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CENTRE FOR THE STUDY OF LIVING STANDARDS

An Analysis of Saskatchewan's Productivity, 1997-2007: Capital Intensity Growth Drives Strong Labour Productivity Performance

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An Analysis of Saskatchewan's Productivity, 1997-2007: Capital Intensity Growth Drives Strong Labour Productivity Performance

Executive Summary

The report, based on the CSLS Provincial Productivity Database, provides an overview of Saskatchewan's productivity performance over the 1997-2007 period. The key findings are the following:

- Saskatchewan's labour productivity grew at an average annual rate of 2.1 per cent during the 1997-2007 period, above the national average of 1.7 per cent per year. In terms of labour productivity growth, Saskatchewan's performance ranked 3rd among the provinces.
- Saskatchewan's FIRE (finance, insurance, real estate, rental and leasing), and transportation and warehousing industries enjoyed the highest labour productivity growth rates in Canada when compared to equivalent industries in the other provinces (3.9 and 2.3 per cent per year, respectively).
- Labour productivity growth in both Saskatchewan and Canada was driven mainly by increases in capital intensity. However, capital intensity growth played an even bigger role in Saskatchewan than it played in Canada, explaining 76.2 per cent of total labour productivity growth (while in Canada it accounts for only 56.1 per cent).
- Saskatchewan's labour productivity level was $35.4 (1997 dollars) per hour in 1997, which represents 98.1 per cent of the Canadian level. This, in turn, implies a labour productivity gap of 1.9 percentage points. The gap was caused by a below average multifactor productivity level.
- Saskatchewan had a labour productivity gap in 10 of the 15 two-digit NAICS industries. In most cases, the below average multifactor productivity level was the main culprit. The exceptions were the retail trade, and FIRE industries, where the below average capital intensity levels were responsible for the gaps.
- Saskatchewan's labour quality grew at an average rate of 0.9 per cent per year during the 1997-2007 period, significantly higher than the national average, which grew at an average annual rate 0f .0.5 per cent. The province ranked 1st in Canada in terms of labour quality growth.
- Capital productivity in Saskatchewan's market sector declined at a rate of 0.6 per cent per year during the 1997-2007 period, the same as the national average. The province ranked 7th in Canada in terms of capital productivity growth.
- Saskatchewan's multifactor productivity grew at an average rate of 0.1 per cent per year during the 1997-2007 period, considerably slower than the national average, which grew at an average annual rate of 0.4 per cent. The province ranked 8th in Canada in terms of multifactor productivity.

An Analysis of Saskatchewan's Productivity, 1997-2007: Capital Intensity Growth Drives Strong Labour Productivity Performance

Productivity is the key factor that determines living standards in the long run. If the amount of output each worker produces does not increase, real wages and incomes cannot rise (Sharpe, 2010a). Since 2000, Canada's labour productivity growth has been abysmal, both from an historical and an international perspective (Sharpe and Thomson, 2010b).[1] Improving this poor performance must be a key objective of Canada's economic agenda. To develop policies with this goal in mind, it is important to understand the nature of labour productivity at both the national and provincial levels, including the sources of growth at the market sector and industry levels.

This report analyzes Saskatchewan's productivity performance over the 1997-2007 period. It is based on the CSLS Provincial Productivity Database. Level and growth rate estimates of labour, capital and multifactor productivity are discussed, with an emphasis on Saskatchewan's market sector. Two-digit NAICS industry level estimates are also presented.[2]

This report is divided into ten sections. The first section provides a brief overview of basic concepts related to productivity, along with the methodology and the data sources used. Section two discusses Saskatchewan's industry composition by nominal GDP and total hours worked. Sections three through nine detail Saskatchewan's productivity performance, focusing on the following topics: labour productivity, capital productivity, multifactor productivity, capital intensity, labour quality, sources of labour productivity growth in the market sector, and sources of labour productivity gap by industry. Section ten concludes. An appendix provides details on the growth accounting framework used in the report.

I. Basic Concepts, Methodology and Data Sources

In this section, we first define the main concepts used in this report, as well as explain important topics related to productivity analysis – such as the difference between partial and total productivity measures, and the distinction between productivity growth rates and levels. This is followed by a brief discussion on methodology and data sources. Although the basics of the growth accounting framework used in the report are presented in this section, its details are only discussed in the Appendix.

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[1] From 1981 to 2000, labour productivity in Canada's business sector grew at an average annual rate of 1.6 per cent. In the 2000-2009 period, labour productivity growth dropped sharply to a mere 0.7 per cent per year in Canada. This slowdown in labour productivity growth in Canada was not experienced in the United States, which grew at an average annual rate of 2.5 per cent during the same period (up from 2.0 per cent during the 1981-2000 period).

[2] This report builds on and extends earlier CSLS work on provincial productivity. The CSLS Provincial Productivity Database is available at http://www.csls.ca/data/mfp_new.asp. Previous CSLS articles on this topic include Sharpe and Arsenault (2009), Sharpe (2010) and Sharpe and Thomson (2010a, 2010b).

