Intangible Assets and Their Contribution to Labour Productivity Growth in Ontario

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ABSTRACT

Recent empirical studies confirm that the contribution of intangible capital investment to labour productivity growth is comparable to that of tangible capital investment for a wide range of countries, including the United States, the United Kingdom, Canada, Germany, and France. Following Corrado *et al*. (2005) and Baldwin *et al.* (2012), this article assesses business sector investment in intangible assets and analyses the contribution of intangible capital to business sector labour productivity growth at the provincial level in Canada, in particular in Ontario. The results of this growth accounting exercise demonstrate that intangible capital contributes significantly to labour productivity growth in Ontario. In 1998-2008 intangible capital contributed on average 26.2 per cent to labour productivity growth while tangible capital contributed 17.9 per cent and labour composition contributed 8.7 per cent. Innovative property contributed the most among all categories of intangible capital, followed by economic competencies and computerized information.

Research has highlighted the important role played by intangible capital, such as the knowledge embodied in the workforce, business plans and practices, and brand names. This research suggests that technological progress and the accumulation of intangible capital together accounted for well over half of the increase in output per hour in the United States during the past several decades.

— Ben Bernanke, Chairman of the Federal Reserve, keynote address to the opening of the *New Building Blocks for Jobs and Economic Growth Conference* (May 2011)

CANADA IN GENERAL AND ONTARIO in particular has a significant prosperity gap with international peers, most notably relative to the United States. According to the Task Force on Competitiveness, Productivity and Economic Progress (2010), this prosperity gap is a productivity gap. In Ontario, average annual labour productivity growth decelerated from 1.3 per cent between 1985 and 2000 to 0.4 per cent between 2001 and 2011 (Government of Ontario, 2013).

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Productivity growth comes from various sources. The contribution of labour composition and physical, or tangible, capital deepening to labour productivity has been well researched. In contrast, until recently, intangible assets were not considered as contributors to labour productivity growth. Currently, the major challenge is to measure investment in intangible assets and assess the size of the stock of intangible capital as well as the contribution of intangible assets to labour productivity growth.

Intangible assets are generally defined as assets that provide future benefits but do not have a physical embodiment, such as software, research and development (R&D), market and consumer research. A study of intangibles, conducted by Corrado *et al.* (2009), pioneered research of intangible assets and their contribution to labour productivity growth in the United States. Similar studies have been conducted in Canada, Japan, Australia and Europe.

Until recently, spending on intangible assets was counted as an intermediate expense in the systems of national accounts rather than as investment in intangible capital. Corrado *et al.* (2009) indicate that specific features of some intangible assets, such as non-rivalness and the lack of verifiability, visibility and appropriability of returns explain the fact that the majority of intangible assets are disqualified as capital. The authors, however, argue that these distinct features do not make intangible assets an intermediate good. They simply differentiate intangible capital from other types of capital. Despite their uniqueness, intangible assets share core characteristics of physical capital. As any other type of capital, intangibles are used in production of goods and services and provide future benefits. As investment in physical capital, investment in intangible assets represents foregone current consumption for the benefit of greater future consumption.

Thus, intangible assets should be classified as capital; and spending on intangibles should be counted as investment rather than operational or intermediate expenses. Otherwise, the aggregate level of output remains underestimated. This potentially creates distortions in business investment and resource allocation. In addition, effectiveness of public policy may also be adversely affected if investment and capital in the economy are measured imprecisely. These distortions could ultimately lead to a decline in productivity and economic growth.

The recent empirical evidence shows that intangible capital contributes significantly to productivity growth, which is ultimately reflected in economic growth. Belhocine (2009b) finds that in Canada, if spending on intangible assets is not included in aggregate investment, real gross domestic product (GDP) growth is on average underestimated by 0.1 percentage point per year from 1999 to 2001. It is underestimated by about 0.25 percentage point for 2004. Corrado *et al.* (2009) indicate that in the United States, if investment in intangibles is not included, GDP growth is underestimated by about 0.25 percentage point per year from 1995 to 2002.

Van Ark *et al.* (2009) examined the contribution of intangible capital deepening to the labour productivity growth in the market sector in the United States and selected European countries for the 1995-2006 period. The authors found that intangible capital deepening contributed on average 0.83 percentage point, or about a quarter, to the annual change in labour productivity in the United States. A similar picture emerges in the larger European countries where growth in intangible capital per unit of labour contributed 0.72 percentage point to labour productivity growth in Denmark, 0.69 percentage

point in the UK, 0.50 percentage point in France, and 0.40 percentage point in Germany.

According to a study of intangible assets and productivity growth conducted by the Australian Government Productivity Commission in 2010, the estimated average annual labour productivity growth rate in Australia's market sector between 1993-1994 and 2005-2006 is 0.24 percentage point higher when all intangibles are capitalized. Moreover, in both the manufacturing and the service sectors, labour productivity growth rate increased after capitalizing all intangibles. Labour productivity growth rates are 0.43 and 0.19 percentage point (or around 19 and 8 per cent) higher in the manufacturing and the services sectors respectively when intangibles are treated as capital.

Growing global interest in intangible capital has drawn much attention to knowledge-creating investments and has led to worldwide recognition of intangibles as an important source of productivity and economic growth. As a result, some categories of intangibles have already been capitalized in the systems of national accounts. In Canada, prior to December 2012, only software and mineral exploration expenditures were treated as investment in the System of National Accounts. As a result of a historical revision of the national accounts (Statistics Canada, 2012), completed by Statistics Canada in December 2012, spending on research and development, along with software and oil and gas and mineral exploration, is treated as investment and capitalized in the national accounts in the intellectual property products category.

The capitalization of intangible assets is important for evaluating both the level and the growth of labour productivity. This capitalization alters the level of output, which in turn affects the labour productivity level. It also affects the labour productivity growth rate if the rate of growth of output with intangibles is different from that without intangibles.[2]

Given the importance of intangible capital as a contributor to output and productivity growth and the lack of studies at the provincial level, this study aims to estimate both investment in intangibles and the stock of intangible capital in Ontario and to evaluate the contribution of intangible assets to the business sector productivity growth in the province. A discussion of the merits of data collection methods and estimation approaches is beyond the scope of this study. Similar to other studies, this article provides rough estimates of business investment in intangible assets and focuses on the relative importance of intangibles for output and productivity growth in Ontario.

