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Business Sector Intangible Capital and Sources of Labour Productivity Growth in Canada

by Wulong Gu and Ryan Macdonald

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Abstract

This paper updates and expands upon the intangible capital estimates presented by Baldwin et al. (2009), who extended already measured intangibles (i.e., research and development [R&D], software, mineral exploration) to include additional asset classes consistent with international research on intangible capital measurement (see Corrado, Hulten and Sichel 2009). The extended set of intangible assets included advertising and brand equity, financial innovation, architectural design, purchased non-R&D science, own-account non-R&D science, firm-specific human capital, and own-account and purchased organizational capital.

This paper estimates the effect of including intangible capital in estimates of gross fixed capital formation (GFCF), capital stock and productivity for the business sector in Canada from 1976 to 2016. It extends previous intangible capital estimates by disaggregating the Canadian business sector among industries and provinces. The results show that minor adjustments to labour productivity resulting from the inclusion of intangible capital continue for the updated years (2009 to 2016). The disaggregation across industries and geography illustrates that this finding also pertains to subdivisions of the Canadian business sector, with only minor change occurring for measures of labour productivity.

In addition to supporting early findings that the inclusion of intangible capital leads to only minor adjustments to measures of labour productivity, the disaggregation of intangible assets across industries and geography extends the original work by illustrating the composition and diversity of innovation in Canada. Moreover, it expounds on the importance of intangibles as a source of capital deepening. Intangible GFCF is undertaken in all industries and in all geographies. Innovation in a given industry or geography is not confined to one particular type of innovative activity. Rather, innovation occurs diffusely throughout the economy, across an array of asset types.

Executive summary

Understanding intangible investments is essential for providing accurate measures of gross fixed capital formation (GFCF), gross domestic product (GDP) and productivity growth, and for understanding the innovation system. Statistical agencies need measures of intangible investment to produce economic statistics on aggregate activity that accurately measure concepts such as GDP, GFCF or savings. The levels of GDP, GFCF and savings will be underestimated to the extent that expenditures are incorrectly classified as intermediate inputs that are fully consumed during the period being measured—and not as investments that are not fully consumed during the period when the expenditures are incurred. Estimates for GDP and productivity growth rates may be similarly underestimated.

Incomplete estimates for intangible GFCF also leave studies on the degree of innovation in the economy without comprehensive data on the types of innovation being conducted. Intangible investments are generally associated with the innovation process, which produces new products and processes. Without detailed data on the nature of intangible investments, the richness of the innovation system is obscured. Furthermore, policy prescriptions that focus only on components that are visible and more easily measured, such as research and development (R&D), may be misguided.

Previous estimates for a broad range of intangibles in the Canadian business sector were compiled by Baldwin et al. (2009). The categories of intangibles included already measured intangibles (R&D, software, mineral exploration) and an extended set of intangible assets (advertising and brand equity, financial innovation, architectural design, purchased non-R&D science, own-account non-R&D science, firm-specific human capital, and own-account and purchased organizational capital). These estimates illustrated the importance of including intangibles when measuring investment and capital stocks, and, paradoxically, that including intangibles did not significantly change measures of labour productivity.

This paper updates the previous estimates to include more recent years; disaggregates the estimates among industries, provinces and territories; and, in doing so, illustrates a minor adjustment to labour productivity growth rates. The disaggregated estimates show the importance of innovation expenditures in all industries and geographies. That importance is spread across various intangible assets types, and this demonstrates the diverse, diffuse nature of innovation in the Canadian economy.

Canadian estimates for intangible capital show that from 1976 to 2016:

- Growth of intangible investments was faster than that of tangible investments. However, growth in intangible investments slowed decade by decade, and, in the most recent decade, intangible growth lagged behind tangible GFCF growth.
- The share of the capital stock going to intangible capital grew in prominence. However, the share of intangible capital in the business sector capital stock declined after 2000 as investment in intangibles slowed more than investment in tangibles.
- The inclusion of intangible capital did not significantly affect the growth rate of labour productivity, but it did highlight the contribution of innovation to productivity growth.

The data also show the importance of certain intangible assets for certain industries (mineral exploration for the mining and oil and gas extraction sector; R&D for the manufacturing sector and the professional, scientific and technical services sector), and the importance of certain intangible assets for certain provinces. Often, across provinces, the importance of an intangible asset is related to that province's main export industries.

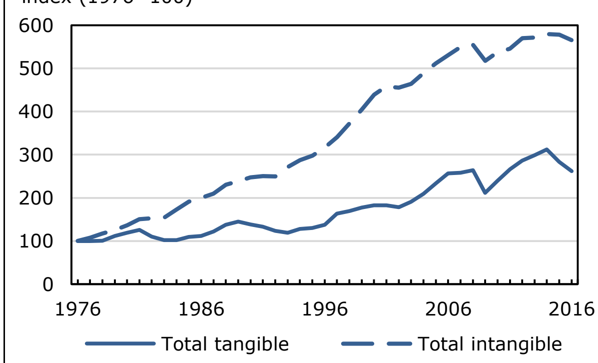
Finally, the data speak to the widespread nature of the innovation process, and changes in the structure of the innovation process over time. Intangible GFCF occurs in all industries and provinces, with economic competencies usually making an important contribution. The innovation process is more diffuse than measures of innovation based solely on R&D would imply.

Executive data summary

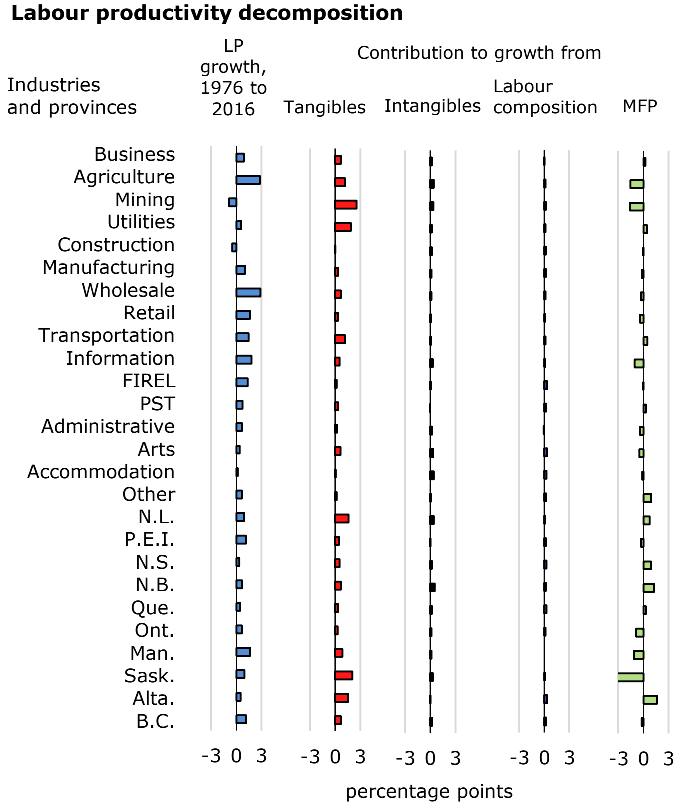
Business sector gross fixed capital formation

	1976	2016
Intangible gross fixed capital formation	$7.1 billion	$134.3 billion
Tangible gross fixed capital formation	$30.1 billion	$234.8 billion
Top three industries by total current intangible expenditures	-Manufacturing -Finance and insurance -Construction	-Finance and insurance -Manufacturing -Construction
Top three assets by current expenditures	-Own-account organizational capital -Architecture -Advertising	-Own-account organizational capital -Architecture -Purchased organizational capital
Percent of research and development in total intangibles	3.4%	10.9%

Real gross fixed capital formation, tangible versus intangible

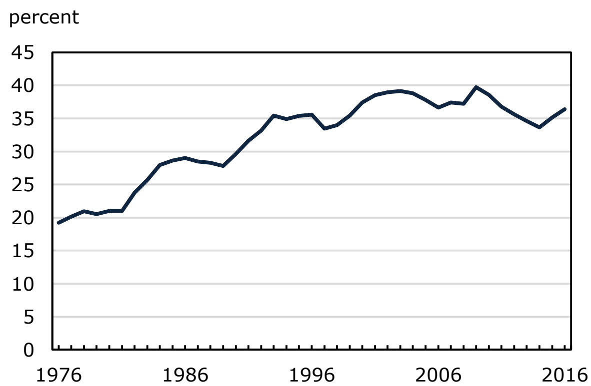


Labour productivity decomposition

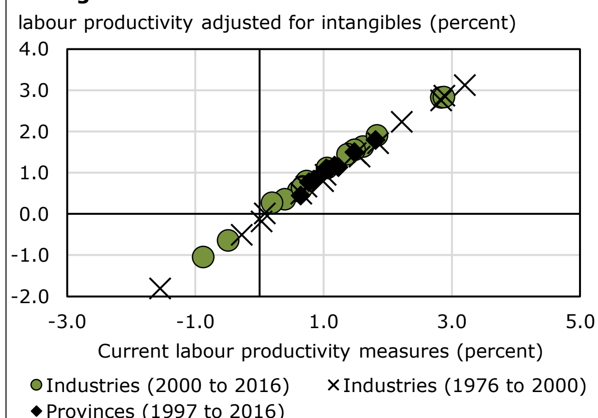


Notes: Labour productivity (LP) growth adjusted for intangibles. MFP: multifactor productivity. Table 5 shows the full names of industries.

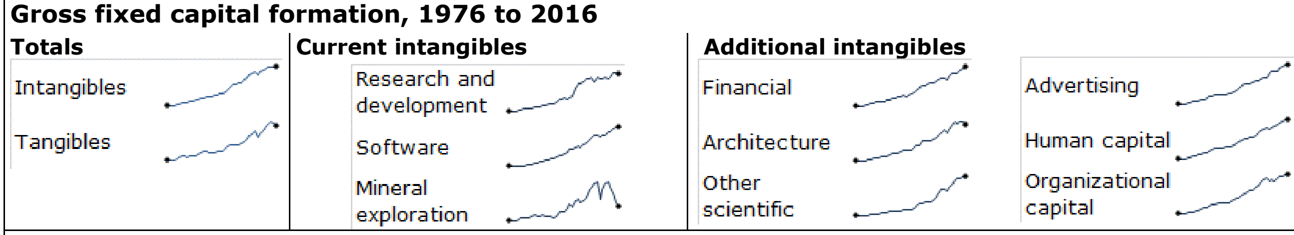
Intangible capital share of total capital stock



Adjusting labour productivity growth for intangibles



Gross fixed capital formation, 1976 to 2016



Sources: Statistics Canada, Canadian System of Macroeconomic Accounts and authors' calculations based on data from supply and use tables, Census of Population, Labour Force Survey, and Workplace and Employee Survey.

1 Introduction

Gross fixed capital formation (GFCF) is the foundation of economic growth (see Solow 1956, for example). GFCF expenditures allow the economic system to enhance productive capacity. They are behind gains in productivity that increase the amount of output that can be produced with existing labour. They are also an essential part of innovation, which involves the discovery and introduction of new processes and new products.

Traditionally, economists have focused on GFCF for tangible capital goods (e.g., machinery, railways, power plants). These types of assets are straightforward to observe and are regularly purchased on markets. However, changes in the structure of the economy as it moves away from goods production and toward service provision, as well as the seemingly increased pace of technological change, have increased the importance of more intangible forms of GFCF. For example, the computer revolution increased the importance of software, which became the new driver of systems for both service provision (e.g., banking and digital assistants) and goods production (through industrial processes or advanced robotics).