Basic Concepts

Productivity is, broadly speaking, a measure of how much output is produced per unit of input used. The output and input measures used will affect, however, the productivity estimates. In this sub-section, we define the input, output and productivity measures used throughout this paper:

- The **labour services input** is defined as total *quality adjusted* hours worked in a particular sector or in the market sector as a whole. It is the weighted sum of hours worked across different categories of workers, with the weights being equal to relative labour compensation shares.

- **Labour quality** (also known as **labour composition**) is defined residually as the difference between growth in labour services and growth in hours worked (*unadjusted* by quality). In Canada, the variables used to differentiate labour quality are education (four education levels), experience (proxied by seven age groups) and class of workers (paid employees versus self-employed workers). Overall, there are 56 different categories of workers.[3]

- The **capital services input** represents the flow of services provided by the capital stock. The difference between capital stock and capital services stems from the fact that not all forms of capital assets provide services at the same rate. Short-lived assets, such as a car or a computer, must provide all of their services in just a few years before they completely depreciate. Office buildings provide their services over decades. As a consequence, over a single year, a dollar's worth of a car provides relatively more capital services than a dollar's worth of a building. Thus, capital services growth is driven by: 1) increases in the level of **capital stock**; and 2) shifts in the **capital composition** caused by more investment in assets that provide relatively more services per dollar of capital stock (i.e. short lived assets).

- **Capital intensity** is defined as capital services per hour worked.

- **Gross domestic product (GDP)** measures the value of all *final* goods and services produced in a defined geographic region during a certain time period, typically a year or a quarter.

- **Labour productivity** is defined as real GDP per hour worked.

- **Capital productivity** is real GDP per unit of capital services.

- **Multifactor Productivity (MFP)**[4] growth is measured as the difference between real output growth and combined input growth. In other words, MFP reflects output growth that is not accounted for by input growth. The inputs that are taken into account to construct a combined input aggregate vary whether we are calculating MFP using a gross output basis or a value

[3] For more information on how Statistics Canada calculates labour quality, see Gu *et al* (2002).
[4] Also known as total factor productivity (TFP).

added basis. The gross output basis takes into consideration labour, capital, and intermediate inputs, while the value added basis takes into account only capital and labour (because intermediate consumption is already subtracted from value added). Thus, MFP captures the residual effects of several elements of the production process, such as improvements in technology and organizations, capacity utilization, increasing returns to scale, mismeasurement, etc. In this report, MFP growth is calculated on a value added basis.

When discussing productivity, there are two important dimensions to consider. The first is whether productivity is measured using a partial productivity approach or a multifactor productivity approach. The second is whether the focus is on growth rates, levels, or both.

There is a fundamental distinction between partial and multifactor productivity (MFP). Partial productivity measures refer to the relationship between output and a single input, such as labour or capital. Multifactor productivity, on the other hand, attempts to measure how efficiently all factors of production are used in the production process. This report provides estimates for two partial productivity measures – labour productivity (the most commonly used measure of productivity) and capital productivity –, as well as multifactor productivity.

Productivity can be expressed either in growth rates or in levels. The economics literature largely focuses on productivity growth rates, which reflect increases in *real* output per hour or per unit of capital. In this report we are also interested in making level comparisons between provinces. Ideally, productivity level comparisons are done in current dollars (i.e. using *nominal* GDP), as these estimates capture changes in relative prices. However, at the time the CSLS Provincial Productivity Database was constructed, nominal GDP figures at the industry level were available only up to 2005. As a consequence, the productivity levels were calculated using real GDP. One advantage of using real GDP instead of nominal GDP for the level comparisons is that the growth rates and changes in levels are consistent with each other. Regardless of whether nominal or real GDP figures are used for productivity level comparisons, it is important to note that these comparisons should be used with caution, due not only to differences in industry composition between provinces, but also due to the lack of industry purchasing power parities (PPPs) estimates at the provincial level.

As mentioned above, this report makes provincial comparisons of both productivity levels and growth rates. These comparisons are done both at the **market sector level** and at the **two-digit NAICS industry level**.[5] The North American Industry Classification System (NAICS) breaks down the economy into 20 sectors:

[5] The words *industry* and *sector* are used interchangeably in this report.

Exhibit A: The North American Industry Classification System (NAICS) at the Two-Digit Level

Sector Number	Description
11	Agriculture, Forestry, Fishing and Hunting
21	Mining, and Oil and Gas Extraction
22	Utilities
23	Construction
31-33	Manufacturing
42	Wholesale Trade
44-45	Retail Trade
48-49	Transportation and Warehousing
51	Information and Cultural Industries
52	Finance and Insurance
53	Real Estate, Rental and Leasing
54	Professional, Scientific, and Technical Services
55	Management of Companies and Enterprises
56	Administrative and Support, Waste Management and Remediation Services
61	Education Services
62	Health Care and Social Assistance
71	Arts, Entertainment, and Recreation
72	Accommodation and Food Services
81	Other Services (except Public Administration)
92	Public Administration

The market sector is comprised by 17 of the 20 sectors, all of which have been highlighted in Exhibit A. The only three sectors that are not included in the market sector are: education services, health care and social assistance, and public administration. For practical purposes, we have grouped the finance and insurance, real estate, rental and leasing, and management of companies and enterprises sectors into only one sector, which will be referred to as the finance, insurance, real estate, rental and leasing (FIRE) sector. Since this change is only a slight departure from the standard NAICS breakdown, we will still refer to these 15 sectors as NAICS sectors.