The article is organized as follows. Section 1 describes the data sources for the estimates of business sector investment in intangibles in Ontario. Section 2 examines the state of investment in intangibles in the province. Section 3 summarizes the results of growth accounting that includes intangible assets as inputs of production. Section 4 concludes.

Data Sources

Corrado *et al.* (2009) have defined the main categories of intangibles to include:

- Computerized information:
  - software, which consists of purchased software and own-account spending on software;
  - computerized databases, i.e. expenditures on data processing and database activities.
- Innovative property:
  - scientific and engineering R&D that leads to a patent or a licence, including industrial R&D, R&D expenditures in mining, oil and

2 Thanks to Andrew Sharpe for this point.

gas extraction and other geophysical and geological explorations;
    - non-scientific R&D, including information sector R&D that leads to a copyright or license and service industries R&D that might not lead to a patent or copyright;
    - new product development costs in the financial industry;
    - new architectural and engineering design; and
    - other science and engineering services.
- Economic competencies:
    - brand equity, i.e. purchased advertising and market and consumer research;
    - investment in human capital that includes direct and indirect expenses on training;
    - organizational structure that comprises cost of purchased and own-account organizational change.

Baldwin *et al.* (2009) expended the list of categories proposed by Corrado *et al.* (2009) by including scientific activities that are not captured in R&D statistics.[3] In order to ensure comparability of the results with the national and international studies, I follow the definitions of both Corrado *et al.* (2005, 2009) and Baldwin *et al.* (2009) regarding the categories of intangible assets. I also use the estimation methods suggested by these authors as much as possible. In the instances where provincial data are not available I use either national data[4] or estimates based on the shares of investment in a particular category of intangibles in the national data or all-industries (i.e. total economy) data.[5] Hence, the findings of the present study may not be fully comparable with those for Canada and other countries.

Computerized Information

Computerized information comprises two categories: software and computerized databases. Since spending on software has been capitalized in the Canadian System of National Accounts, Statistics Canada publishes provincial all-industries software investment data as part of non-residential investment (CANSIM Table 031-0004) and provincial business sector investment in total intellectual property products, which includes oil and gas and mineral exploration, research and development, and software (CANSIM Table 031-0002). Ontario's business sector investment in software is estimated using the all-industries average for the share of investment in software in the intellectual property product category.

Statistics Canada also provides detailed estimates of own-account and purchased software expenditures at the national level. Data are currently unavailable for both business sector own-account and purchased software expenditures at the provincial level.

Computerized databases are not capitalized in the national accounts. Expenditure on computerized databases is used as a proxy for investment in this category of intangibles. Such an expenditure, however, is not directly observed, so as in Belhocine (2009b), expenditure on computerized databases is approximated by the operating revenues of the data processing, hosting and related service industries (NAICS 51821), which are published by Statistics Canada in CANSIM Table 354-0005.

Innovative Property

Two categories of innovative property – "research and development" and "oil and gas and mineral exploration" – are capitalized in the Canadian System of National Accounts. Currently, business investments in R&D and in oil

3 See Innovative Property section for details.

4 For example, direct and indirect annual spending on training per employee.

5 For example, estimates of Ontario's business sector investment in software.

and gas and mineral exploration are not available at the provincial level. Statistics Canada publishes total economy investments in R&D and in oil and gas and mineral exploration as parts of non-residential investment (CANSIM Table 031-0004) at the provincial level, as well as provincial business sector investment in total intellectual property products (CANSIM Table 031-0002). As with investment in software, I estimate Ontario's business sector investments in R&D and in oil and gas and mineral exploration using the total economy shares of investment in R&D and investment in oil and gas and mineral exploration in the intellectual property product category.

As in Corrado *et al.* (2009) and Baldwin *et al.* (2012), other categories of innovative property are approximated by expenditure on:

- new product development costs in the financial industry;
- new architectural and engineering design; and
- other science and engineering services (purchased and own-account).

Similar to other industries, the financial industry is engaged in R&D of new processes and products. According to Baldwin *et al.* (2012), this industry's R&D expenditure should be accounted for in the total investment in intangible assets. Since it is not explicitly observed, development cost in the financial industry is approximated by total intermediate purchases by the financial industry (NAICS 521 and 522).[6] Following Corrado *et al.* (2005), I count only 20 per cent of the purchases as investment.

Following Corrado *et al.* (2005), I estimated Ontario's business sector investment in new architectural and engineering design as 50 per cent of the revenues of architectural and engineering design industries (NAICS 5413). Data on the revenues of these industries are obtained from Statistics Canada's input-output tables for Ontario. The revenue of architectural and engineering design industries data are combined with "purchased other science and engineering services" so as to meet confidentiality requirements. Purchased other science and engineering services are approximated by Ontario's business sector spending on royalties and licensing fees, which are also obtained from the Ontario input-output tables.

Baldwin *et al.* (2009) suggest that knowledge creation happens not only in the natural and social sciences, humanities, finance and other fields, as outlined by Corrado *et al.* (2005), but also in other industries, the scientific activities of which are not captured in R&D statistics. Thus, the innovative property category of intangibles should include own-account other science and engineering expenditures and purchased other science and engineering expenditures.

Similarly to Baldwin *et al.* (2009), I approximate own-account other science and engineering investment by the labour compensation of scientists and engineers and count only 20 per cent of total expenditure as investment. As in Baldwin *et al.* (2009), I exclude the following industries: financial services (NAICS 521), architectural, engineering and related services (NAICS 5413), management, scientific, and technical consulting services (NAICS 5416), scientific research and development services (NAICS 5417), advertising and related services (NAICS 5418), and other professional, scientific and technical services (NAICS 5419). Investments in intangible assets in these industries are already captured in other categories of intangibles. To avoid double-counting, the wage component of software and R&D expenditure is also excluded from this category.

6 Baldwin *et al.* (2012) indicate that partial double-counting is possible.

Economic Competencies

Economic competencies is the third broad category of intangible assets. It is commonly accepted that knowledge that is imbedded in brand names, firm-specific human capital and organizational structure should be treated as intangible assets, and that business expenditure on these assets should be counted as investment.[7] Following existing studies of intangible investment, this study includes advertising expenditure as brand equity, direct and indirect firm expenses on training as firm-specific human capital and purchased and own-account organizational structure in the economic competence category of intangible assets.