Examining these intangible investments is essential for providing accurate measures of economic activity, and for understanding the innovation system. Statistical agencies need measures of intangible investment to produce economic statistics on aggregate activity that accurately measure concepts such as gross domestic product (GDP), GFCF or savings. The levels of GDP, GFCF and savings—and measures of the capital stock and national wealth—will be underestimated to the extent that expenditures are incorrectly classified as intermediate inputs that are fully consumed during the period being measured, and not as investments. To the extent that intangible investment growth differs from overall growth, estimates for GDP and productivity growth rates can also be affected (Baldwin, Gu and Macdonald 2012).

This paper examines intangible investment by updating estimates for the Canadian business sector from Baldwin et al. (2009) and by extending previously reported measures of intangible GFCF and capital stocks, and their contribution to labour productivity growth, by disaggregating estimates among industries and among provinces and territories. Updates to business sector intangible capital and estimates for intangibles from 2009 to 2016 are based on updated input series from the Canadian System of Macroeconomic Accounts.

Because of the lack of complete estimates for intangible GFCF, studies on the degree of innovation in the economy do not have comprehensive data on the types of innovation being conducted. Previous papers (Baldwin et al. 2009; Baldwin, Gu and Macdonald 2012) have argued that intangibles and innovation are closely related. This paper supports that line of reasoning. Intangible investments are an important input for innovation. Although not all expenditures lead to innovation, expenditures on intangibles indicate the presence and intensity of innovative activity. Moreover, in numerous instances, expenditures on intangibles directly lead to assets that are protected by law, which results in an intangible asset (the result of the innovation) in a form with rivalrous properties and that can be traded on markets.

For example, mineral exploration leads to an improved understanding of the natural world. The process for making subsurface asset claims provides the claim holder with exclusive subsurface mineral rights. These legally protected rights can be sold on markets and can lead to the creation of new industries. This was the case with diamond mining in Canada. Similarly, research and development (R&D) expenditures lead to the creation of new products and processes, as do expenditures on internal engineering and science services. Advertising expenditures produce recognizable brands and support firms' economic competencies. The outcome of these expenditures (e.g., patents, copyrights and trademarks) are the legally protectable manifestations of the knowledge assets that are created. Moreover, knowledge such as trade secrets can become embedded in production processes that can subsequently be sold. In the same vein, changes in organizational structure represent management activities that affect the actual physical structure of firms. These may be acquired by another party through a takeover.

This paper's decomposition of estimates of intangibles among industries and among provinces and territories provides insights on the breadth and importance of innovation in Canada. Without these detailed data on the nature of intangible investments, the richness of the innovation system is obscured. Furthermore, policy prescriptions that focus only on components that are visible and more easily measured, such as R&D, may be misguided.

Although they are not a perfect measure of innovation, the ties between intangibles and innovation are sufficiently robust to illustrate that innovation is not confined to R&D-intensive industries, and that innovation expenditures are diffuse, with important expenditures occurring in all industries and geographies. Furthermore, although including intangible assets in measures of economic growth (GDP, labour productivity) does not greatly affect growth rates, this inclusion does illustrate the diversity, richness and importance of the contribution of intangibles to innovation, and the significant level of current innovation expenditure.

It must be noted that this paper's measures of intangible GFCF do not form an exhaustive list of intangible assets. For example, databases and artistic originals are not captured. Also, measurement of intangible GFCF is not always direct. The nature of intangible investment (that it does not necessarily produce a physical manifestation; that it is often done within a firm rather than through markets) means that rules of thumb, approximations or assumptions must be imposed to produce measures of intangible GFCF and its capital stock. As a result, estimates for intangible GFCF will contain measurement error (the level of which is unknown), and will not perfectly align with theoretical measures of intangible assets. Nevertheless, the estimates reported in this paper were compiled based on current best practices from both the 2008 System of National Accounts (SNA) (UN et al., 2009) and the international literature on intangible GFCF. Methodologies are consistent with SNA recommendations, and parameter values—when not available from Canadian sources—were taken from the published literature (particularly Corrado, Hulten and Sichel 2009) to promote comparability across countries.

The remainder of this paper examines measures for a broad range of intangible assets, and their importance for understanding the levels, composition and growth rates of GFCF, GDP and labour productivity. Section 2 discusses intangible capital assets and how they are measured in the Canadian statistical system. Section 3 discusses the growth account framework, and how expenditures on intangible assets can be integrated into it. Section 4 provides the results of expanding the concepts of GFCF, GDP, productivity and capital stocks currently used in Canada. Section 5 concludes the paper.

2 Intangible investment measurement

Measurement of intangible capital has evolved over the last 30 years. Before that, estimates of GFCF by national statistical agencies contained only physical assets, although the importance of R&D capital and human capital was recognized in theoretical and academic work (for example, see Solow 1956; Mincer 1958; Mankiw, Romer and Weil 1992). Beginning in the 1990s, and particularly with the introduction of the 1997 SNA, estimates for intangible assets began to be incorporated into official measures of investment and capital stocks. Initially, measures of mineral exploration and software were incorporated into the Canadian System of Macroeconomic Accounts (CSMA) (Lal 1994, 2002, Statistics Canada 2001, Jackson 2002). The intangible asset estimates in Canada were subsequently expanded to include R&D, following the introduction of the 2008 SNA (Barber Dueck 2008).

Preceding the changes in GFCF in national statistical agencies, the literature examined the intangible economic concepts, their measurement and, often, a satellite account for how to integrate the new asset into the SNA. The literature on intangibles initially focused on mineral exploration, software and R&D because these were the assets of interest to researchers on economic growth, and because of the prominence of software in the 1990s computer revolution. However, as these measures were developed and their uses expanded, it became apparent that they did not capture the full extent of non-physical GFCF.

Coupled with this realization, changes in advanced economies toward services, increased return on capital (Hall 2001), and increased speed of technological change led researchers to consider a broader range of intangible capital assets. Corrado, Hulten and Sichel (2005, 2009) compiled the first set of intangible capital estimates to understand intangible assets for the American business sector.[1] These assets focused on three business function areas: computerized information, innovative property and economic competencies. These studies illustrated the importance of intangible investment for the United States, and showed that it had been growing over time. Subsequent work continued to examine measurement methods (Corrado et al. 2012) and to demonstrate the importance of intangible capital in modern economies (Haskel and Westlake 2017).

These results were echoed in Canada. Results from Baldwin et al. (2009) were the first to illustrate the importance of a wide range of intangible estimates. In addition to the assets included by Corrado, Hulten and Sichel (2005, 2009), Baldwin et al. (2009) included expenditures on scientists and engineers not involved in the production of other intangible assets. The purpose of these expenditures is to increase knowledge of production systems and to integrate new physical capital or processes with existing capital and processes. Thus, the expenditures form an important source of knowledge about "how to get things done," which is not captured in the asset classification used by Corrado, Hulten and Sichel (2005, 2009). Baldwin et al. (2009) also provided the first set of industry-based intangible GFCF estimates.

Baldwin, Gu and Macdonald (2012) moved to integrate the GFCF estimates for Canada with those from Corrado, Hulten and Sichel (2005, 2009). This involved applying the same ratios used to separate investment from current expenditure, and calculating capital stocks and undertaking a Canada–United States comparison of labour productivity growth, using the standard growth accounting framework. This was done only for the business sector total. As with previous estimates, the rising importance of intangible GFCF as a share of total GFCF was highlighted. Also, consistent with results from the United States, the inclusion of a broader range of intangible capital estimates changed the levels of important economic metrics (such as GFCF, labour productivity and GDP). However, this inclusion did not tend to change the growth rates of these metrics significantly.

Estimates of intangibles were also developed for other countries (Haskel and Westlake 2017 for the United Kingdom; Rooijen-Horsten et al. 2008 for the Netherlands; van Ark et al. 2009 for several European countries). Those studies also found a growing importance of intangibles in total GFCF in those countries.

Measures of intangible capital in this paper continue to be based on the categories defined by Corrado, Hulten and Sichel (2005, 2009), and include components enumerated by those authors in addition to the additional asset for non-R&D scientific and engineering expenditures, which is important for Canada (Baldwin et al. 2009; Baldwin, Gu and Macdonald 2012). Intangible GFCF is broadly grouped based on three types of intangible assets: computerized information, innovative property and economic competencies (Table 1).[2] Specific intangible assets are enumerated within these broad classifications, and the measurement of each asset is described in detail below.

1. Intangible assets in other sectors are also being researched. Investment in, and the construction of, human capital stock estimates has also gained attention (see Jorgenson and Fraumeni 1989, Gu and Wong 2010, UNECE 2016).
2. See Corrado, Hulten and Sichel (2005, 2009) and Baldwin, Gu and Macdonald (2012) for the issues related to the measurement of intangibles in Canada.

Table 1
Intangible gross fixed capital formation (GFCF) categories and data sources

Category	Data source	Currently included in CSMA as GFCF
Computerized information		
Purchased software	CSMA	Yes
Custom software	CSMA	Yes
Own-account software	CSMA	Yes
Innovative property		
Purchased research and development	CSMA	Yes
Own-account research and development	CSMA	Yes
Mineral exploration	CSMA	Yes
Financial industry development costs	SUTs	No
New architecture and design	SUTs	No
Purchased other science	SUTs	No
Own-account other science	LFS, CP	No
Economic competencies		
Advertising	SUTs	No
Firm-specific human capital	CP, WES, LFS	No
Purchased organizational capital	SUTs	No
Own-account organizational capital	CP, LFS	No

Notes: CSMA: Canadian System of Macroeconomic Accounts; SUTs: supply and use tables; LFS: Labour Force Survey; CP: Census of Population; WES: Workplace and Employment Survey.

Source: Statistics Canada.

2.1 Computerized information

Computerized information as an intangible asset in Canada is composed of computer software expenditures. These expenditures are currently capitalized in the CSMA, and are included in measures of GFCF, GDP and productivity (see Jackson 2002).

2.2 Innovative property

Innovative property expenditures are primarily undertaken to understand and manipulate the natural environment to produce new products and processes. The base of innovative property includes the type of R&D activities outlined in the *Frascati Manual 2015* (Organization for Economic Cooperation and Development [OECD] 2015) and mineral explorations. However, it also includes scientific and engineering expenditures outside the Frascati Manual definition, and costs relating to new architecture and engineeringp design and the development of new products in the financial industry, the latter of which sometimes borrows from the physical sciences (for example, see Black and Scholes 1973).

2.2.1 Science and engineering research and development

This category includes business expenditures on R&D that are consistent with the definitions in the Frascati Manual. It includes mining R&D (the development of new exploration techniques and associated research), but not mineral exploration activities. Estimates of business expenditures relating to R&D are currently capitalized in the CSMA, and estimates of R&D expenditures are obtained from the CSMA (see Statistics Canada 2008; Gu, Terefe and Wang 2012).[3]

3. The estimates produced by Baldwin, Gu and Macdonald (2012) were produced from R&D surveys before these estimates were incorporated into the National Accounts. This paper uses the National Accounts estimates.

2.2.2 Mineral exploration

Mineral exploration consists of all exploration, drilling, and geological and geophysical expenditures associated with the predevelopment stage of mineral and oil and gas extraction. Mineral exploration has been capitalized in Canada since 1997, and estimates are taken from the CSMA (see Lal 2002).

2.2.3 Costs relating to the development of new products in the financial services industry

The financial services industry produces long-lasting financial products. However, there are no broad survey data on the resources this industry devotes to these activities. The methodology developed by Corrado, Hulten and Sichel (2005, 2009) is followed to estimate the value of financial innovation using the costs of new-product development by the financial services industry. It is calculated as 20% of total intermediate purchases by that industry. The data on the total intermediate purchases are taken from Statistics Canada supply and use tables (SUTs).