The provincial comparisons are done by ranking the productivity growth rates and levels of different provinces from 1 (highest) to 10 (lowest). Each province has two market sector ranks: an **equally-weighted rank** and an **industry composition weighted rank**. The industry composition weighted market sector rank, which will be referred throughout this report simply as the market sector rank, takes into account the province's market sector output, labour input and capital input, which are basically a sum of the outputs and inputs of the 15 two-digit NAICS industries in the province. Thus, it gives more weight to the sectors that comprise a more significant part of the province's economy. The equally-weighted market sector rank, as the name implies, attributes equal weights to all industries. Comparing the two ranks allows for important characteristics of the province's productivity performance to be identified. For instance, a province with a high market sector rank and a low equally-weighted market sector rank in labour productivity growth will most likely have strong labour productivity growth in its largest industries, but low productivity growth in most of the fifteen two-digit NAICS industries.

Lastly, we also perform **growth accounting** exercises in order to measure how different factors contributed to labour productivity growth. Contributions to labour productivity growth were broken

down into three factors: 1) capital intensity[6]; 2) labour quality; and 3) multifactor productivity.[7] Formally, this decomposition is a consequence of the growth accounting framework adopted in this report. However, it is also quite intuitive:

- Workers that have access to more capital (i.e. higher capital intensity) tend to have, *ceteris paribus*, higher labour productivity. Imagine, for example, two teams with two workers each. In the first team, one worker has a shovel and the other has a snow blower. In the second team, both workers have snow blowers. The second team uses capital more intensively than the first, and thus is able to clear much more snow in the same period of time.

- Improvements in labour quality tend to increase the amount of output a worker can produce in a given time period. Thus, an experienced coal miner will normally be able to extract more coal than a novice miner during a given timeframe.

- Technological progress can substantially increase output per worker. A logger with a chainsaw, for instance, is much more productive than one with an axe. This is an example of productivity growth driven by MFP. It should be noted, however, that technological progress is only one of the several possible factors to drive MFP growth.

Methodology and Data Sources

Statistics Canada has detailed the methodologies and data sources used in the preparation of its estimates of multifactor productivity (MFP) at the national level in Baldwin *et al*. (2007). The provincial estimates used in this report have been prepared by Statistics Canada for the Centre for the Study of Living Standards (CSLS) and largely follow the methodologies used for the national estimates. There are, however, certain differences between the national and provincial estimates which are discussed in detail in Sharpe and Arsenault (2009). CSLS supplemented Statistics Canada data by calculating multifactor productivity level estimates for the provinces relative to the Canadian average.[8]

The growth accounting framework used in this report is the same as the one used in Sharpe and Thomson (2010a). It assumes a Cobb-Douglas production function such that:

$$Y = AK^{\alpha}L^{1-\alpha}$$

where *Y* is real output, *K* stands for capital services, *L* for labour input (quality adjusted hours), *A* for multifactor productivity and α is the share of output that takes the form of capital compensation. For more information, refer to the Appendix.

[6] Note, once again, that capital intensity has been defined here as capital services per hour worked, *not* capital stock per hour worked.
[7] To understand the reasons behind this decomposition, refer to the Appendix.
[8] For more details, see Appendix.

II. Industry Composition by Nominal GDP and Total Hours Worked

In order to understand Saskatchewan's overall productivity performance, it is essential to understand how each of the 15 two-digit NAICS industries contributed to the province's market sector in terms of nominal GDP and actual hours worked. Table 1 details these contribution shares for 1997 and 2007. In Saskatchewan, the industries that had the highest GDP shares in 2007 were mining, and oil and gas extraction (31.7 per cent of the province's nominal GDP in the market sector), FIRE (finance, insurance, real estate, rental and leasing) (8.8 per cent), construction, and manufacturing (both of which had shares equal to 8.1 per cent). In terms of total hours worked, the three industries that had the highest contributions in 2007 were agriculture, forestry, fishing and hunting (14.7 per cent of total hours worked), retail trade (13.5 per cent), and construction (10.2 per cent).