Investment in advertising is estimated as 60 per cent of total business sector expenditure on various advertising services and products.[8] It can be argued that advertising spending only redistributes sales among firms, and does not create value.[9] However, "such spending is necessary for developing new brands and maintaining the value of existing brands" (Corrado *et al.*, 2005). Direct firm expenses on firm-specific human capital comprise the costs of developing workforce skills, such as on-the-job training, and tuition reimbursement. Indirect expenses are related to the opportunity cost of employee time spent on formal and informal training. Direct and indirect expenses are estimated as the annual spending by the business sector on learning and development. Currently, provincial data are not available, thus business investment on firm-specific human capital in Ontario is estimated using the data on Canadian business sector direct annual spending per employee.

Investment in organizational structure plays an important role in building the stock of intangible capital. According to the economic literature, successful implementation of information and communication technology (ICT), namely achievement of a significant productivity improvement, is possible if the implementation is accompanied by organizational change (Guiri *et al.*, 2005). As in Corrado *et al.* (2005), purchased investment in organizational structure is approximated by the total revenue of the management consulting services industry (NAICS 54161). Own-account investment in organizational structure is estimated as 20 per cent of labour compensation of total management occupations.

It should be noted that the estimates of intangibles for Ontario in this study are not entirely comparable to the estimates for Canada in Baldwin *et al.* (2012) due to the use of different data sources and measurements: some data, such as direct and indirect business expenses on learning and development, are unavailable at the provincial level; and the investment in intangible assets in this study is mainly estimated from the supply side,[10] as opposed to from the demand side.[11] Further research is needed to develop comparable measures of intangibles at the provincial level.

Investment in Intangibles in Ontario

It is estimated that in 2008, Ontario's businesses spent $51.6 billion[12] on intangibles – an increase of $22.2 billion as compared to 1998 (Chart 1). According to these estimates, in every year starting from 2001, business investment in

7 See Corrado *et al.* (2005, 2009), Baldwin *et al.* (2012), Van Ark *et al.* (2009).

8 See Appendix for a complete list.

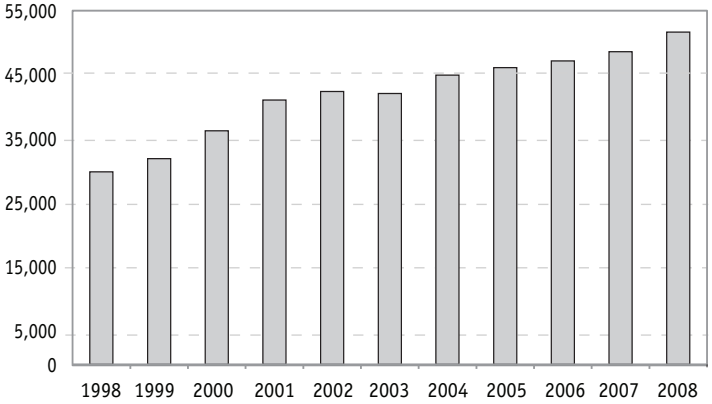
9 Thanks to Andrew Sharpe for bringing this to my attention.

10 This approach was taken in Corrado *et al.* (2005, 2009).

11 This approach was taken in Baldwin *et al.* (2012).

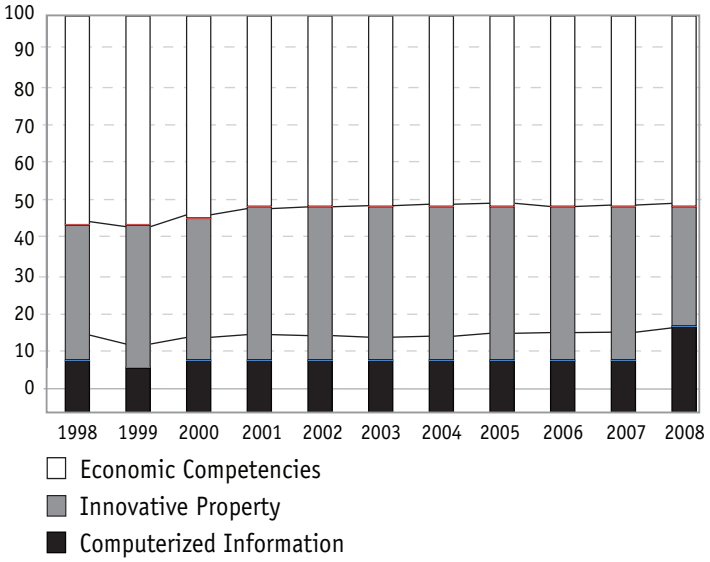
12 All monetary values given in the article are expressed in current Canadian dollars, unless otherwise indicated.

Chart 1
Nominal Investment in Intangibles in Ontario, 1998-2008
(million dollars)



Source: Statistics Canada, author's calculations.

Chart 2
Composition of the Total Investment in Intangibles in Ontario, 1998-2008
(per cent)



Source: Statistics Canada, author's calculations.

intangibles assets in Ontario exceeded business investment in tangible assets.

Similar to existing studies of intangible assets in the United States, the United Kingdom, Canada, Europe and Australia, this study found that economic competencies is the largest category of investment in intangibles in Ontario (Chart 2).

In 2008, the Ontario business sector spent almost $26 billion on brand equity, firm-specific human capital and organizational change. The share of the economic competencies category in the total amount of nominal investment in intangibles was around 50 per cent for the better part of the last decade.

Brand equity (advertising expenditure) and organizational structure are the largest components of the economic competencies category. In 2008, businesses in Ontario spent around $12 billion on brand equity and $10 billion on organizational structure. Estimated expenditure by Ontario businesses on advertising contributed almost 70 per cent to total business spending on advertising in Canada in 2008 (as estimated by Baldwin *et al.* (2009)). In the same year, estimated expenditure by Ontario businesses on organizational structure accounted for almost 15 per cent of business spending on organizational structure in Canada. Given that some data are not available at the provincial level and that the estimation approach that we used for the purpose of this study differs from the one adopted by Baldwin *et al.* (2009), the estimates of business sector expenditure in Ontario on firm-specific human capital cannot be compared with the national estimates.[13]

Innovative property is the second largest component of investment in intangibles in Ontario. According to the estimates, Ontario businesses

13 In this paper, purchased organizational assets is estimated by the output of the management consulting services industries. Baldwin et al. (2009) estimate purchased organizational assets from the demand side - by actual expenditures on organizational assets by Canadian industries. The difference is net exports and production in the other industries.