2.2.4 New architecture and engineering design

Intangible assets are also created by efforts in the architectural and engineering services industry to develop new products for specific clients that generate knowledge that can be transferred to other products. This is estimated as half of total expenditures on architectural and engineering services by the business sector.[4]

2.2.5 Other product-development and science-related expenditures

This category includes science-related and engineering-related expenditures other than those covered by official R&D measures. The development of new products and new scientific activities—primarily in the area of applied engineering—occurs in many industries (Baldwin, Beckstead and Gellatly 2005). This paper distinguishes between two types of other science-related and engineering-related activities: own-account science and engineering services, and purchased science and engineering services.

Own-account science and engineering expenditures consist of wages and salaries for scientists and engineers in each year. This category is created from occupational data on scientists gathered from the Census of Population and the Labour Force Survey (LFS). To avoid double counting with other categories of intangibles where the wages and salaries of scientists and engineers are used to approximate intangible asset expenditures, scientists and engineers in the following sectors are excluded: monetary authorities—central bank; architectural, engineering and related services; management, scientific and technical consulting services; scientific research and development services; advertising, public relations, and related services; and other professional, scientific and technical services. Following the assumptions of Corrado, Hulten and Sichel (2005, 2009), it is assumed that only 20% of those other own-account science and engineering expenditures (i.e., compensation of scientists and engineers) are GFCF. The remaining 80% are classified as current expenses. The 20–80 split between investment and current expenses for expenditures on scientists and engineers is the same as the split for the value of managers’ time between investment and current expenses.

4. In some cases, the supply and use tables refer to North American Industry Classification System (NAICS) products. A number of these categories are included in intangible calculations, including architectural, engineering and related services (NAICS product 5413); monetary authorities—central bank (NAICS product 521); management, scientific and technical consulting services (NAICS product 5416); scientific research and development services (NAICS product 5417); advertising, public relations, and related services (NAICS product 5418); and other professional, scientific and technical services (NAICS product 5419).

The purchased science and engineering expenditures are estimated as 50% of business expenditures on scientific R&D services, and as 50% of expenditures on other professional, scientific and technical services. The 50–50 split between investment and current expenses is the same as for new architecture and engineering design. The data on total expenditures are not available for the individual four-digit North American Industry Classification System (NAICS) industries used to estimate the expenditures on purchased science and engineering. Data are available only for more aggregated industries. Compensation data from the Census of Population and the LFS are used to allocate the aggregate gross output data to those four-digit NAICS industries.

2.3 Economic competencies

Economic competencies cover intangible assets related to a firm's ability to compete and organize. They include three types of assets: brand name, firm-specific human capital and organizational structure.

2.3.1 Brand equity

Spending on brand equity is approximated by expenditures on advertising, which have long been recognized as a valuable asset. Expenditures on advertising are obtained from the SUTs. Total expenditures on advertising services were much higher than the gross output of the advertising, public relations, and related services industries, since advertising services are often produced in industries other than advertising industries. It is assumed that 60% of total advertising expenditures are for advertising that had long-lasting effects. These are included as GFCF.

2.3.2 Firm-specific human capital

Firm-specific human capital is estimated from the costs of employer-provided workplace training. The costs of employer-provided training are obtained from the Workplace and Employee Survey (WES), conducted by Statistics Canada, for the years 1999 to 2005. The total spending obtained from the WES includes direct firm expenses (outlays on instructors, tuition reimbursements, etc.) and, in most cases, the wage and salary costs of employee time spent in formal training.

Training expenditures for other years are extrapolated using worker compensation by province and industry in the CSMA. This extrapolation method was chosen because the ratio of training expenditures to compensation was more or less constant across the years for which data on training expenditures are available, namely 1999, 2001, 2003 and 2005. A similar extrapolation method was used by O'Mahony (2012) for estimates of training expenditures for several European countries.

2.3.3 Organizational capital

Investments in organizational change and development have both own-account and purchased components.

The own-account component of organizational capital is estimated as 20% of the compensation of managers in the business sector. Data on the compensation of managers are obtained from the occupation data included in the Census of Population and the LFS. The compensation of managers is estimated as hours worked multiplied by hourly compensation. Total hours worked by managers are estimated using data from the LFS, and hourly compensation is estimated using data from the Census of Population. Data on hours worked and compensation are benchmarked to data in the CSMA.

The purchased component of organizational capital is estimated as total expenditures on management consulting services.

2.4 Revisions to previous estimates

There are differences in the estimates of intangibles between Baldwin et al. (2009), Baldwin, Gu and Macdonald (2012), and the estimates in this paper. Baldwin et al. (2009) estimated several categories indirectly from the wages of scientists and engineers, whereas Baldwin, Gu and Macdonald (2012) used assumptions derived from Corrado, Hulten and Sichel (2005, 2009) using intermediate purchases to provide estimates that are comparable to those of the United States.

This paper also uses the assumptions from Corrado, Hulten and Sichel (2005, 2009), but the procedures used to remove some wage and scientist estimates from the intermediate purchases have been adjusted to avoid double counting. The CSMA also revised some series during its historical revision process, and incorporated measures of R&D GFCF and capital. Finally, the component entitled “purchases of management services” has been revised because of revisions to this series in the SUTs. Some series have been revised by approximately 10% to 20%, and the largest change comes from the purchases of management services.

2.5 Data suitability

The estimates of intangibles in this paper are primarily based on information from the CSMA, which generates internally consistent data that are used to produce economic aggregates such as GDP, GFCF and consumption.

Some of the individual intangible components are recognized by the National Accounts as investments. Software, R&D and mineral exploration are now included in investment totals, but were previously considered intermediate expenditures. These components have been incorporated into the official estimates, and have therefore been vetted for suitability by the process that produces the National Accounts. However, other components have not, and the estimates provided in this paper should therefore be regarded as experimental.

Before the CSMA began to treat R&D, software and mineral exploration expenditures as investments, it treated them as intermediate expenses, and the categories were measured less comprehensively, if at all. Once these items came to be treated as investments rather than expenditures, the accuracy of their measurement improved. The estimates for intangible GFCF outside the measures currently in the CSMA continue to follow this path.

Most of the other categories of intangibles reported in this paper are still treated as intermediate expenditures in the CSMA. In some cases, the intermediate expenditure category used is not even measured separately. For example, there is no set of expenditures on scientists employed in developing new products outside of R&D. There is also no information on investments made in management practices and procedures. These are estimated as a percentage of salaries paid to management.

The actual percentage of the categories that are used to measure the magnitude of investments as opposed to intermediate expenses has generally been chosen arbitrarily. The level was chosen to provide results that are comparable with those produced for the United States (Corrado, Hulten and Sichel 2005, 2009) and for European countries (Corrado et al. 2012). More research is required to determine how much of each category reported in this paper consists of an investment as opposed to an intermediate expenditure.

The list of intangible assets is also incomplete. In particular, databases and artistic originals are not included. Finally, it should be noted that this paper covers the business sector only, and excludes public administration and non-profit institutions serving households.

3 Sources of growth accounting

This paper uses the standard sources of growth (SOG) decomposition for labour productivity growth that is found in discussions of intangible capital (see Corrado, Hulten and Sichel 2009; Baldwin, Gu and Macdonald 2012):

$$\Delta lp_t = s_k \Delta(k/l)_t + s_n \Delta(\mathrm{n}/l)_t + s_l \Delta lcomp_t + \Delta mfp_t \tag{1}$$

where Δlp is the change in labour productivity, which is defined as real GDP per hour worked, $\Delta(k/l)$ is the change in the amount of tangible capital per hour worked (tangible capital deepening), $\Delta(n/l)$ is the change in intangible capital per hour worked (intangible capital deepening), $\Delta lcomp_t$ is the contribution of changes in labour composition, and Δmfp_t is the contribution of multifactor productivity (MFP) growth. The cost shares of tangibles, intangibles and labour input in total cost are denoted as s_k, s_n, s_l, respectively. The contributions from capital deepening and labour composition are calculated as the change in the capital deepening and labour composition weighted by their respective importance in GDP.

To implement the SOG decomposition, it is necessary to adjust measures of GDP, real GDP and capital services to include intangible assets not currently included in GDP in the CSMA (see Baldwin, Gu and Macdonald 2012). The adjustments to GDP and real GDP occur in one of two ways.

First, for assets where the intermediate purchase is recorded in the SUTs, the asset is reclassified as the purchase of a final asset rather than as the purchase of an intermediate input. When the purchase is reclassified in this way, intermediate inputs decline by the value of the purchase, while GFCF rises by the same amount. Labour input and labour income for the industry are unaffected, but the gross operating surplus rises by an amount equal to the purchase of the asset, which reflects the higher level of capital services available after recognizing the intangible asset as a form of capital.

Second, for assets where the SUTs do not currently record the expenditure as an intermediate expenditure (e.g., with own-account organizational capital), a new output is created. The new output raises gross output for the industry, and GFCF rises by the same amount since the new output is, by assumption, an investment in an intangible asset. Because there is no change in intermediate inputs, and labour input and labour income are unchanged, gross operating surplus rises by the same amount as the new GFCF.

In both cases, GDP rises and both the level and the growth rate are affected. In the second case, if the intangible asset's growth rate is higher than the industry's growth rate, then the growth rate for GDP or real GDP will also increase. However, the effect of including the new intangible asset significantly depends on the relative size of the asset compared with all other components.

There are two steps to adjust the flow of capital services to account for the new intangible assets.

In the first step, the capital stock for each intangible asset is calculated. This is accomplished using the perpetual inventory method, with deflated values for intangible GFCF used as investments over time. Deflated values are formed based on prices in the SUTs. If the asset is not in the SUTs, a GDP deflator is applied. This follows recommendations found in the 2008 SNA, and practices from earlier works (Corrado, Hulten and Sichel 2009; Corrado et al. 2012; Baldwin, Gu and Macdonald 2012). To apply the perpetual inventory method, the depreciation rates from Corrado, Hulten and Sichel (2009) and Corrado et al. (2012) are employed for assets not currently capitalized in the CSMA (Table 2). As a point of comparison, the average depreciation rates for buildings and for machinery and equipment from 1985 to 2010 are included at the bottom of the table.

Table 2
Depreciation rates by asset and source

Assets	Sources	Depreciation rates
Intangible assets		
Research and development services	CSMA	0.275
Own-account research and development services (except software development)	CSMA	0.275
General purpose software	CSMA	0.550
Custom software design and development services	CSMA	0.330
Own-account software design and development services	CSMA	0.330
Mineral and oil and gas exploration	CSMA	0.080
Development costs in financial industry	2005 CHS	0.200
New architecture and engineering design	2005 CHS	0.200
Own-account other science and engineering services	2005 CHS	0.200
Purchased other science and engineering services	2005 CHS	0.200
Advertising	2005 CHS	0.600
Firm-specific human capital	2005 CHS	0.400
Purchased organizational capital	2005 CHS	0.400
Own-account organizational capital	2005 CHS	0.400
Tangible assets		
Buildings	2015 BLT	0.100 [1]
Machinery and equipment	2015 BLT	0.218 [1]
Computers, associated hardware and word processors	2015 BLT	0.431 [1]

1. Average value, 1985 to 2010.

Notes: CSMA: Canadian System of Macroeconomic Accounts; 2005 CHS: Corrado, Hulten and Sichel (2005); 2015 BLT: Baldwin, Liu and Tanguay (2015).

Source: Statistics Canada.

In the second step, the flow of capital services is recalculated to take into account the new forms of capital. Here, a standard user cost of capital equation is employed:

$$c_t = \left(\frac{1-u_t z_t}{1-u_t}\right)\left[P_{t-1}^I r_t + P_t^I \delta - P_{t-1}^I \pi_t\right], \tag{2}$$

where u_t is the corporate income tax rate, z_t is the present value of depreciation deductions for tax purposes on a dollar's investment in an asset over the lifetime of the investment, c_t is the user cost of capital, P_t^I is the market price of an investment asset, and $\pi_t = (P_t^I - P_{t-1}^I)/P_{t-1}^I$ is the capital gain or loss of an asset.