Table 1: Industry Share of Nominal GDP and Total Hours Worked in Saskatchewan

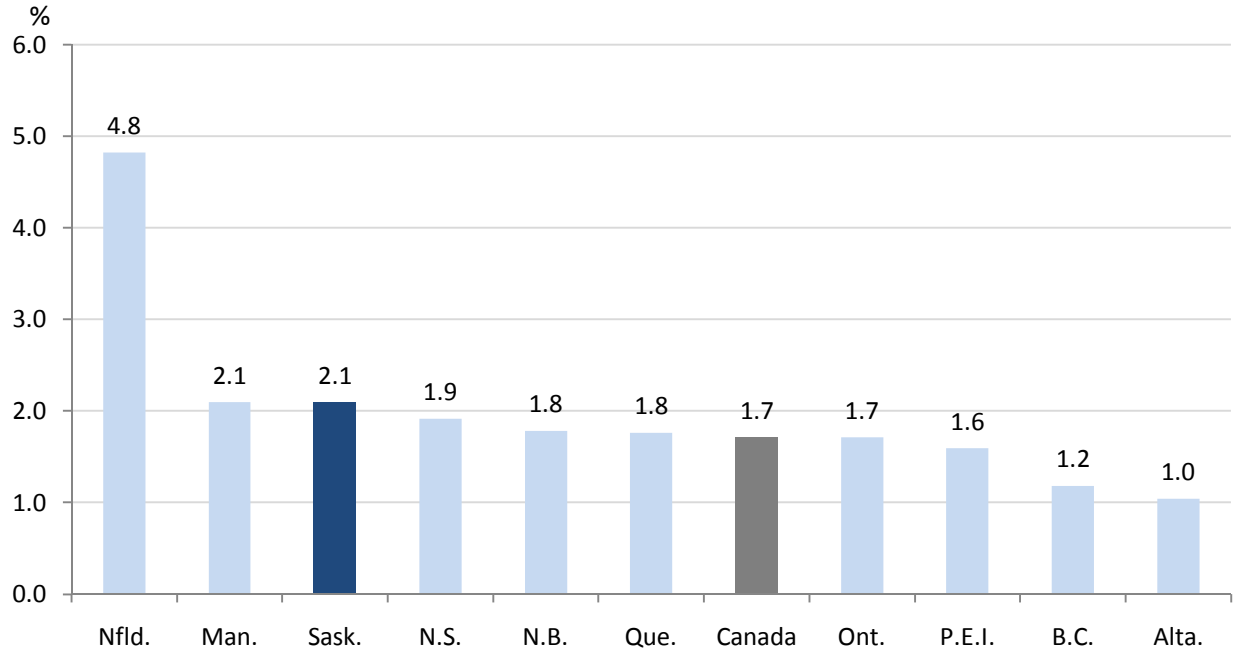
	1997				2007			
	GDP		Hours Worked		GDP		Hours Worked	
	Canada	Saskatchewan	Canada	Saskatchewan	Canada	Saskatchewan	Canada	Saskatchewan
Market Sector	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
Agriculture, Forestry, Fishing and Hunting	3.2	11.9	5.4	22.8	2.1	7.4	3.4	14.7
Mining, and Oil and Gas Extraction	5.5	20.3	1.7	3.8	11.1	31.7	2.0	5.9
Utilities	4.2	3.7	0.9	0.6	3.0	2.6	0.8	0.8
Construction	7.0	7.7	7.9	8.3	9.0	8.1	10.1	10.2
Manufacturing	23.2	9.5	18.3	6.5	16.8	8.1	14.8	7.9
Wholesale Trade	7.1	7.1	7.4	6.1	7.1	7.4	6.9	5.9
Retail Trade	6.9	6.0	13.1	12.4	7.4	6.1	12.9	13.5
Transportation and Warehousing	6.2	7.5	6.3	7.0	5.6	6.5	6.6	8.5
Information and Cultural Industries	4.3	3.5	2.5	2.5	4.3	2.6	2.7	2.2
FIRE*	15.0	10.5	7.5	6.5	14.6	8.8	7.8	6.0
Professional, Scientific and Technical Services	4.9	2.8	6.3	4.3	6.2	2.5	7.9	4.1
ASWMR**	2.5	1.4	4.0	2.6	3.3	1.3	5.7	3.1
Arts, Entertainment and Recreation	0.9	0.6	1.5	0.8	0.9	0.6	1.9	1.7
Accommodation and Food Services	3.2	3.1	7.8	7.7	2.8	2.2	7.0	7.4
Other Services (Except Public Administration)	5.7	4.6	9.4	8.2	5.8	3.9	9.5	8.1

Source: Shares calculated by the CSLS, based on Statistics Canada data (Cansim Table 383-0011).
*Finance, insurance, real estate, rental and leasing **Administrative and support, waste management and remediation services

III. Labour Productivity

Labour productivity, defined as real GDP per hour worked,[9] grew at an average rate of 2.1 per cent per year in Saskatchewan's market sector during the 1997-2007 period, which was slightly higher than the national average of 1.7 per cent per year. Saskatchewan ranked 3rd among the provinces in terms of labour productivity growth (Chart 1).

Chart 1: Labour Productivity Growth in Canada and the Provinces, Market Sector, 1997-2007
(Average Annual Growth Rates)



Source: CSLS Provincial Productivity Database, Appendix Tables, http://www.csls.ca/data/mfp_new.asp.

During the period in question, the industry that experienced the highest labour productivity growth rate in Saskatchewan was agriculture, forestry, fishing and hunting (4.7 per cent per year), followed by information and cultural industries (4.1 per cent), and retail trade (4.0 per cent) (Table 2). The industry that had the lowest labour productivity growth rate was mining, and oil and gas extraction (-4.7 per cent per year), followed by arts, entertainment and recreation (-3.8 per cent), and manufacturing (0.1 per cent).

In terms of labour productivity growth, the province ranked 8th or below in only three of the 15 two-digit NAICS industries, none of which ranked 10th. Furthermore, it ranked 3rd or above in seven of the 15 two-digit NAICS industries. In particular, Saskatchewan ranked 1st in the following two industries: FIRE, and transportation and warehousing.

[9] Note that the total hours worked figures used to calculate labour productivity are unadjusted for labour quality.