Table 1
Estimates of Business Sector Nominal Investment in Intangible Capital, Ontario
(millions of dollars)

	Ontario		Percentage of Total	
	2000	2008	2000	2008
Total Intangible Assets	35,896	51,560	100	100
1 Computerized information	4,946	8,410	13.78	16.31
1.1 Software	3,993	6,615	11.12	12.83
1.2 Computerized databases	963	1,795	2.68	3.48
2 Innovative property	11,784	17,207	32.83	33.37
2.1 Business R&D	4,508	6,589	12.56	12.78
2.2 Oil, gas and mineral exploration	81	588	0.23	1.14
2.3 New product development costs in the financial industry	978	1,408	2.72	2.73
2.4 New architectural and engineering design, and 2.5 Other science and engineering services	6,216	8,621	17.32	16.72
3 Economic competencies	19,166	25,943	53.39	50.32
3.1 Brand equity	8,381	11,877	23.35	23.04
3.2 Firm-specific human capital	3,998	4,445	11.14	8.62
3.3 Organizational structure	6,787	9,621	18.91	18.66

Source: Baldwin *et al*. (2012), Statistics Canada, author's calculations.
* data are combined to meet confidentiality requirements

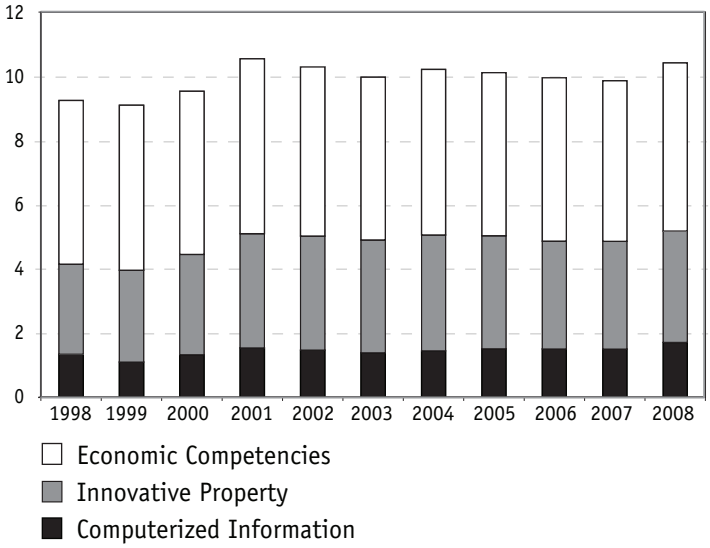
spent around $17 billion on this category of intangible assets in 2008. This expenditure amounted to 33.4 per cent of total business spending on intangibles.

Expenditure on research and development and combined expenditure on new architectural and engineering design and purchased other science and engineering are the major business sector investments in innovative property in Ontario. In 2008, these two categories amounted to 38.3 per cent and 50.1 per cent of total business expenditure on innovative property respectively. Development cost in the financial industry is a non-negligible component of investment in innovative property. In Ontario, estimated business spending on this type of intangibles was around $1.4 billion in 2008.

In Canada, oil, gas and mineral exploration is a relatively significant part of business spending on innovative property, accounting for about 8 per cent of total business investment in intangibles in 2008. Perhaps because other provinces in Canada are either better endowed with natural resources or at a more advanced stage of resource exploration, Ontario's share of business expenditure on oil, gas and mineral exploration is quite modest – 1.1 per cent of total business spending on intangibles in the province.

Computerized information is the smallest category of total investment in intangibles. In 2008, the share of computerized information in total business spending on intangibles was $8.4 billion or 16.3 per cent of the total spending on intangibles by businesses in Ontario. Software is the largest component of this category of intangible assets. In 2008, Ontario business sector spending on software amounted to 79 per cent of total business sector spending on computerized information.

Chart 3
Investment in Intangibles as a percentage of Ontario's Business Sector Output, 1998-2008



Source: Statistics Canada, author's calculations.

Empirical evidence shows that investment in intangible capital contributes significantly to the total value of business sector output. In Ontario, as a share of the total business sector output, business investment in intangible assets increased from 9.2 per cent in 1998 to 10.4 per cent in 2008 (Chart 3).[14] At the same time, the share of investment in tangible assets (i.e. machinery and equipment and buildings and structures) fell from 12 per cent of business sector output in 1998 to 10 per cent in 2008.

In real terms, business investment in intangible assets in Ontario has been growing steadily for the better part of the 1998-2008 period (Table 2). Similar to business investment in tangible capital, investment in intangibles is highly volatile and very sensitive to business cycles. According to the estimates, the peak of the annual growth in real investment in intangibles in Ontario was in 2001, when investment in intangibles grew at the annual rate of 5.6 per cent. After the "dot com" bust in 2000, the growth rate of investment in intangibles dropped to -0.3 per cent in 2003, but recovered quickly to 2.7 per cent in 2004. After a dip to 0.9 per cent during the recent recession of 2007, the annual growth rate of investment in intangibles increased to 2.1 per cent in 2008. In contrast, the growth rate of investment in tangible capital was only 1.1 per cent in 2008.

During the 1998-2008 period, expenditure on software, computerized databases and oil, gas and mineral exploration and evaluation were the fastest growing categories of business investment in intangibles in Ontario. However, given its modest contribution to total intangible investment, Ontario's business expenditure on mineral exploration and evaluation did not have a significant impact on the overall growth rate of expenditure on intangibles.

Growth Accounting

The Solow-Jorgenson-Griliches source-of-growth framework is traditionally used to evaluate the contribution of various inputs of production to labour productivity growth (Jorgenson and Griliches, 1967). The method is based on an evaluation of the income shares, s, and the growth rates, g, of the inputs of production:

$$g_{Q,t} = s_{L,t} \times g_{L,t} + s_{K,t} \times g_{K,t} + g_A \quad (1)$$

where Q is business sector output, A is technology, K is tangible capital, and L is labour.

Corrado *et al.* (2009) argue that since intangible capital is not included in this framework, the framework underestimates output and productivity growth and the

14 Revised output – estimates of business sector investment in intangibles are included in business sector output. In this paper "business sector output" refers to revised, or adjusted, output. Growth accounting is also based on adjusted output.

