		-1.9	
Total business sector	0.82	0.88	-6.2	100.0	100.0	0.0	0.8	-6.3	-0.7

1. Capital–gross domestic product ratio.
2. Gap is measured as the percent difference between Canada and the United States.
3. Share of an industry in gross domestic product.
Note: Results shown are from authors' calculations.
Sources: Statistics Canada; and Bureau of Economic Analysis.

Table E.6
Decomposition of Canadian-U.S. engineering capital intensity gap, by industry, based on Bureau of Economic Analysis depreciation rates, business sector, 2003 (1997 dollars)

	K/Y[1] Canada	K/Y United States	Gap[2]	Yi/Y[3] Canada	Yi/Y United States	Gap	Structure contri-bution	Intensity contri-bution	Residual contri-bution
	(1)	(2)	(3)	(4)	(5)	(6)= (4)-(5)	(7)	(8)	(9)= (3)-(7)-(8)
	ratio		percent						
Agriculture	1.04	0.00	-100.0	1.8	1.3	0.5		-16.7	
Forestry, fishing, hunting and mining	4.06	3.35	21.4	9.5	2.2	7.4		3.7	
Construction	0.00	0.00	-13.8	7.4	6.5	0.8		-0.5	
Manufacturing	0.09	0.01	1305.6	21.8	17.7	4.1		33.0	
Wholesale trade	0.01	0.00	1140.7	7.1	6.6	0.5		9.1	
Retail trade	0.02	0.00	460.7	7.5	8.1	-0.5		7.1	
Transportation, warehousing and utilities	3.01	2.16	39.4	9.4	6.7	2.7		10.1	
Information	1.00	0.70	43.4	4.6	6.1	-1.6		3.3	
Finance, insurance, real estate and rental and leasing	0.01	0.01	-37.8	15.1	20.2	-5.1		-4.2	
Professional and business services	0.01	0.04	-69.5	9.4	16.4	-7.1		-8.1	
Other services	0.01	0.02	-69.8	6.4	8.1	-1.7		-4.4	
Total business sector	0.64	0.25	150.5	100.0	100.0	0.0	96.1	32.3	22.1

1. Capital–gross domestic product ratio.
2. Gap is measured as the percent difference between Canada and the United States.
3. Share of an industry in gross domestic product.
Note: Results shown are from authors’ calculations.
Sources: Statistics Canada; and Bureau of Economic Analysis.

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