For intangible assets, the capital cost allowance rates are "1," and the present value of depreciation deductions for tax purposes on a dollar's investment in the asset is also "1" since those assets are treated as intermediate expenses for tax purposes.

The user cost of capital for an asset (c_t) can be thought of as the price of an asset, in a well-functioning market, that an owner is renting to a user. That price would comprise a term that reflects the opportunity cost of capital (r_t), a term that reflects the depreciation of the asset (δ), and a term that reflects capital gains or losses from holding the asset (π_t). That user cost of capital must be adjusted to take into account the effects of tax parameters, which include the effects of the corporate tax rates and capital cost allowance for depreciable assets, as in Equation (2).

Except for the nominal rate of return (r_t), each term on the right-hand side can be calculated for each intangible asset. Two main alternatives have been used to estimate the rate of return on capital and the user cost of capital for intangible assets: endogenous rates of return that are calculated from capital income, and exogenous rates of return that are chosen from observed market rates (such as a government bond rate, a corporate debt rate, or a weighted average of corporate debt and corporate equity rates). Corrado, Hulten and Sichel (2005, 2009) used endogenous rates of return to calculate the user cost of intangible capital for the United States and the United Kingdom. In contrast, Rooijen-Horsten et al. (2008) used exogenous rates of return for the Netherlands.

For this paper, the endogenous rates of return for estimating the user cost of intangible assets are used for a comparison with the results for the United States from Corrado, Hulten and Sichel (2009). The endogenous rate of return is solved using an equation where the sum of capital costs across all capital assets is equal to the adjusted gross operating surplus.

After all adjustments, the shares of tangibles, intangibles and labour costs in total costs can be determined. Next, the SOG decomposition is employed to determine the relative importance of tangible assets, intangible assets, labour composition and MFP in labour productivity growth.

4 Results

Results are reported in three stages. First, results for GFCF are discussed. Second, the composition of the business sector capital stock is examined. Finally, the results from the SOG decomposition are discussed. Because the results have industry and geographical dimensions, results are first discussed for the business sector as a whole, then for the business sector decomposed by industry, and finally for the business sector decomposed by geography.

4.1 Gross fixed capital formation

Consistent with earlier estimates (Baldwin, Gu and Macdonald 2012), intangible GFCF has been growing more rapidly than tangible GFCF since 1976 (Chart 1, Table 3). The growth rate was highest in the 1970s and 1980s, and then slowed over time. By the end of the period examined, the growth rate for intangible GFCF was lower than that of tangible GFCF. The same pattern is reflected in real estimates and nominal estimates.

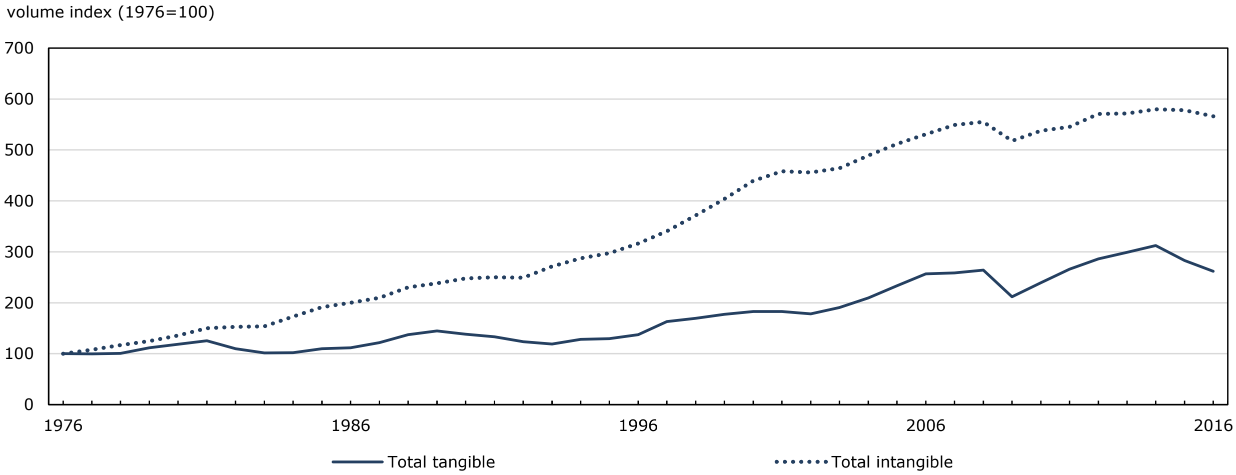
When the GFCF share of GDP is examined, the largest adjustments resulting from the addition of new intangible assets occurred in the 1970s and 1980s (Chart 2). Consequently, the share rose in all years once intangible assets were added, and the decline observed in the share of GFCF in GDP during the 1970s and 1980s seen in current measures was largely removed. The share of GFCF in GDP became more stable around a long-term average of 24.7%. In the later years, although the level adjusted, there was no noteworthy revision to GDP or GFCF growth rates, and the pattern was maintained (Table 4).

Table 3
Compound annual growth rates, tangible and intangible gross fixed capital formation (GFCF)

	Growth in nominal GFCF		Growth in real GFCF	
	Total tangible	Total intangible	Total tangible	Total intangible
	percent			
1976 to 2016	5.3	7.6	2.4	4.4
1976 to 1980	13.7	16.9	4.4	8.0
1980 to 1990	5.7	10.7	1.5	6.2
1990 to 2000	3.8	7.5	2.8	5.9
2000 to 2010	4.0	4.5	2.7	2.0
2010 to 2016	3.9	2.3	1.5	0.9

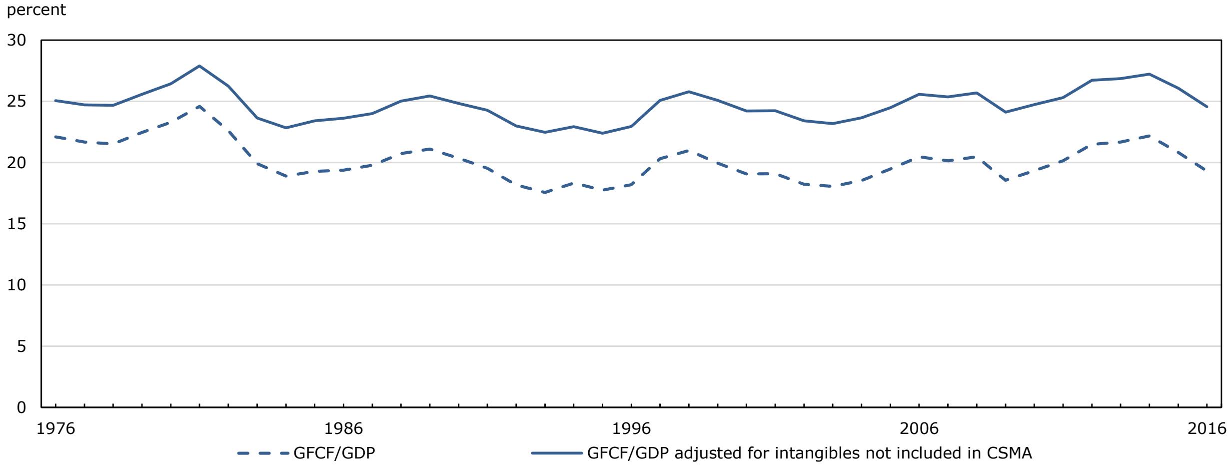
Sources: Statistics Canada, Canadian System of Macroeconomic Accounts and authors' calculations based on data from supply and use tables, Census of Population, Labour Force Survey, and Workplace and Employee Survey.

Chart 1
Tangible and intangible gross fixed capital formation, 1976 to 2016



Sources: Statistics Canada, Canadian System of Macroeconomic Accounts and authors' calculations based on data from supply and use tables, Census of Population, Labour Force Survey, and Workplace and Employee Survey.

Chart 2
Gross fixed capital formation (GFCF) share of gross domestic product (GDP), current measure versus adjusting for all intangible assets



Note: CSMA: Canadian System of Macroeconomic Accounts.
Sources: Statistics Canada, Canadian System of Macroeconomic Accounts and authors' calculations based on data from supply and use tables, Census of Population, Labour Force Survey, and Workplace and Employee Survey.

Table 4
Growth rates of real gross domestic product (GDP) and real gross fixed capital formation (GFCF), current measures and measures adjusted for all intangible assets

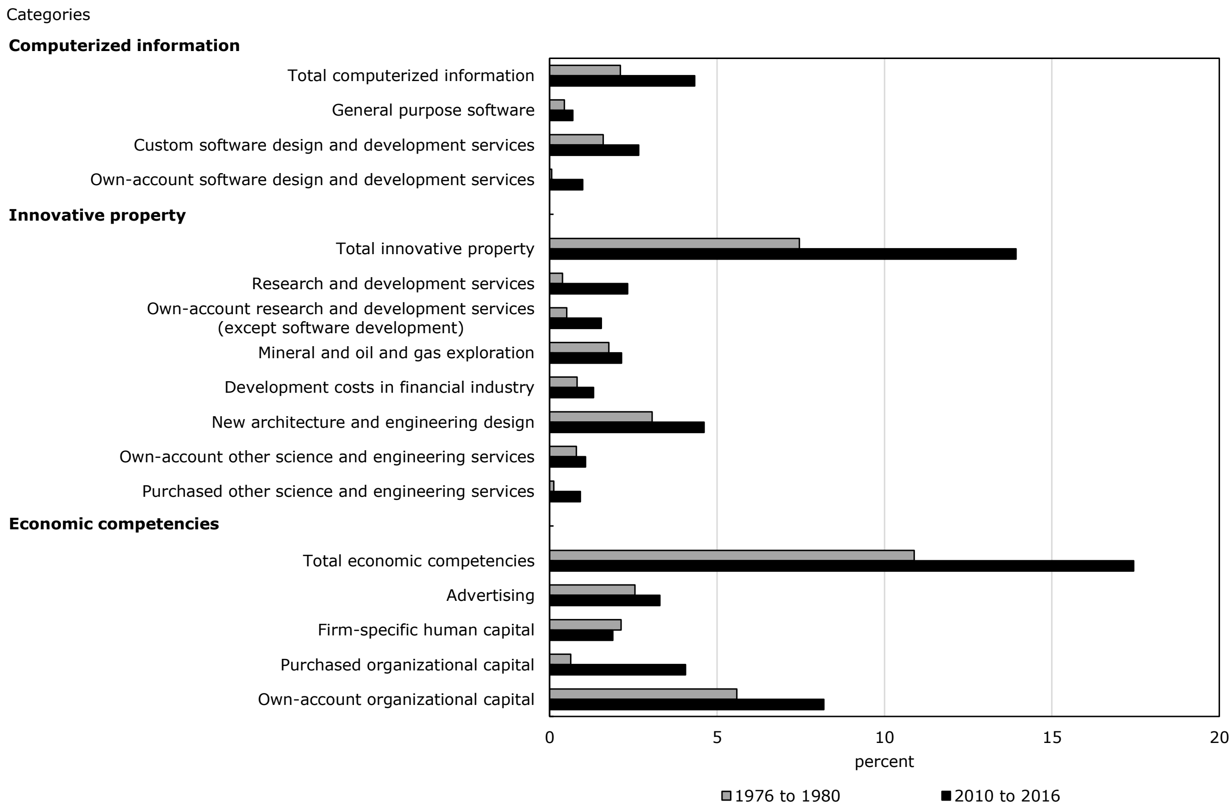
	1976 to 2016	1980 to 1990	1990 to 2000	2000 to 2010	2010 to 2016
			percent per year		
GDP, constant dollars	2.72	3.04	3.43	1.49	2.29
GDP adjusted for intangibles not included in CSMA, constant dollars	2.79	3.19	3.51	1.53	2.27
GFCF, constant dollars	2.64	1.82	3.55	2.60	1.05
GFCF adjusted for intangibles not included in CSMA, constant dollars	2.93	2.66	3.84	2.46	1.23

Note: CSMA: Canadian System of Macroeconomic Accounts.