Table 2
Real Investment, Business Sector
(average annual per cent change)

	1999-2003	2003-2008	1999-2008
Total Tangible Assets	0.4	2.3	1.3
Total Intangible Assets	1.3	2.9	2.2
1 Computerized information	4.5	4.2	4.6
1.1 Software	5.9	3.0	4.6
1.2 Computerized databases	-0.6	9.1	4.5
2 Innovative property	0.4	3.4	2.1
2.1 Business R&D	0.8	4.1	2.3
2.2 Oil, gas and mineral exploration	11.7	8.4	9.2
2.3 New product development costs in the financial industry	1.0	1.8	1.3
2.4 New architectural and engineering design, and 2.5.2 Purchased other science and engineering services	-0.5	4.2	2.1
2.5.1 Own account other science and engineering services	1.0	0.7	1.0
3 Economic competencies	0.7	1.9	1.5
3.1 Brand equity	0.5	2.6	1.8
3.2 Firm-specific human capital	0.4	1.3	0.8
3.3 Organizational structure	1.0	1.5	1.5

Source: Statistics Canada, author's calculations.

estimates of the contribution of physical capital, labour and technology are biased. Thus, intangible capital should be included in the analysis of output and productivity growth.

The first step is to estimate intangible capital stock. I construct the series of estimates of the real intangible capital stock, R_t, by using the perpetual inventory method. This method uses the capital accumulation equation and an estimate of the initial capital stock, R_0.

$$R_t = N_t + (1 - \delta) \times R_{t-1} \quad (2)$$

$$R_0 = \frac{N_0}{\delta + g} \quad (3)$$

Real investment in all categories (excluding software) of intangibles, N_t, is estimated using output deflators. Real investment in software is estimated using a software price index. The investment growth rate, g, is estimated as the annual average growth rate of investment in intangibles for the first three years of the available data series. Depreciation rates, δ, for each category of intangible assets are taken from Corrado *et al* (2009) and Baldwin *et al.* (2012) (Table 3).

The estimates indicate that real intangible capital stock grew steadily for the better part of the last decade and reached $163 billion in 2008. Innovative property is the largest category of intangible capital. It accounts for more than half of the total stock of intangibles. Innovative property is followed by the economic competencies and computerized information categories of intangible capital, which reached $49 and $21 billion in 2008 respectively. Real intangible capital stock grew at an average annual growth rate of 2.5 per cent in the 1998-2008 period. Computerized databases, being one of the smallest categories of intangibles, was the fastest growing category of intangible capital. It grew at an average annual rate of 5.8 per cent for the same period. "Business R&D" and "new architectural and engineering design" combined with "purchased other science and engineering services"

Table 3
Depreciation Rates for Intangible Capital

1 Computerized Information	0.33
2 Innovative Property	
2.1 Business R&D	0.2
2.2 Oil, gas and mineral exploration and evaluation	0.134
2.3 New product development costs in financial the industry	0.2
2.4 New architectural and engineering design	0.2
2.5 Other science and engineering services	0.2
3 Economic Competencies	
3.1 Brand equity	0.6
3.2 Firm-specific human capital	0.4
3.3 Organizational structure	0.4

Source: Corrado *et al.* (2009), Baldwin *et al.* (2012).

also grew at the above average rate of 4.1 per cent and 3.1 per cent respectively. The annual average growth rate of intangible capital in the software and firm-specific human capital categories was the lowest among all intangible assets. In the period 1998-2008, each of these two categories grew at the average annual growth rate of 0.9 per cent.

Having estimated the stock of intangible capital, growth accounting can be applied. It is assumed that the production function is a constant returns to scale function:

$$Y_t = F(A_t, K_t, R_t, L_t) \quad (4)$$

where Y_t is business sector output, A_t is technology, K_t is tangible capital, R_t is intangible capital, and L_t is labour.

In contrast to the conventional production function, equation (4) includes intangible capital as an input of production. The accumulation equation for intangible capital is similar to that of tangible capital and is given by equation (2). Intangible capital is also included in the output identity equation:

$$P_{Q,t} \times Q_t = P_{L,t} \times L_t + \sum_{i=1}^{n} (P_{Ki,t} \times K_{i,t}) + \sum_{j=1}^{m} (P_{Rj,t} \times R_{j,t})$$

$$= P_{C,t} \times C_t + \sum_{i=1}^{n} (P_{Ii,t} \times I_{i,t}) + \sum_{j=1}^{m} (P_{Nj,t} \times N_{j,t}) \quad (5)$$

where Q is adjusted business sector output, C is consumption, I is investment in tangible capital, P_K and P_R are the user costs associated with the user services of respective input, and i and j are categories of tangible and intangible capital respectively.[15]

Following Corrado *et al.* (2009), intangible capital is added to the conventional growth accounting method to examine the contribution of intangible capital to productivity growth in Ontario.[16]

It is assumed that income shares, s, are equal to corresponding output elasticities and that each input is paid the value of its marginal product. The source-of-growth system of equations is then derived taking logarithmic differentiation of equation (4):

$$g_{Q,t} = s_{L,t} \times g_{L,t} + s_{K,t} \times g_{K,t} + s_{R,t} \times g_{R,t} + g_A \quad (6)$$

The income shares of the inputs of production are also derived from the output identity equation:

$$s_{L,t} = \frac{P_{L,t} \times L_t}{P_{Q,t} \times Q_t} \quad (7)$$

$$s_{K,t} = \frac{P_{K,t} \times K_t}{P_{Q,t} \times Q_t} \quad (8)$$

$$s_{R,t} = \frac{P_{R,t} \times R_t}{P_{Q,t} \times Q_t} \quad (9)$$

where K_t is a sum of all categories of tangible capital and R_t is a sum of all categories of intangible capital.

The growth rates of labour and capital inputs are calculated using annual data on labour input, tangible capital stock and annual estimates of intangible capital stock. Both tangible and intangible capital are not consumed entirely in the production process. Thus, the user cost of capital services is required to estimate an income

15 Adjusted, or revised, business sector output consists of consumption, investment in tangible capital, investment in intangible assets, and net exports.