Saskatchewan's labour productivity level in 2007 was $35.38 (1997 dollars) per hour, which represents 98.1 per cent of the Canadian level, up from 94.5 per cent in 1997. The province had the 5th highest labour productivity level in Canada in 2007.

In 2007, only five of the 15 two-digit NAICS industries in Saskatchewan had labour productivity levels above the Canadian average. The industries with the highest relative labour productivity levels in the province were utilities (130.8 per cent of the Canadian level), mining, and oil and gas extraction (120.2 per cent), and transportation and warehousing (119.8 per cent). The industries that had the lowest relative levels in the province were professional, scientific and technical services (83.1 per cent of the Canadian level), agriculture, forestry, fishing and hunting (86.4 per cent), and manufacturing (86.9 per cent).

In terms of labour productivity levels, the province ranked 4th or above in seven of the 15 two-digit NAICS industries. In particular, Saskatchewan's transportation and warehousing, wholesale trade, and other services ranked 1st among all the provinces. The only industry in the province that ranked 10th in terms of labour productivity levels was information and cultural industries.

Table 2: Labour Productivity Levels and Growth Rates in Saskatchewan, 1997-2007

	Compound Annual Growth Rate, 1997-2007	Rank	Province's Labour Productivity Level Relative to Canada's, 1997	Province's Labour Productivity Level Relative to Canada's, 2007	Labour Productivity Level, 2007	Rank, 2007
	(per cent)		(Canada=100)	(Canada=100)	(1997 Dollars)	
Market Sector	**2.1**	**3**	**94.5**	**98.1**	**35.4**	**5**
Agriculture, Forestry, Fishing and Hunting	4.7	5	82.4	86.4	23.5	6
Mining, and Oil and Gas Extraction	-4.7	8	154.6	120.2	94.6	3
Utilities	0.7	2	111.1	130.8	176.1	3
Construction	1.0	8	98.6	92.1	29.4	4
Manufacturing	0.1	9	107.9	86.9	41.6	5
Wholesale Trade	3.9	5	113.8	115.8	48.6	1
Retail Trade	4.0	3	86.0	91.5	20.2	6
Transportation and Warehousing	2.3	1	102.4	119.8	38.1	1
Information and Cultural Industries	4.1	6	78.0	87.1	59.7	10
FIRE*	3.9	1	75.7	95.2	66.9	7
Professional, Scientific and Technical Services	2.0	2	77.7	83.1	22.4	5
ASWMR**	1.7	2	79.4	90.9	18.0	5
Arts, Entertainment and Recreation	-3.8	5	114.5	87.4	14.1	4
Accommodation and Food Services	0.9	6	93.3	91.8	12.6	7
Other Services (Except Public Administration)	3.7	2	97.0	113.6	18.5	1
Absolute Equally-Weighted Average Rank		4.3				4.5
Equally-Weighted Market Sector Rank		**2**				**4**

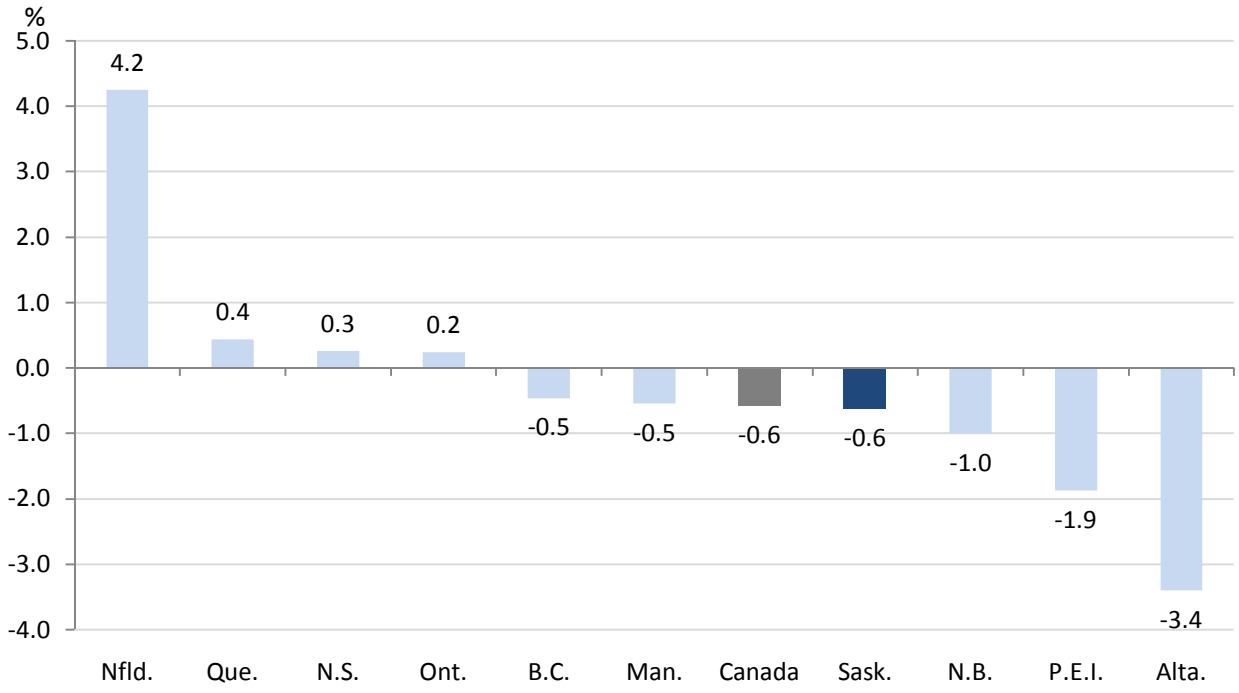
Source: CSLS Provincial Productivity Database, Appendix Tables, http://www.csls.ca/data/mfp_new.asp.
*Finance, insurance, real estate, rental and leasing **Administrative and support, waste management and remediation services