Sources: Statistics Canada, Canadian System of Macroeconomic Accounts and authors' calculations based on data from supply and use tables, Census of Population, Labour Force Survey, and Workplace and Employee Survey.

From 1976 to 2016, the share of intangible GFCF in total GFCF rose for all assets except firm-specific human capital (Chart 3). For this asset, the level of expenditures rose, but at a slower rate than overall GFCF expenditures, which led to a decline in its share of GFCF. The general increase in the importance of intangible assets in GFCF reflects the increased importance of innovation in Canada.

Chart 3
Share of intangibles categories in total gross fixed capital formation, average from 1976 to 1980 versus average from 2010 to 2016



Sources: Statistics Canada, Canadian System of Macroeconomic Accounts and authors' calculations based on data from supply and use tables, Census of Population, Labour Force Survey, and Workplace and Employee Survey.

4.1.1 Intangible gross fixed capital formation by industry

Intangible GFCF is undertaken by all industries, and all industries invest in almost all assets (Table 5). The exceptions are mineral exploration—where only the mining and oil and gas extraction industry undertakes GFCF—and financial innovation, where only the finance, insurance, real estate and rental and leasing industry invests.

Expenditures are widely dispersed, illustrating the diffuse nature of the innovative process associated with intangible expenditures. Also, expenditures are not concentrated in one particular asset category. Across most industries, the largest component of intangible GFCF is firm organizational capital, which constitutes the largest asset by expenditure in 11 out of 15 industries.

R&D, which is consistent with the Frascati Manual and is currently capitalized in the CSMA, constitutes a minor share of intangible GFCF. Although its share of intangible GFCF is minor, R&D is not unimportant. It is a major source of new products and processes. Rather, its share suggests the overlooked significance of additional sources of innovation in Canada. The innovation process is significantly broader in scope than traditional measures of R&D imply.

4.1.2 Intangible gross fixed capital formation by geography

Intangible GFCF occurs across all provinces, and investments in all assets are undertaken in all jurisdictions (Table 6). Consistent with expenditures across industries, the largest component is firm organizational capital. However, in Alberta, Saskatchewan, and Newfoundland and Labrador, the mining and oil and gas extraction industry makes an important contribution to intangible GFCF through its expenditures on mineral exploration. And, while there is mining activity in all provinces, these hydrocarbon-rich economies are where the largest expenditures are made, both in terms of the level of expenditures and in terms of their contribution.

Table 5
Industry intangible composition as a share of total intangible gross fixed capital formation, average from 1976 to 2016 — Part 1

Intangible assets	Agriculture, forestry, fishing and hunting	Mining and oil and gas extraction	Utilities	Construction	Manufacturing	Wholesale trade	Retail trade
	percent						
Research and development services	1.1	0.9	2.5	0.1	4.3	2.2	0.1
Own-account research and development services (except software development)	11.7	4.7	8.6	0.5	25.4	5.4	0.4
General purpose software	1.8	0.2	7.1	0.4	1.7	2.4	2.1
Custom software design and development services	4.1	0.7	14.5	0.3	4.6	9.7	5.9
Own-account software design and development services	2.2	1.1	8.3	0.5	3.0	3.6	2.7
Mineral and oil and gas exploration	0.0	63.6	0.0	0.0	0.0	0.0	0.0
Development costs in financial industry	0.0	0.0	0.0	0.0	0.0	0.0	0.0
New architecture and engineering design	12.3	8.0	3.9	68.6	14.4	1.4	0.2
Own-account other science and engineering services	6.3	4.1	8.3	1.5	1.1	0.7	0.2
Purchased other science and engineering services	0.7	1.5	1.7	0.8	0.6	1.9	1.4
Advertising	10.3	0.8	3.7	1.6	10.6	20.7	20.0
Firm-specific human capital	4.8	2.0	13.9	3.0	8.3	6.0	6.7
Purchased organizational capital	2.0	5.1	9.8	4.4	3.4	12.8	14.0
Own-account organizational capital	42.5	7.3	17.5	18.3	22.8	33.0	46.4

Sources: Statistics Canada, Canadian System of Macroeconomic Accounts and authors' calculations based on data from supply and use tables, Census of Population, Labour Force Survey, and Workplace and Employee Survey.

Table 5
Industry intangible composition as a share of total intangible gross fixed capital formation, average from 1976 to 2016 — Part 2

Intangible assets	Transportation and warehousing	Information and cultural industries	Finance, insurance, real estate and rental and leasing	Professional, scientific and technical services	Administrative and support, waste management and remediation services	Arts, entertainment and recreation	Accommodation and food services	Other private services
	percent							
Research and development services	1.0	5.4	0.5	4.4	0.5	0.1	0.0	1.0
Own-account research and development services (except software development)	1.9	11.9	1.1	11.9	1.8	0.3	0.1	6.4
General purpose software	6.3	5.8	3.7	2.3	2.8	3.4	1.0	2.9
Custom software design and development services	19.1	13.0	10.4	3.9	5.7	8.6	2.9	6.5
Own-account software design and development services	8.5	8.4	6.8	3.3	6.6	4.3	0.9	2.8
Mineral and oil and gas exploration	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Development costs in financial industry	0.0	0.0	21.8	0.0	0.0	0.0	0.0	0.0
New architecture and engineering design	7.3	1.3	0.1	12.4	0.6	0.0	0.0	0.1
Own-account other science and engineering services	2.9	1.2	0.3	12.2	0.6	0.9	0.2	1.3
Purchased other science and engineering services	1.2	1.9	2.8	4.2	7.2	1.6	1.4	1.3
Advertising	9.0	13.3	6.4	4.1	17.0	24.7	18.1	14.5
Firm-specific human capital	5.0	5.2	4.7	6.4	10.1	5.3	7.5	7.9
Purchased organizational capital	4.7	9.6	15.3	12.8	24.1	8.6	5.0	5.5
Own-account organizational capital	33.1	23.0	26.0	22.1	22.9	42.1	62.9	49.9

Sources: Statistics Canada, Canadian System of Macroeconomic Accounts and authors' calculations based on data from supply and use tables, Census of Population, Labour Force Survey, and Workplace and Employee Survey.

Table 6
Provincial intangible composition as a share of total intangible gross fixed capital formation, average from 1976 to 2016

Intangible assets	Newfoundland and Labrador	Prince Edward Island	Nova Scotia	New Brunswick	Quebec	Ontario	Manitoba	Saskatchewan	Alberta	British Columbia
					percent					
Research and development services	0.5	0.9	0.7	0.8	2.9	2.1	1.6	0.6	0.8	1.3
Own-account research and development services (except software development)	2.6	3.2	3.2	4.1	13.5	8.9	5.2	3.3	4.9	6.1
General purpose software	1.7	3.6	2.9	2.7	2.4	2.8	2.4	2.7	2.3	2.8
Custom software design and development services	3.5	5.9	5.5	7.0	6.8	8.1	6.5	5.7	5.5	5.5
Own-account software design and development services	1.8	2.8	3.5	4.8	4.1	4.4	4.7	2.4	3.1	3.5
Mineral and oil and gas exploration	23.3	0.7	8.2	2.0	1.6	1.0	3.8	17.3	18.6	8.9
Development costs in financial industry	2.7	6.2	5.0	4.5	3.4	4.0	3.9	3.4	2.5	4.8
New architecture and engineering design	24.8	11.3	11.8	11.5	10.0	9.7	12.6	21.7	17.8	12.8
Own-account other science and engineering services	3.3	2.3	2.7	2.4	1.6	2.0	2.4	2.0	4.5	2.8
Purchased other science and engineering services	2.3	2.0	1.3	2.4	1.6	2.6	1.7	1.6	2.6	2.2
Advertising	4.6	10.5	9.1	10.7	10.5	10.5	9.3	6.4	5.1	8.2
Firm-specific human capital	4.3	8.3	7.6	7.6	8.2	5.4	5.4	4.5	3.2	3.8
Purchased organizational capital	9.4	14.8	10.7	15.6	10.7	11.3	12.6	10.8	10.1	11.5
Own-account organizational capital	15.3	27.6	27.7	24.0	22.7	27.3	27.8	17.4	18.9	25.9

Sources: Statistics Canada, Canadian System of Macroeconomic Accounts and authors' calculations based on data from supply and use tables, Census of Population, Labour Force Survey, and Workplace and Employee Survey.

4.2 Capital stocks

Consistent with the growth pattern for intangible and tangible GFCF since 1976, the composition of the capital stock shifted away from physical assets and toward intangible assets between 1976 and the early 2000s (Chart 4, Table 7). This corresponds to the period of rapidly rising intangible GFCF in current and real dollars. After the early 2000s, the pattern reversed and intangible GFCF growth fell below tangible GFCF.

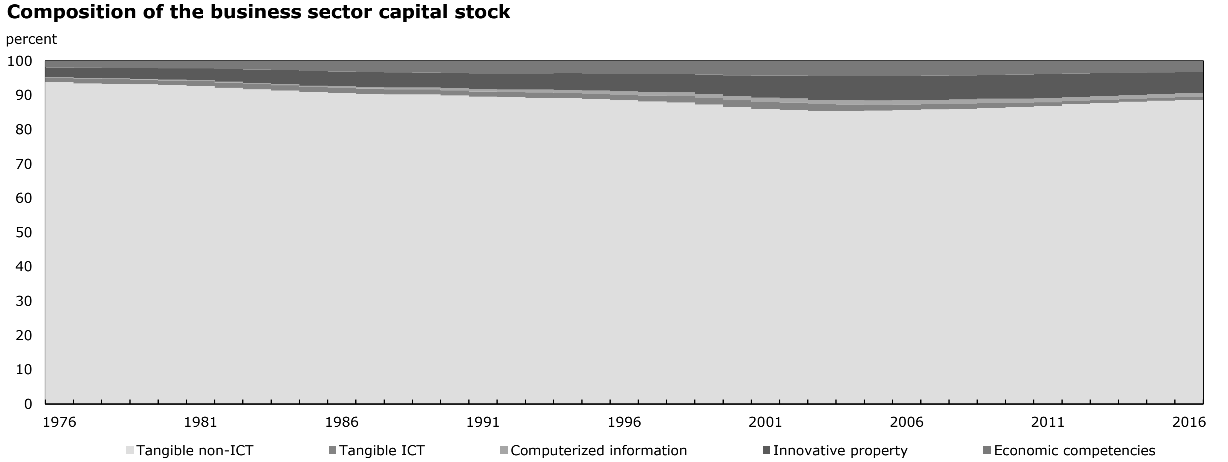
Table 7
Capital stock by asset group and asset, selected years

	1976	2000	2016	1976	2000	2016
	percent			millions of dollars		
Tangible non-ICT	93.7	86.5	88.6	375.3	1,669.9	4,195.4
Tangible ICT	1.3	2.0	0.8	5.3	39.5	39.2
Research and development services	0.1	0.2	0.2	0.5	4.3	10.7
Own-account research and development services (except software development)	0.4	1.0	0.8	1.6	18.6	37.2
General purpose software	0.0	0.2	0.2	0.0	3.2	7.3
Custom software design and development services	0.1	0.7	0.6	0.2	13.3	28.1
Own-account software design and development services	0.1	0.4	0.4	0.4	7.0	18.2
Mineral and oil and gas exploration	0.6	1.7	2.1	2.2	33.8	99.4
Development costs in financial industry	0.2	0.6	0.5	0.9	11.7	23.9
New architecture and engineering design	1.2	1.9	1.7	4.8	37.4	81.8
Own-account other science and engineering services	0.3	0.4	0.4	1.3	7.0	18.8
Purchased other science and engineering services	0.0	0.2	0.3	0.1	4.1	16.4
Advertising	0.3	0.6	0.5	1.4	11.5	21.6
Firm-specific human capital	0.5	0.5	0.4	1.9	9.9	18.1
Purchased organizational capital	0.1	0.7	0.8	0.4	14.1	39.0
Own-account organizational capital	1.0	2.3	1.6	4.0	45.2	77.4

Note: ICT: information and communications technology.