16 Solow-Jorgenson-Griliches sources-of-growth framework.

share of each category of capital. The measure of the user cost of capital is based on the rate of return to capital and a price of investment in each category of capital. The growth accounting framework allows for either an endogenous or exogenous rate of return to capital. Following Corrado *et al.* (2009), I use an endogenous rate of return to capital. If an arbitrage opportunity exists then business investments will flow to a specific category of capital until an arbitrage opportunity is eliminated. Thus, it is assumed the net real rate of return to capital is equalized across all categories of tangible and intangible capital. There is an ongoing debate in economic literature whether the real or nominal rate of return should be used in growth accounting.[17] For the purposes of this study, I use the net real rate of return. The user cost of capital is calculated using equation:

$$P_t^{R_j} = (r_t + \delta_j - \pi_{j,t}) \times P_t^{N_j} \qquad (10)$$

where r is the real rate of return and π is expected capital gains. The expected capital gains term is calculated using a three-year moving average of changes in the output deflator.

The modified growth accounting equation (6) was used to estimate the contribution of tangible capital, intangible capital, and labour and technology to the labour productivity growth. The results indicate that multifactor productivity (MFP) and total capital deepening were the major contributors to labour productivity growth in Ontario in the 1998-2008 period.

Intangible assets contribute significantly to business sector output and labour productivity growth in Ontario. In the 1998-2008 period, intangibles contributed on average 0.34 percentage point, while tangible capital contributed on average 0.23 percentage point to productivity growth in Ontario. For almost every year from 1998 to 2008 the contribution of intangible assets to the labour productivity growth in the province exceeded that of tangible capital. Moreover, in contrast to tangible capital, in each year from 1998 to 2008 the contribution of intangibles to labour productivity growth was positive.

Unsurprisingly, when intangibles are included in growth accounting, the contribution of total capital deepening to labour productivity growth is greater than the contribution of tangible capital deepening.

At the same time, the contributions of labour and of MFP are smaller when compared with the results of no-intangibles growth accounting. In a study of labour productivity in Ontario, which does not include intangible assets, the Centre for the Study of Living Standards (De Avillez, 2011) estimated that capital deepening contributed 32.3 per cent to labour productivity growth in the business sector from 1997 to 2007, while labour quality and MFP contributed 18.8 and 48.1 per cent respectively. The findings of this study and the CSLS results differ because in the latter the contribution of intangible assets to the labour productivity growth was partially and implicitly counted in the contribution of labour and MFP. Thus, by including intangibles into productivity analysis we not only expand our knowledge of productivity and the sources of productivity growth but we also partially eliminate the biases inherent in the conventional growth accounting framework.

The contribution of each major category of intangibles – computerized information, innovative property and economic competencies – to the labour productivity growth varies for different jurisdictions (see Table 5).[18] According to Van Ark *et al.* (2009), in Austria, Spain

17 Baldwin and Gu (2007) provide an excellent discussion on the alternative ways to estimate capital services.

Table 4
Labour Productivity Growth by Source, Ontario

Sources	Muntean 1998-2008	de Avillez 1997-2007
Labour productivity growth	1.30	1.70
Contribution of:		
1 Capital deepening	0.57	0.55
1.1 Tangibles	0.23	0.55
1.2 Intangibles	0.34	
2 Labour composition	0.11	0.32
3 Multifactor productivity	0.61	0.82

Source: de Avillez (2011), author's calculations.

and Germany innovative property contributes more than half of the total contribution of intangibles to labour productivity growth in the market sector. The authors estimate that the greatest contribution of innovative property to labour productivity growth was in Germany. It reached 60.5 per cent of the total contribution of intangibles in the 1995-2006 period. Economic competencies are reported to contribute the most to labour productivity growth in the US and the UK, at 41.7 and 45.9 per cent of the total contribution of intangible assets respectively.[19] Van Ark *et al.* (2009) also reports that computerized information contributed the most to the labour productivity growth in Denmark over the same period – 40.3 per cent of the total contribution of intangibles.

In other jurisdictions, such as the United States, the United Kingdom and France, computerized information contributed almost one-third of the total contribution of intangibles. Moreover, in the United States the share of computerized information has increased from 27.9 per cent in 1973-1998 to 32.1 per cent in 1995-2003.

In Canada, according to Baldwin *et al.* (2012), innovative property and economic competencies were the major contributors to the labour productivity growth in the 2000-2008 period – 0.2 percentage point each. Computerized information contributed 0.1 percentage point to productivity growth in the same period.

This study estimates that in Ontario innovative property contributed the most to business sector labour productivity growth in the 1998-2008 period (0.15 percentage point), followed by economic competencies (0.11 percentage point) and computerized information (0.06 percentage point).

Innovative property, business research and development and new architectural and engineering design, combined with purchased other science and engineering services, contributed 0.07 percentage point each. The development costs of new products in the financial industry contributed 0.008 percentage point. The contributions of oil, gas and mineral exploration and own-account other science and engineering services were relatively small – only 0.003 and 0.004 percentage point respectively.

This study estimates that brand equity from the economic competencies category contributed 0.07 percentage point to labour productivity growth. Purchased organizational structure and own account organizational structure contributed equally – 0.02 percentage point each. Firm-specific human capital was not a significant source of productivity growth in 1998-2008 in Ontario. This category added only 0.0016 percentage point to the labour productivity growth.

In contrast to the US, the UK, France, Italy, Austria and Denmark, computerized informa-

18 Due to differences in estimation techniques and data sources and collection methods, the estimates of labour productivity growth are not entirely comparable across the jurisdictions.