IV. Capital Productivity

Capital productivity, defined as real GDP per unit of capital services, declined at a rate of 0.6 per cent per year in Saskatchewan's market sector during the 1997-2007 period, the same as the national average. Saskatchewan ranked 7th in Canada in terms of capital productivity growth (Chart 2).

In Saskatchewan, six of the 15 two-digit NAICS industries had negative capital productivity growth rates during the period. The industries that experienced the worst performances were professional, scientific and technical services (-9.6 per cent per year), administrative and support, waste management and remediation services (-8.7 per cent), and arts, entertainment and recreation (-8.4 per cent) (Table 3). The industries that had the best performances were other services (8.1 per cent per year), retail trade (3.6 per cent), and wholesale trade (2.7 per cent).

Chart 2: Capital Productivity Growth Rates in Canada and the Provinces, Market Sector, 1997-2007
(Average Annual Growth Rates)



Source: CSLS Provincial Productivity Database, Appendix Tables, http://www.csls.ca/data/mfp_new.asp.

Although the province ranked 7th in Canada in terms of its market sector rank, its equally-weighted market sector rank was significantly higher, at 2nd place, only below Quebec. This indicates that, despite having sub-par capital productivity growth rates during the period in its market sector, most of Saskatchewan's industries performed very well when compared to equivalent industries in other provinces. In fact, nine of the 15 two-digit NAICS industries ranked 4th or above. Moreover, Saskatchewan's other services, retail trade, and transportation and warehousing industries ranked 1st in Canada in terms of capital productivity growth. The only industry that ranked 10th place was administrative and support, waste management and remediation services.

Saskatchewan's capital productivity level in the market sector in 2007 was 72.5 per cent of the Canadian level, slightly down from 72.9 per cent in 1997. Only four of the 15 two-digit NAICS industries in the province had capital productivity levels above the Canadian average: retail trade (157.3 per cent of the Canadian level), other services (137.1 per cent), FIRE (107.9 per cent), and utilities (100.9 per cent). The industries with the lowest capital productivity levels in the province were arts, entertainment and recreation (41.2 per cent of the Canadian level), administrative and support, waste management and remediation services (55.7 per cent), and agriculture, forestry, fishing and hunting (68.3 per cent).

Saskatchewan's market sector had the 9th lowest capital productivity level in Canada in 2007, only above Alberta. This reflects the low overall capital productivity levels in the province, which ranked 7th or below in eight of the 15 two-digit NAICS industries. In particular, Saskatchewan ranked 10th place in the following three industries: arts, entertainment and recreation, accommodation and food services, and agriculture, forestry, fishing and hunting. The main exception to the overall low capital productivity levels at the industry level was the retail trade industry, which ranked 1st in Canada.

Table 3: Capital Productivity Levels and Growth Rates in Saskatchewan, 1997-2007

	Compound Annual Growth Rate, 1997-2007	Rank	Province's Capital Productivity Level Relative to Canada's, 1997	Province's Capital Productivity Level Relative to Canada's, 2007	Capital Productivity Level, 2007	Rank, 2007
	(per cent)		(Canada=100)	(Canada=100)	(1997 Dollars)	
Market Sector	**-0.6**	**7**	**72.9**	**72.5**	**1.67**	**9**
Agriculture, Forestry, Fishing and Hunting	1.7	6	70.4	68.3	1.43	10
Mining, and Oil and Gas Extraction	-5.0	7	85.4	91.8	0.71	8
Utilities	0.4	4	96.9	100.9	1.30	5
Construction	2.1	2	67.3	71.9	4.91	7
Manufacturing	2.0	3	84.9	88.0	2.40	7
Wholesale Trade	2.7	2	64.9	86.1	2.74	6
Retail Trade	3.6	1	99.9	157.3	7.20	1
Transportation and Warehousing	1.9	1	66.4	97.5	2.35	8
Information and Cultural Industries	-1.4	9	121.3	99.9	1.92	5
FIRE*	-0.3	2	101.6	107.9	1.77	2
Professional, Scientific and Technical Services	-9.6	8	98.7	72.2	1.77	7
ASWMR**	-8.7	10	104.5	55.7	1.72	10
Arts, Entertainment and Recreation	-8.4	9	62.6	41.2	0.85	10
Accommodation and Food Services	0.1	3	79.3	83.4	3.59	6
Other Services (Except Public Administration)	8.1	1	57.9	137.1	7.30	2
Absolute Equally-Weighted Average Rank		4.5				6.3
Equally-Weighted Market Sector Rank		**2**				**9**