Sources: Statistics Canada, Canadian System of Macroeconomic Accounts and authors' calculations based on data from supply and use tables, Census of Population, Labour Force Survey, and Workplace and Employee Survey.

Chart 4
Composition of the business sector capital stock



Note: ICT: information and communications technology.
Sources: Statistics Canada, Canadian System of Macroeconomic Accounts and authors' calculations based on data from supply and use tables, Census of Population, Labour Force Survey, and Workplace and Employee Survey.

Despite the rise in the importance of intangible assets, and a significant share of intangibles in GFCF, physical assets continue to be the mainstay of the capital stock. This reflects the higher depreciation rates for intangibles compared with tangibles (Table 2), and the relatively larger expenses on tangible GFCF. Non-information-and-communications-technology (ICT) capital constitutes at least 85.5% of the capital stock in all years. ICT capital adds at least another 0.8 percentage points. Therefore, the inclusion of intangible capital affects capital at the margin rather than leading to a seismic change.

For intangible assets, the largest share of the capital stock is composed of organizational capital and new architecture and engineering design. For the former, the share reflects the relatively large expenditures on firm organizational capital. Mineral exploration also has a noteworthy contribution, but one that can depend significantly on resource cycles. Finally, R&D capital makes the fourth-largest contribution, with own-account R&D comprising a larger share than purchased R&D, but with the difference declining over time.

4.2.1 Intangible capital stock by industry

Across industries, the stock of intangible assets tends to make up a small percentage of the capital stock (Table 8). However, there are certain industries where intangible capital has larger importance. In mining and oil and gas extraction, the stock of information from mineral exploration constitutes 12.3% of the capital stock. New architecture and engineering design makes up 41.9% of the capital stock for construction. R&D capital is the most important in the manufacturing and the professional, scientific and technical services industries. The professional, scientific and technical services industry also has larger shares of its capital stock in new architecture and engineering design, and in economic competencies. Finally, economic competencies make up a larger share of the capital stock in administrative and support, waste management and remediation services.

Table 8
Industry intangible capital stock as a share of total capital stock, average from 1976 to 2016 — Part 1

Intangible assets	Agriculture, forestry, fishing and hunting	Mining and oil and gas extraction	Utilities	Construction	Manufacturing	Wholesale trade	Retail trade
				percent			
Research and development services	0.0	0.1	0.0	0.0	0.8	0.4	0.0
Own-account research and development services	0.1	0.3	0.2	0.2	4.5	1.1	0.1
General purpose software	0.0	0.0	0.1	0.1	0.1	0.3	0.2
Custom software design and development services	0.0	0.0	0.2	0.1	0.6	1.6	0.8
Own-account software design and development services	0.0	0.0	0.1	0.1	0.4	0.7	0.4
Mineral and oil and gas exploration	0.0	12.3	0.0	0.0	0.0	0.0	0.0
Development costs in financial industry	0.0	0.0	0.0	0.0	0.0	0.0	0.0
New architecture and engineering design	0.1	0.4	0.1	41.9	3.6	0.4	0.0
Own-account other science and engineering services	0.1	0.3	0.2	0.9	0.3	0.3	0.1
Purchased other science and engineering services	0.0	0.1	0.0	0.3	0.1	0.4	0.3
Advertising	0.0	0.0	0.0	0.3	1.0	2.3	2.0
Firm-specific human capital	0.0	0.1	0.2	1.1	1.0	1.3	1.1
Purchased organizational capital	0.0	0.2	0.1	1.1	0.4	1.7	1.7
Own-account organizational capital	0.2	0.4	0.2	6.2	2.9	6.6	6.8

Sources: Statistics Canada, Canadian System of Macroeconomic Accounts and authors' calculations based on data from supply and use tables, Census of Population, Labour Force Survey, and Workplace and Employee Survey.

Table 8
Industry intangible capital stock as a share of total capital stock, average from 1976 to 2016 — Part 2

Intangible assets	Transportation and warehousing	Information and cultural industries	Finance, insurance, real estate and rental and leasing	Professional, scientific and technical services	Administrative and support, waste management and remediation services	Arts, entertainment and recreation	Accommodation and food services	Other private services
	percent							
Research and development services	0.0	1.1	0.0	3.2	0.6	0.0	0.0	0.2
Own-account research and development services	0.1	1.8	0.0	7.6	1.0	0.0	0.0	1.7
General purpose software	0.1	0.5	0.1	0.8	0.6	0.2	0.2	0.3
Custom software design and development services	0.6	1.7	0.4	2.2	1.8	1.0	0.9	0.9
Own-account software design and development services	0.3	1.1	0.3	1.4	1.5	0.5	0.3	0.4
Mineral and oil and gas exploration	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Development costs in financial industry	0.0	0.0	1.6	0.0	0.0	0.0	0.0	0.0
New architecture and engineering design	0.5	0.3	0.0	16.3	0.4	0.0	0.0	0.0
Own-account other science and engineering services	0.1	0.5	0.0	17.4	0.2	0.2	0.1	0.4
Purchased other science and engineering services	0.1	0.3	0.2	2.8	2.7	0.2	0.6	0.3
Advertising	0.2	1.2	0.2	1.8	5.2	2.5	3.5	1.7
Firm-specific human capital	0.2	0.8	0.2	6.0	6.8	0.9	2.4	1.6
Purchased organizational capital	0.1	1.0	0.5	5.1	5.8	0.8	1.2	0.8
Own-account organizational capital	1.3	2.9	1.1	16.1	5.9	5.5	19.0	10.3

Sources: Statistics Canada, Canadian System of Macroeconomic Accounts and authors' calculations based on data from supply and use tables, Census of Population, Labour Force Survey, and Workplace and Employee Survey.

4.2.2 Intangible capital stock by geography

Across provinces, the share of the capital stock from intangible assets tends to be closely related to major industries within each province, and particularly with major export industries (Table 9). British Columbia, Alberta, Saskatchewan, Nova Scotia and Newfoundland and Labrador have larger shares from mineral exploration in their capital stocks, while Ontario and Quebec have greater shares from R&D.

Across all provinces, new architecture and engineering design makes up 1% to 3% of the capital stock, and economic competencies tend to make up a noticeable share of the capital stock, particularly own-account organizational capital.

4.3 Labour productivity decomposition

Adding intangible capital to labour productivity does not lead to significant changes in labour productivity growth rates (Chart 5). The largest changes occurred during the late 1970s and early 1980s, which corresponds to the period of rapid intangible GFCF growth, and the expansion of intangible assets in the overall business sector capital stock. After the 1990s, there was little difference between the growth rate for labour productivity before and after the full set of intangible capital assets were included. This similarity is present in the trends for labour productivity growth and its fluctuations.

Consistent with the results for labour productivity growth, the inclusion of the full set of intangible capital assets in the SOG decomposition leads to minor changes from components (Chart 10). From 1976 to 2000, there was a modest increase in the labour productivity growth rate from capital deepening and MFP growth. After 2000, there was essentially no change in the overall labour productivity growth rate or in the importance of major components.

Despite minor adjustments to labour productivity and broad sources of growth, intangibles made a noteworthy contribution to capital deepening, particularly between 1976 and 2000 (Table 10). With respect to capital deepening, an average of 0.09 percentage points of growth was the result of increasing computerized information stocks per hour worked. Innovative property stocks per hour worked contributed 0.11 percentage points to labour productivity growth, and economic competencies contributed 0.17 percentage points. In contrast, ICT capital deepening, which is often associated with innovative activities, contributed 0.15 percentage points to labour productivity growth.

Table 9
Provincial intangible stock as a share of total capital stock, from 1997 to 2016

Intangible assets	Newfoundland and Labrador	Prince Edward Island	Nova Scotia	New Brunswick	Quebec	Ontario	Manitoba	Saskatchewan	Alberta	British Columbia
	percent									
Research and development services	0.04	0.05	0.06	0.07	0.29	0.25	0.11	0.05	0.10	0.12
Own-account research and development services (except software development)	0.18	0.19	0.26	0.38	1.49	1.09	0.41	0.29	0.47	0.56
General purpose software	0.07	0.12	0.12	0.12	0.13	0.17	0.10	0.11	0.11	0.13
Custom software design and development services	0.24	0.30	0.36	0.53	0.61	0.78	0.43	0.40	0.45	0.46
Own-account software design and development services	0.13	0.19	0.25	0.36	0.34	0.42	0.33	0.19	0.25	0.29
Mineral and oil and gas exploration	4.25	0.13	1.94	0.52	0.40	0.25	0.73	3.29	5.38	1.99
Development costs in financial industry	0.30	0.55	0.52	0.53	0.47	0.61	0.37	0.38	0.33	0.58
New architecture and engineering design	2.91	1.07	1.26	1.34	1.37	1.56	1.32	2.07	2.00	1.72
Own-account other science and engineering services	0.31	0.24	0.27	0.30	0.21	0.29	0.27	0.20	0.52	0.34
Purchased other science and engineering services	0.20	0.17	0.11	0.23	0.18	0.33	0.14	0.13	0.27	0.23
Advertising	0.20	0.35	0.36	0.50	0.55	0.57	0.37	0.28	0.25	0.38
Firm-specific human capital	0.27	0.41	0.42	0.48	0.62	0.45	0.31	0.28	0.26	0.26
Purchased organizational capital	0.50	0.80	0.56	0.94	0.75	0.87	0.67	0.60	0.62	0.73
Own-account organizational capital	0.97	1.47	1.64	1.63	1.76	2.31	1.66	1.09	1.39	1.87

Sources: Statistics Canada, Canadian System of Macroeconomic Accounts and authors' calculations based on data from supply and use tables, Census of Population, Labour Force Survey, and Workplace and Employee Survey.