19 See Corrado *et al.* (2009) for estimates for the US and Haskel *et al.* (2011) for estimates for the UK.

Table 5

Business Sector Labour Productivity Growth by Source, Ontario and Selected Jurisdictions

	US 1973-1998		US 1995-2003		UK 1995-2006		Canada 2000-2008		Ontario 1998-2008	
Sources	**ar**	**%c**	**ar**	**%c**	**ar**	**%c**	**ar**	**%c**	**ar**	**%c**
Labour productivity growth	1.63	100	3.09	100	2.24	100	0.8		1.30**	100
Contribution of:										
1 Capital deepening	0.97	59.5	1.68	54.4	1.18	52.7	1.4		0.57	44.2
1.1 Tangibles	0.55	33.7	0.85	27.5	0.67	29.9	0.8		0.23	17.9
1.2 Intangibles	0.43	26.4	0.84	27.2	0.51	22.8	0.6		0.34	26.2
2 Labour composition	0.25	15.3	0.33	10.7	0.16	7.1	0.3		0.11	8.7
3 Multifactor productivity	0.41	25.2	1.08	35.0	0.9	40.2	-0.8		0.61	47.2
Contribution of Intangibles										
1.2 Intangible capital deepening	0.43	100	0.84	100	0.37	100	0.6	*	0.34	*
1.2.1 Computerized information	0.12	27.9	0.27	32.1	0.1	27.0	0.1	16.7	0.06	17.6
1.2.2 Innovative property	0.13	30.2	0.22	26.2	0.09	24.3	0.2	33.3	0.15	44.1
1.2.3 Economic competencies	0.17	39.5	0.35	41.7	0.17	45.9	0.2	33.3	0.11	32.4

	Germany 1995-2006		France 1995-2006		Italy 1995-2006		Spain 1995-2006	Austria 1995-2006		Denmark 1995-2006	
Sources	**ar**	**%c**	**ar**	**%c**	**ar**	**%c**	**ar**	**ar**	**%c**	**ar**	**%c**
Labour productivity growth	1.79	100	2.00	100	0.29		0.47	2.36	100	2.11	100
Contribution of:											
1 Capital deepening	1.06	59.2	0.91	45.5	0.52		0.8	0.79	33.5	1.4	66.4
1.1 Tangibles	0.68	38.0	0.43	21.5	0.4		0.68	0.24	10.2	0.68	32.2
1.2 Intangibles	0.38	21.2	0.48	24.0	0.12		0.12	0.55	23.3	0.72	34.1
2 Labour composition	-0.15	-8.4	0.4	20.0	0.22		0.64	0.22	9.3	0.17	8.1
3 Multifactor productivity	0.88	49.2	0.69	34.5	-0.45		-0.96	1.35	57.2	0.53	25.1
Contribution of Intangibles											
1.2 Intangible capital deepening	0.38	100	0.48	100	0.12	100	0.12	0.55	100	0.72	100
1.2.1 Computerized information	0.07	18.4	0.15	31.3	0.03	25.0	0.05	0.13	23.6	0.29	40.3
1.2.2 Innovative property	0.23	60.5	0.18	37.5	0.05	41.7	0.15	0.29	52.7	0.27	37.5
1.2.3 Economic competencies	0.07	18.4	0.15	31.3	0.04	33.3	-0.08	0.13	23.6	0.17	23.6

ar average annual rate of change.

%c per cent contribution.

Source: US estimates are from Corrado *et al.* (2009), Canadian estimates are from Baldwin *et al.* (2012), UK estimates are from Haskel *et al.* (2011), Ontario estimates are author's calculations, remaining estimates are from Van Ark *et al.* (2009).

* Detail may not sum to totals due to rounding

** The number appears too high if compared with the data published by Statistics Canada, which can be explained by i) adjustment for intangibles, ii) lack of or limited provincial data on intangibles and its impact on estimates used in growth accounting. The results will be refined when more data is available and estimation approaches are improved

tion contributed the least to labour productivity growth in Ontario – only 0.06 percentage point or 17.6 per cent of the total intangible capital contribution in the 1998-2008 period. At the same time the contribution of computerized information in the province was greater than that in Canada. According to Baldwin *et al.* (2012) computerized information accounted for 16.7 per cent of the total intangible capital contribution to labour productivity growth in Canada (Table 5).

Inclusion of intangible assets in growth accounting did not alter dramatically the estimate of the contribution of MFP to the labour productivity growth. The results show that in the 1998-2008 period MFP accounted for 47.2

Table 6
Percentage Point Contribution of Intangible Capital to Labour Productivity Growth by Source, Ontario

Sources	1998-2008
Total Intangible Capital Contribution	0.34
1.1 Software	0.06
1.2 Computerized databases	0.02
2.1 Business R&D	0.07
2.2 Oil, gas and mineral exploration	0.003
2.3 New product development costs in the financial industry	0.008
2.4 New architectural and engineering design, and 2.5.2 Purchased other science and engineering services	0.07
2.5.1 Own account other science and engineering services	0.004
3.1 Brand equity	0.07
3.3.1 Purchased organizational structure	0.02
3.3.2 Own account organizational structure	0.02
3.2 Firm-specific human capital	0.0016

Source: Author's calculations. Detail may not sum to totals due to rounding.

per cent of the labour productivity growth. A no-intangibles study of productivity in Ontario, conducted by the CSLS, indicates that in the 1997-2007 period MFP contributed 48.1 per cent to labour productivity growth, which is higher than in our study. This indicates that more research is needed to fully understand MFP and through which channels the technological advances are transmitted into labour productivity growth. This study also shows that when spending on intangible assets is not included in aggregate investment, average annual growth for Ontario's GDP is underestimated by 0.3 percentage point in 1998-2008.

Conclusion

This study aimed to provide the answers to the following questions:

- How much do Ontario's businesses spend on various categories of intangible assets?
- How big is Ontario's stock of intangible capital and how fast is it growing?
- How important are intangibles as a contributor to the business sector labour productivity growth in Ontario?

In line with existing research on intangible assets in various jurisdictions, the results of this study confirm that intangible assets are a valuable component of business sector output in Ontario. The nominal investment in intangibles has grown from $29 billion in 1998 to almost $52 billion in 2008. As a percentage of business sector output, investment in intangibles increased from 9.2 per cent in 1998 to 10.4 per cent in 2008.

By nature, capital investment is highly volatile and very sensitive to changes in economic conditions. The tides and waves of investment usually follow business cycle expansions and downturns. In Ontario, the growth rate of the business sector's real investment in intangibles oscillated from -0.25 per cent to 5.65 per cent in the 1998-2008 period. However, on average in the same period the growth rate of investment in intangibles exceeded the growth rate of investment in tangibles. In addition, investment in intangibles was not as volatile as investment in tangible capital.

According to this study, real intangible capital stock grew at an average rate of 2.5 per cent from 1998 to 2008 and reached $163 billion in 2008. Computerized databases, although one of the smallest categories of intangibles, was the fastest growing category in 1998-2008. It grew at an average annual rate of 5.8 per cent, followed by business R&D with an average annual growth rate of 4.1 per cent.