Source: CSLS Provincial Productivity Database, Appendix Tables, http://www.csls.ca/data/mfp_new.asp.
*Finance, insurance, real estate, rental and leasing **Administrative and support, waste management and remediation services

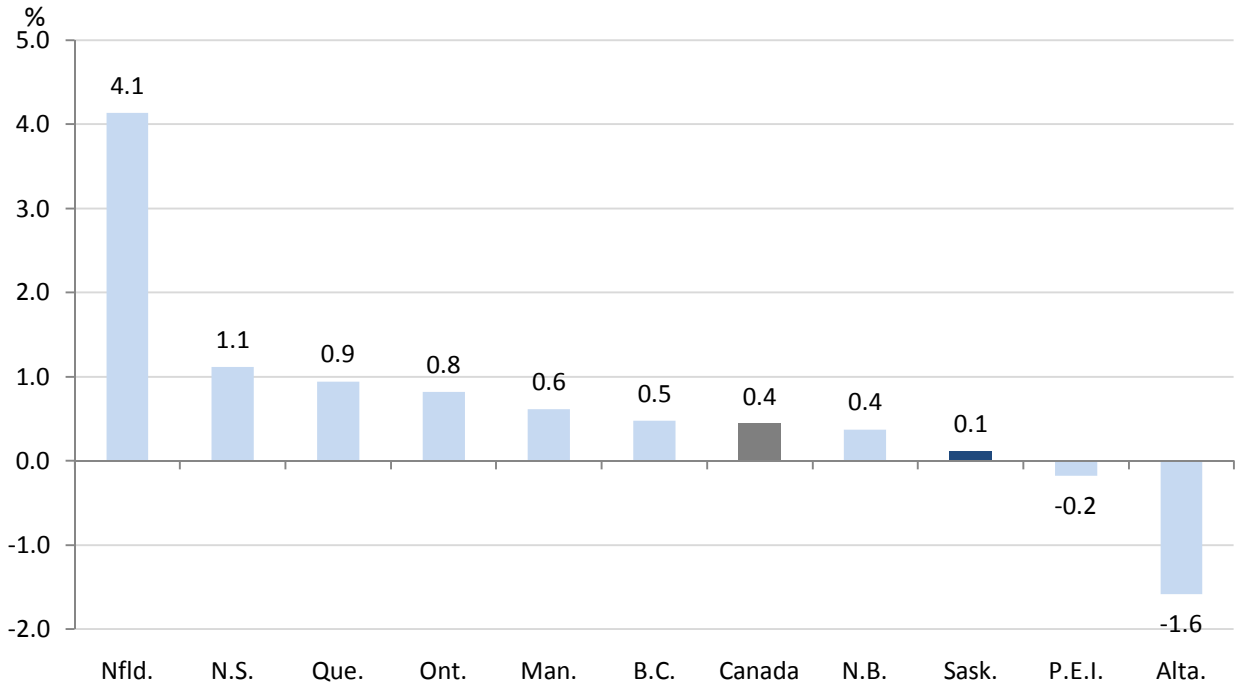
V. Multifactor Productivity

Saskatchewan's multifactor productivity in the market sector grew at an average rate of 0.1 per cent per year during the 1997-2007 period, only one-fourth of the national average, which grew at an average annual rate of 0.4 per cent. The province ranked 8th in Canada in terms of multifactor productivity growth (Chart 4).

The industry that experienced the highest multifactor productivity growth rate in Saskatchewan was other services (4.4 per cent per year), followed by retail trade (4.0 per cent), and wholesale trade (3.1 per cent). The industries that had the lowest multifactor productivity growth rates were mining, and oil and gas extraction (-4.9 per cent per year), arts, entertainment and recreation (-4.5 per cent), and administrative and support, waste management and remediation services (-1.6 per cent).

Although the province ranked 8th in Canada in terms of its market sector rank, its equally-weighted market sector rank was significantly higher, at 2nd place, only below Quebec. Of the 15 two-digit NAICS industries, only four were ranked at 7th place or lower, and none of those ranked 10th. Transportation and warehousing, FIRE, and other services ranked 1st in Canada.

Chart 3: Multifactor Productivity Growth in Canada and the Provinces, Market Sector, 1997-2007
(Average Annual Growth Rates)



Source: CSLS Provincial Productivity Database, Appendix Tables, http://www.csls.ca/data/mfp_new.asp.

The province's multifactor productivity level was 82.1 per cent of the Canadian level in 2007, down from 84.8 per cent in 1997. Consistent with this low level at the market sector, at the industry level only six of the 15 two-digit NAICS industries in Saskatchewan had multifactor productivity level above Canada's. The industries with the highest multifactor productivity levels in the province were other services (119.6

per cent of the Canadian level), transportation and warehousing (109.3 per cent), retail trade (108.5 per cent). In contrast, the industries with the lowest multifactor productivity levels in the province were arts, entertainment and recreation (72.2 per cent of the Canadian level), agriculture, forestry, fishing and hunting (76.3 per cent), and administrative and support, waste management and remediation services (78.1 per cent).