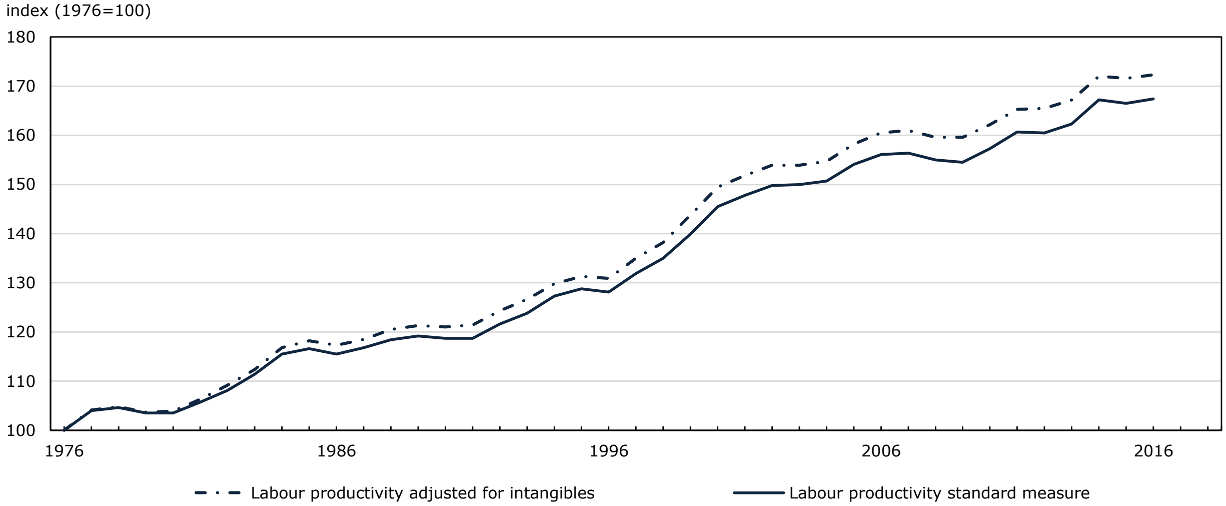
Table 10
Sources of growth to adjusted labour productivity

	1976 to 2000	2000 to 2016
	percentage points	
Labour productivity adjusted for intangibles	**1.69**	**0.89**
Contribution from:		
ICT tangibles	**0.15**	**0.09**
Non-ICT tangibles	**0.38**	**0.58**
Computerized information	**0.09**	**0.05**
General purpose software	0.03	0.02
Custom software design and development services	0.04	0.02
Own-account software design and development services	0.02	0.01
Innovative property	**0.11**	**0.11**
Research and development services	0.00	0.01
Own-account research and development services	0.02	0.01
Mineral and oil and gas exploration	0.03	0.02
Development costs in financial industry	0.02	0.01
New architecture and engineering design	0.03	0.04
Own-account other science and engineering services	0.00	0.01
Purchased other science and engineering services	0.00	0.02
Economic competencies	**0.17**	**0.07**
Advertising	0.03	0.01
Firm-specific human capital	0.01	0.01
Purchased organizational capital	0.04	0.04
Own-account organizational capital	0.10	0.02
Labour composition	**0.34**	**0.21**
Multifactor productivity	**0.44**	**-0.22**

Note: ICT: information and communications technology.

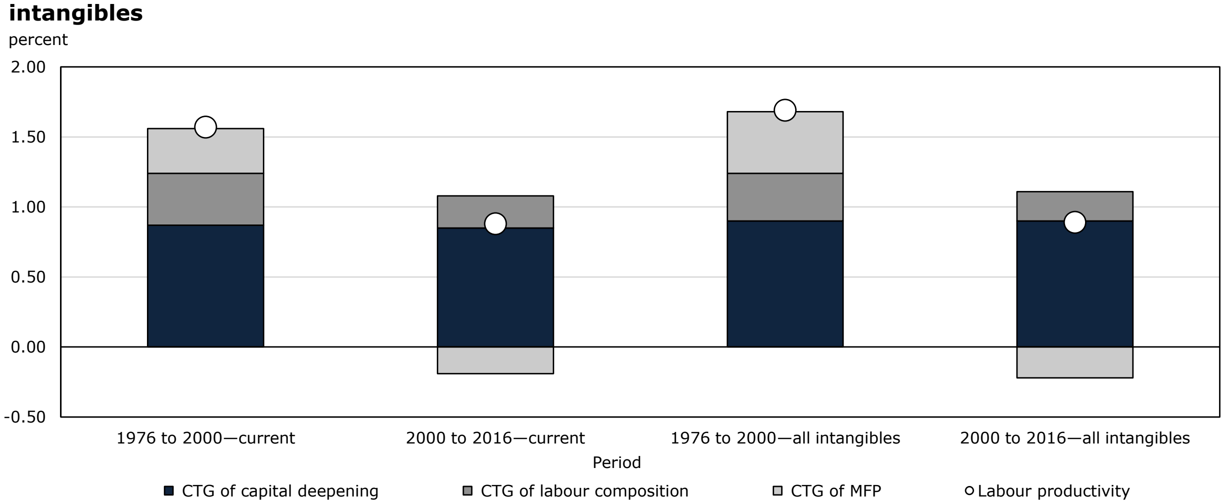
Sources: Statistics Canada, Canadian System of Macroeconomic Accounts and authors' calculations based on data from supply and use tables, Census of Population, Labour Force Survey, and Workplace and Employee Survey.

Chart 5
Labour productivity before and after adjusting for expanded intangibles



Sources: Statistics Canada, Canadian System of Macroeconomic Accounts and authors' calculations based on data from supply and use tables, Census of Population, Labour Force Survey, and Workplace and Employee Survey.

Chart 6
Contributions to labour productivity growth by source, before and after adjusting for expanded intangibles



Note: CTG: contribution to growth; MFP: multifactor productivity.
Sources: Statistics Canada, Canadian System of Macroeconomic Accounts and authors' calculations based on data from supply and use tables, Census of Population, Labour Force Survey, and Workplace and Employee Survey.

Across specific intangible assets, the contribution to labour productivity growth is broadly based. This widespread contribution corresponds with the diffuse nature of innovation. No single asset type dominates, indicating that the knowledge frontier expands along multiple dimensions simultaneously in a diverse economy. This also suggests that innovation may be occurring interdependently. For example, software innovation allows for greater collaborative opportunities, and, to take advantage of the software innovation, organizations may need to undertake organizational innovations. In this case, workplace design and employee skills would undergo change, which would lead to further innovations in additional intangible asset classes.

From 2000 to 2016, the contribution of intangible capital deepening continued to be spread across asset types, but the contribution slowed for all asset classes. The contribution also declined relative to ICT and non-ICT tangible capital deepening, suggesting a broadly based shift in innovation.

4.3.1 Labour productivity growth decomposition by industry

Across industries, the contribution of intangible capital deepening to labour productivity continues to be diffuse. However, unlike the total business sector, there are industries where one asset can be noticeably more important than others (Tables 11 and 12). For example, capital deepening for mineral exploration makes a sizable contribution to labour productivity in the mining and oil and gas extraction industry.

Of the major types of intangible assets, economic competencies make the largest contributions to labour productivity growth, followed by innovative property or computerized information. The difference stems from the nature of the intangible assets required for innovation within a given industry. Innovative property is particularly important in natural resource industries, while computerized information is important for finance, insurance, real estate and rental and leasing; wholesale trade; or information and cultural industries. Manufacturing industries have an equal contribution from computerized information and innovative property, with the latter resulting from R&D and new architecture and engineering design.

4.3.2 Labour productivity decomposition by geography

The pattern of diffuse contributions to productivity growth from intangible assets is found across all provinces. As with industries, particular provinces have larger contributions from assets that are more important to their respective economies (Table 13). In most cases, large intangible assets are related to an important export industry, such as mining, oil and gas for Alberta, Saskatchewan, and Newfoundland and Labrador, or finance and manufacturing for Ontario. Economic competencies also continue to be the major source of labour productivity growth from the major types of intangible investments.

Table 11
Labour productivity adjusted for intangibles, sources of growth, 1976 to 2000 — Part 1

	Agriculture, forestry, fishing and hunting	Mining and oil and gas extraction	Utilities	Construction	Manufacturing	Wholesale trade	Retail trade
				percent per year			
Labour productivity adjusted for intangibles	**2.221**	**0.734**	**1.027**	**0.988**	**3.197**	**2.881**	**1.851**
Contribution from:							
ICT tangibles	**0.008**	**0.004**	**0.176**	**0.029**	**0.095**	**0.127**	**0.078**
Non-ICT tangibles	**0.271**	**1.086**	**-0.240**	**0.111**	**0.406**	**0.021**	**0.302**
Computerized information	**0.017**	**0.021**	**0.075**	**0.012**	**0.075**	**0.166**	**0.091**
General purpose software	0.004	0.004	0.033	0.004	0.017	0.058	0.033
Custom software design and development services	0.008	0.012	0.025	0.008	0.041	0.074	0.037
Own-account software design and development services	0.004	0.004	0.017	0.000	0.017	0.033	0.021
Innovative property	**0.029**	**0.412**	**0.029**	**0.192**	**0.149**	**0.062**	**0.008**
Research and development services	0.000	0.000	0.004	0.000	0.008	0.012	0.000
Own-account research and development services	0.008	-0.004	0.008	0.004	0.054	0.041	0.000
Mineral and oil and gas exploration	0.000	0.379	0.000	0.000	0.000	0.000	0.000
Development costs in financial industry	0.000	0.000	0.000	0.000	0.000	0.000	0.000
New architecture and engineering design	0.012	0.021	0.008	0.180	0.087	0.004	0.000
Own-account other science and engineering services	0.008	0.008	0.004	0.004	0.000	-0.004	0.000
Purchased other science and engineering services	0.000	0.008	0.004	0.004	0.000	0.008	0.008
Economic competencies	**0.004**	**0.066**	**0.054**	**0.140**	**0.165**	**0.263**	**0.324**
Advertising	0.004	0.004	0.004	0.008	0.037	0.025	0.054
Firm-specific human capital	0.004	0.004	0.008	0.008	0.021	0.008	0.008
Purchased organizational capital	0.004	0.029	0.017	0.012	0.012	0.066	0.070
Own-account organizational capital	-0.008	0.029	0.025	0.111	0.095	0.164	0.192
Labour composition	**0.344**	**0.160**	**0.103**	**0.223**	**0.440**	**0.424**	**0.360**
Multifactor productivity	**1.537**	**-1.004**	**0.835**	**0.274**	**1.837**	**1.796**	**0.674**

Note: ICT: information and communications technology.

Sources: Statistics Canada, Canadian System of Macroeconomic Accounts and authors' calculations based on data from supply and use tables, Census of Population, Labour Force Survey, and Workplace and Employee Survey.

Table 11
Labour productivity adjusted for intangibles, sources of growth, 1976 to 2000 — Part 2

	Transportation and warehousing	Information and cultural industries	Finance, insurance, real estate and rental and leasing	Professional, scientific and technical services	Administrative and support, waste management and remediation services	Arts, entertainment and recreation	Accommodation and food services	Other private services
	percent per year							
Labour productivity adjusted for intangibles	**1.501**	**2.830**	**1.560**	**0.649**	**0.033**	**-1.552**	**-0.280**	**0.083**
Contribution from:								
ICT tangibles	**0.160**	**0.558**	**0.219**	**0.699**	**0.231**	**0.337**	**1.612**	**0.184**
Non-ICT tangibles	**-0.055**	**0.115**	**0.866**	**-0.059**	**0.025**	**0.033**	**0.215**	**0.078**
Computerized information	**0.083**	**0.207**	**0.202**	**0.100**	**0.066**	**0.087**	**0.029**	**0.042**
General purpose software	0.029	0.087	0.062	0.041	0.029	0.033	0.012	0.017
Custom software design and development services	0.033	0.066	0.103	0.041	0.029	0.041	0.012	0.017
Own-account software design and development services	0.021	0.054	0.037	0.017	0.008	0.012	0.004	0.008
Innovative property	**0.012**	**0.033**	**0.107**	**0.136**	**0.025**	**0.004**	**0.004**	**0.012**
Research and development services	0.000	0.004	0.004	0.037	-0.004	0.000	0.000	0.000
Own-account research and development services	-0.004	0.021	0.004	0.062	0.004	0.000	0.000	0.008
Mineral and oil and gas exploration	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Development costs in financial industry	0.000	0.000	0.087	0.000	0.000	0.000	0.000	0.000
New architecture and engineering design	0.012	0.004	0.000	0.074	0.004	0.000	0.000	0.000
Own-account other science and engineering services	0.004	-0.004	0.000	-0.046	0.004	0.000	0.000	0.000
Purchased other science and engineering services	0.000	0.008	0.012	0.008	0.017	0.004	0.004	0.004
Economic competencies	**0.058**	**0.202**	**0.223**	**0.148**	**0.222**	**0.198**	**0.230**	**0.116**
Advertising	0.004	0.054	0.029	0.025	0.099	0.037	0.062	0.021
Firm-specific human capital	0.004	0.000	0.004	-0.042	-0.050	-0.013	0.004	0.000
Purchased organizational capital	0.008	0.046	0.062	0.054	0.070	0.033	0.017	0.017
Own-account organizational capital	0.041	0.103	0.127	0.111	0.103	0.139	0.147	0.078
Labour composition	**0.259**	**0.192**	**0.219**	**0.406**	**0.298**	**0.522**	**0.207**	**0.267**
Multifactor productivity	**0.981**	**1.504**	**-0.275**	**-0.778**	**-0.829**	**-2.704**	**-2.520**	**-0.607**

Note: ICT: information and communications technology.