The estimates indicate that innovative property contributed the most to labour productivity growth in Ontario in the 1998-2008 period. On average, innovative property contributed 0.15 percentage point to labour productivity growth, which is 44.1 per cent of the total contribution of intangible capital. The contribution of economic competencies was somewhat comparable to that of innovative property. In the 1998-2008 period, economic competencies contributed on average 0.11 percentage point to labour productivity growth

or 32.4 per cent of total contribution of intangibles. Computerized information contributed only 0.06 percentage point or 17.6 per cent of the total contribution of intangibles to labour productivity growth. It appears that, in contrast to other jurisdictions, Ontario businesses do not invest significantly in organizational structure, which in turn might explain the low contribution of the computerized information category of intangibles to labour productivity growth. According to Bresnahan *et al.* (2002), organizational change should accompany ICT adoption in order to boost labour productivity growth.

This study is an initial attempt to measure investment in intangible assets, estimate the stock of intangible capital and evaluate the contribution of intangibles to labour productivity growth in Ontario. The study aims to raise awareness of the importance of intangibles to output and productivity growth in the province. Governments around the world provide significant support for innovative activities by businesses. However, they may place a disproportionately greater emphasis on selected categories of intangible assets, such as R&D. R&D has been traditionally viewed as a main driver of innovation and MFP growth. As a result, R&D activities have been encouraged and extensively supported by governments. Theoretical findings and empirical evidence, however, indicate that private R&D stock generally represents no more than 20-25 per cent of total business stock of intangible capital. Therefore, government policies, which predominantly support R&D, may not result in desired or targeted output and productivity growth. Empirical studies of intangible capital indicate that other categories of intangibles, such as brand equity and organizational structure also contribute significantly to productivity growth. This contribution should not be ignored.

Existing government policies that support education, entrepreneurship and R&D, and strengthen intellectual property rights have a positive impact on investment in knowledge-based capital. The recent research and analyses by the Organisation for Economic Co-operation and Development (OECD) (OECD 2013a, 2013b, 2013c, 2013d), however, indicate that existing policy frameworks should be updated to reflect the importance of intangible capital. The accumulation of intagible capital can also be encouraged by product market liberalization; bankruptcy regimes that do not penalize business failures too severely; a focus on broad concepts innovation, and labour market reforms. The OECD also warns that public policy to maximize the growth potential of knowledge-based capital may have ambiguous effects and trade-offs may emerge with other policy goals. Therefore, further research is needed to deepen our understanding of intangibles and their role in the economic activity of the business sector so that governments will have a more complete understanding ofthe state of business investment in intangibles; and whether support measures are needed to encourage and boost such investment.

The next steps for this study are to continue improving the measures of intangible assets in Ontario and refining the estimates of the contribution of intangibles to output and productivity growth in the province.

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Appendix

Asset	Description
1 Computerized Information	
1.1 Software	Spending on software has been capitalized in the Canadian System of National Accounts. Statistics Canada publishes provincial software investment data as part of non-residential investment (*CANSIM Table 031-0004*).
1.2 Computerized databases	Expenditure on computerized databases is approximated by the operating revenues of the data processing, hosting and related services industries (NAICS code 51821), which are published by Statistics Canada in the *CANSIM Table 354-0005*.
2 Innovative Property	
2.1 Business R&D	Business spending on R&D has been capitalized in the Canadian System of National Accounts. Statistics Canada publishes provincial R&D investment data as part of non-residential investment (*CANSIM Table 031-0004*).
2.2 Oil, gas and mineral exploration	Spending on oil, gas and mineral exploration has been capitalized in the Canadian System of National Accounts. Statistics Canada publishes provincial oil, gas and mineral exploraton investment data as part of non-residential investment (*CANSIM Table 031-0004*).
2.3 New product development costs in the financial industry	Estimated as 20% of all intermediate purchases of the Financial Services industry (NAICS 521 and 522). Source: Ontario *Input-Output Tables*
2.4 New architectural and engineering design	Estimated as 50% of total expenditure on architectural and engineering services (NAICS 5413). Source: Ontario *Input-Output tables* Note: combined with 2.5.2 to meet confidentiality requirements.
2.5 Other science and engineering services	2.5.1 plus 2.5.2.
2.5.1 Own account other science and engineering services	Estimated as 20% of labor compensation of scientists and engineers. To avoid double-counting, financial services (NAICS 521) is excluded. Ontario data is not available for NAICS 521, so it was estimated as 1/6 of NAICS 52 (NAICS 52 consists of 6 categories). It is captured in 2.3. Architectural, engineering and related services (NAICS 5413) is also excluded. It is captured in 2.4. Management, scientific and technical consulting services (NAICS 5416) are excluded as well. Captured in 3.3. Scientific research and development services (NAICS 5417) are equally excluded. Captured in 2.1. In addition, advertising and related services (NAICS 5418) and other professional, scientific and technical services (NAICS 5419)are ecluded. Captured in 3.1.1 and 2.1 respectively. Source: Statistics Canada *Customized Tables* (LFS)
2.5.2 Purchased other science and engineering services	Estimated as 50% of total expenditure on royalties and licensing fees. Source: Ontario *Input-Output tables* Note: combined with 2.4 to meet confidentiality requirements.
3 Economic Competencies	
3.1 Brand Equity	3.1.1 plus 3.1.2.
3.1.1 Advertising expenditure	Estimated as 60% of business sector expenditure on: (1) advertising flyers, catalogs and directories (2) advertising in print media, (3) advertising services, and (4) advertising and promotion Source: Ontario *Input-Output tables*
3.1.2 Market and consumer research	n/a for Ontario
3.2 Firm-specific human capital (training cost)	3.2.1 plus 3.2.2.
3.2.1 Direct firm expenses	Estimated by using *Conference Board of Canada* data on Canadian business sector direct annual spending per employee and the total number of employees (Statistic Canada) Caveat: data are in constant 2010 dollars only
3.2.2 Indirect expenses	Estimated by using *Conference Board of Canada* data on Canadian business sector indirect direct annual spending per employee and total number of employees (Statistic Canada). Caveat: data are in constant 2010 dollars only.
3.3 Organizational structure	3.3.1 plus 3.3.2.
3.3.1.Purchased	Approximated as the total operating revenue of the "management consulting services" industry (MAICS 54161), *CANSIM Table 360-0001*
3.3.2 Own account	Estimated as 20% of the labor compensation of total management occupations. Source: Statistics Canada, customized tables