Sources: Statistics Canada, Canadian System of Macroeconomic Accounts and authors' calculations based on data from supply and use tables, Census of Population, Labour Force Survey, and Workplace and Employee Survey.

Table 12
Labour productivity adjusted for intangibles, sources of growth, 2000 to 2016 — Part 1

	Agriculture, forestry, fishing and hunting	Mining and oil and gas extraction	Utilities	Construction	Manufacturing	Wholesale trade	Retail trade
				percent per year			
Labour productivity adjusted for intangibles	**2.829**	**-0.879**	**0.603**	**-0.492**	**1.052**	**2.868**	**1.609**
Contribution from:							
ICT tangibles	**0.031**	**0.044**	**0.077**	**0.025**	**0.055**	**0.072**	**0.103**
Non-ICT tangibles	**1.154**	**2.520**	**1.765**	**0.018**	**0.299**	**0.623**	**0.223**
Computerized information	**0.000**	**0.006**	**0.074**	**0.012**	**0.050**	**0.104**	**0.031**
General purpose software	0.000	0.000	0.031	0.006	0.019	0.006	0.006
Custom software design and development services	0.000	-0.006	0.031	-0.006	0.012	0.085	0.025
Own-account software design and development services	0.000	0.012	0.012	0.012	0.019	0.012	0.000
Innovative property	**0.006**	**0.215**	**0.025**	**0.119**	**0.050**	**0.069**	**0.012**
Research and development services	0.006	0.000	0.012	0.000	0.019	0.019	0.000
Own-account research and development services	0.000	0.050	-0.012	0.000	0.049	0.000	0.000
Mineral and oil and gas exploration	0.000	0.023	0.000	0.000	0.000	0.000	0.000
Development costs in financial industry	0.000	0.000	0.000	0.000	0.000	0.000	0.000
New architecture and engineering design	0.000	0.105	0.006	0.107	-0.031	0.012	0.006
Own-account other science and engineering services	0.000	0.025	0.012	0.006	0.006	0.013	0.000
Purchased other science and engineering services	0.000	0.012	0.006	0.006	0.006	0.025	0.006
Economic competencies	**0.019**	**0.062**	**0.050**	**0.007**	**0.092**	**0.342**	**0.134**
Advertising	0.006	0.006	-0.006	0.000	0.000	0.184	0.055
Firm-specific human capital	0.000	0.000	0.012	-0.006	0.037	0.012	0.006
Purchased organizational capital	0.000	0.031	0.025	0.037	0.019	0.098	0.037
Own-account organizational capital	0.013	0.025	0.019	-0.024	0.037	0.048	0.036
Labour composition	**0.337**	**0.084**	**0.006**	**0.129**	**0.259**	**0.206**	**0.237**
Multifactor productivity	**1.257**	**-3.720**	**-1.384**	**-0.788**	**0.234**	**1.427**	**0.848**

Note: ICT: information and communications technology.

Sources: Statistics Canada, Canadian System of Macroeconomic Accounts and authors' calculations based on data from supply and use tables, Census of Population, Labour Force Survey, and Workplace and Employee Survey.

Table 12
Labour productivity adjusted for intangibles, sources of growth, 2000 to 2016 — Part 2

	Transportation and warehousing	Information and cultural industries	Finance, insurance, real estate and rental and leasing	Professional, scientific and technical services	Administrative and support, waste management and remediation services	Arts, entertainment and recreation	Accommodation and food services	Other private services
	percent per year							
Labour productivity adjusted for intangibles	**1.480**	**1.826**	**1.375**	**0.734**	**0.672**	**0.389**	**0.191**	**0.659**
Contribution from:								
ICT tangibles	**0.096**	**0.351**	**0.147**	**0.136**	**0.024**	**0.017**	**0.369**	**0.060**
Non-ICT tangibles	**1.058**	**0.168**	**0.041**	**0.212**	**0.190**	**0.599**	**-0.316**	**0.097**
Computerized information	**0.062**	**0.116**	**0.012**	**0.130**	**0.143**	**0.105**	**0.012**	**0.031**
General purpose software	0.012	0.043	0.018	0.037	0.025	0.031	0.006	0.006
Custom software design and development services	0.043	0.098	-0.006	0.037	0.037	0.043	0.006	0.019
Own-account software design and development services	0.006	-0.025	0.000	0.056	0.081	0.031	0.000	0.006
Innovative property	**0.025**	**0.167**	**0.043**	**0.131**	**0.062**	**0.019**	**0.006**	**-0.006**
Research and development services	0.006	0.025	0.000	0.000	0.000	0.000	0.000	0.006
Own-account research and development services	0.006	0.129	0.000	0.025	0.000	0.000	0.000	-0.019
Mineral and oil and gas exploration	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Development costs in financial industry	0.000	0.000	0.031	0.000	0.000	0.000	0.000	0.000
New architecture and engineering design	0.000	0.006	0.000	-0.012	0.000	0.000	0.000	0.000
Own-account other science and engineering services	0.006	-0.013	0.006	0.063	0.006	0.006	0.000	0.006
Purchased other science and engineering services	0.006	0.019	0.006	0.056	0.056	0.012	0.006	0.000
Economic competencies	**-0.050**	**0.123**	**0.018**	**0.153**	**0.122**	**0.097**	**-0.073**	**0.055**
Advertising	0.006	0.006	-0.006	0.006	-0.037	0.006	-0.037	0.012
Firm-specific human capital	0.000	0.012	0.000	0.006	0.000	0.006	0.006	0.000
Purchased organizational capital	0.006	0.055	0.025	0.110	0.116	0.019	0.006	0.000
Own-account organizational capital	-0.062	0.049	0.000	0.030	0.043	0.066	-0.048	0.043
Labour composition	**0.225**	**0.089**	**0.164**	**0.229**	**0.335**	**-0.061**	**0.159**	**0.337**
Multifactor productivity	**0.064**	**0.794**	**0.928**	**-0.254**	**-0.201**	**-0.385**	**0.012**	**0.065**

Note: ICT: information and communications technology.

Sources: Statistics Canada, Canadian System of Macroeconomic Accounts and authors' calculations based on data from supply and use tables, Census of Population, Labour Force Survey, and Workplace and Employee Survey.

Table 13
Labour productivity adjusted for intangibles, sources of growth, 1997 to 2016

	Newfoundland and Labrador	Prince Edward Island	Nova Scotia	New Brunswick	Quebec	Ontario	Manitoba	Saskatchewan	Alberta	British Columbia
	percent per year									
Labour productivity adjusted for intangibles	**1.476**	**1.039**	**0.770**	**0.986**	**0.848**	**1.078**	**1.806**	**1.228**	**0.636**	**1.169**
Contribution from:										
Tangibles	**1.341**	**0.445**	**0.575**	**0.802**	**0.391**	**0.292**	**0.938**	**1.971**	**1.580**	**0.720**
Computerized information	**0.021**	**0.042**	**0.026**	**0.053**	**0.042**	**0.053**	**0.037**	**0.047**	**0.074**	**0.042**
General purpose software	0.005	0.021	0.016	0.016	0.011	0.016	0.011	0.021	0.021	0.021
Custom software design and development services	0.011	0.021	0.011	0.021	0.021	0.026	0.016	0.021	0.037	0.011
Own-account software design and development services	0.005	0.000	0.000	0.016	0.011	0.011	0.011	0.005	0.016	0.011
Innovative property	**0.230**	**0.074**	**0.089**	**0.063**	**0.089**	**0.105**	**0.100**	**0.256**	**0.277**	**0.116**
Research and development services	0.000	0.005	0.000	0.005	0.011	0.005	0.011	0.000	-0.005	0.005
Own-account research and development services	0.016	0.011	0.005	0.005	0.011	0.005	0.011	0.005	0.016	0.016
Mineral and oil and gas exploration	0.140	0.005	0.031	0.005	0.005	0.005	0.016	0.115	0.104	0.037
Development costs in financial industry	0.011	0.016	0.011	0.016	0.011	0.011	0.016	0.011	0.011	0.016
New architecture and engineering design	0.031	0.016	0.031	0.026	0.026	0.021	0.026	0.099	0.084	0.011
Own-account other science and engineering services	0.016	0.000	0.005	0.000	0.005	0.005	0.000	0.011	0.026	0.005
Purchased other science and engineering services	0.016	0.005	0.005	0.016	0.011	0.016	0.011	0.011	0.021	0.011
Economic competencies	**0.000**	**0.016**	**0.000**	**-0.011**	**0.011**	**0.037**	**0.011**	**0.005**	**0.021**	**0.016**
Advertising	0.058	-0.005	0.047	0.047	0.068	0.131	0.079	0.089	0.157	0.063
Firm-specific human capital	0.005	0.011	0.016	0.016	0.011	0.011	0.011	0.011	0.005	0.005
Purchased organizational capital	0.063	0.005	0.042	0.052	0.047	0.058	0.047	0.052	0.078	0.047
Own-account organizational capital	-0.011	-0.037	-0.011	-0.011	0.000	0.026	0.011	0.021	0.052	-0.005
Labour composition	**0.115**	**0.161**	**0.140**	**0.186**	**0.176**	**0.202**	**0.186**	**0.207**	**0.171**	**0.073**
Multifactor productivity	**-0.292**	**0.332**	**-0.112**	**-0.171**	**0.084**	**0.332**	**0.469**	**-1.319**	**-1.593**	**0.166**

Sources: Statistics Canada, Canadian System of Macroeconomic Accounts and authors' calculations based on data from supply and use tables, Census of Population, Labour Force Survey, and Workplace and Employee Survey.

5 Conclusion

The growth of investment in intangibles has been perceived as indicating a shift in the underlying expenditures that drive growth. This is a shift toward less tangible expenditures and away from heavy equipment that involves investment in machinery. Less tangible expenditures include expenditures on software to operate machinery and support the provision of services, expenditures on knowledge to develop new products and processes through research and development (R&D), and improvements in management practices.

This paper examines the evidence of these changes in the Canadian economy from 1976 to 2016. The data show that, during this period, the growth of intangible investments was faster than that of tangible investments. However, the growth in intangibles slowed decade by decade, and, in the most recent decade, intangible growth lagged behind tangible growth. The composition of the capital stock adjusted as intangible capital grew, but the share of intangible capital in the business sector capital stock declined after 2000 as investment slowed. Also, the growth rate of labour productivity was not significantly affected when intangible capital was added to the sources of growth decomposition, but the richness of the contribution of innovation to productivity growth was more fully recognized.

The data also show the importance of particular intangible assets for particular industries (mineral exploration for mining and oil and gas extraction; R&D for professional, scientific and technical services), and the importance of particular intangible assets for particular provinces. Across provinces, the importance of an intangible asset is often related to that province's main export industries.

The data also speak to the diffuse nature of the innovation process, and to the change in its structure over time. Intangible GFCF occurs in all industries and provinces, with economic competencies usually making an important contribution. The innovation process is more diffuse than measures of innovation based solely on R&D imply.

Finally, during the four decades from 1976 to 2016, there were changes in the composition of intangible investment and capital that suggest changes in the innovation process. The increased share of investment in software over time reflects the importance of the digital revolution. There was also a gradual increase in specialization, which often happens as a production process matures. There was a gradual shift from own-account science that is not included in R&D toward purchased science inputs. Similarly, there was a gradual shift from own-account expenditures on management to purchased management consulting services.

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