In terms of multifactor productivity levels, Saskatchewan's market sector ranked 8th in Canada in 2007 (the province ranked 5th according to its equally-weighted market sector ranking). At the industry level, six of the 15 two-digit NAICS industries ranked 4th or above. In particular, Saskatchewan's other services industry ranked 1st in Canada. The only industry that ranked 10th place in the province was agriculture, forestry, fishing and hunting.

Table 4: Multifactor Productivity Levels and Growth Rates in Saskatchewan, 1997-2007

	Compound Annual Growth Rate, 1997-2007	Rank	Province's Multifactor Productivity Level Relative to Canada's, 1997	Province's Multifactor Productivity Level Relative to Canada's, 2007	Rank, 2007
	(per cent)		(Canada=100)	(Canada=100)	
Market Sector	**0.1**	**8**	**84.8**	**82.1**	**8**
Agriculture, Forestry, Fishing and Hunting	2.4	7	77.4	76.3	10
Mining, and Oil and Gas Extraction	-4.9	7	96.2	95.0	8
Utilities	0.5	3	100.0	107.8	3
Construction	1.7	3	85.6	86.1	6
Manufacturing	1.0	6	96.0	88.7	5
Wholesale Trade	3.1	3	92.5	100.7	4
Retail Trade	4.0	2	90.4	108.5	3
Transportation and Warehousing	1.9	1	86.2	109.3	2
Information and Cultural Industries	1.4	7	94.6	93.8	9
FIRE*	1.4	1	88.3	101.5	3
Professional, Scientific and Technical Services	-0.8	5	82.4	81.6	6
ASWMR**	-1.6	8	88.2	78.1	8
Arts, Entertainment and Recreation	-4.5	6	93.2	72.2	7
Accommodation and Food Services	0.5	6	90.3	89.5	7
Other Services (Except Public Administration)	4.4	1	87.4	119.6	1
Absolute Equally-Weighted Average Rank		4.4			5.5
Equally-Weighted Market Sector Rank		**2**			**5**

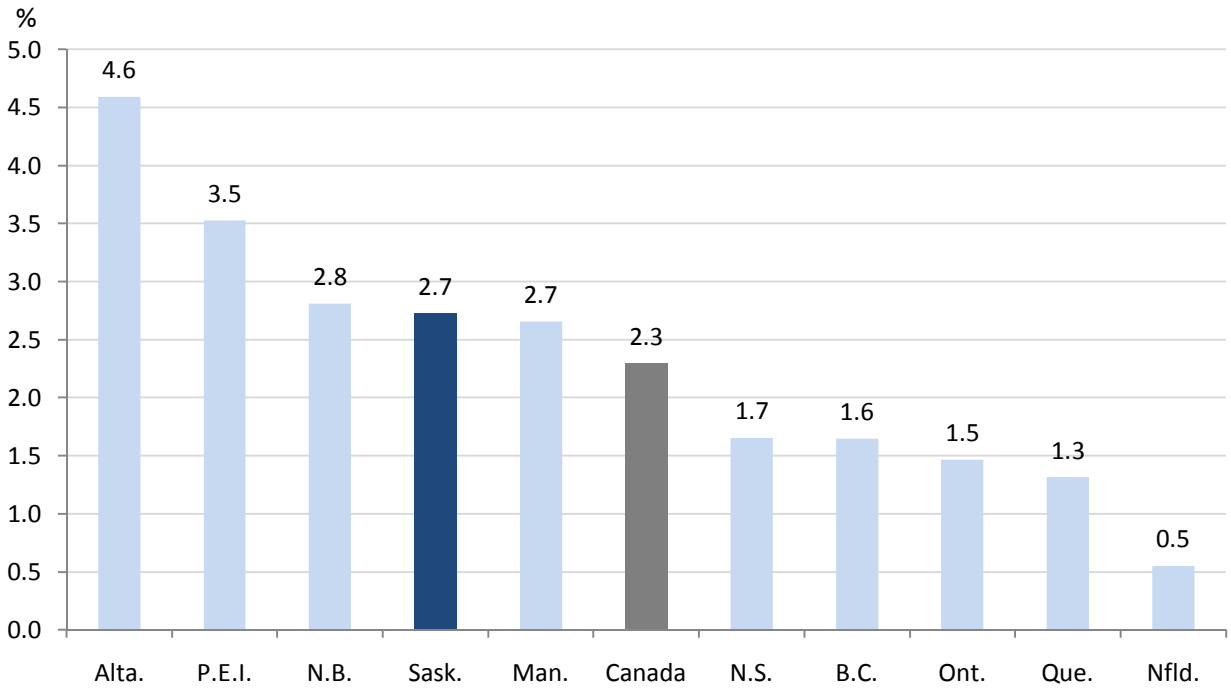
Source: CSLS Provincial Productivity Database, Appendix Tables, http://www.csls.ca/data/mfp_new.asp.

*Finance, insurance, real estate, rental and leasing **Administrative and support, waste management and remediation services

VI. Capital Intensity

Capital intensity, defined as capital services per hour worked (unadjusted for labour quality), grew at an average rate of 2.7 per cent per year in Saskatchewan's market sector during the 1997-2007 period, above the national average of 2.3 per cent per year. The province ranked 4th among the ten provinces in terms of capital intensity growth (Chart 4).

Chart 4: Capital Intensity Growth in Canada and the Provinces, Market Sector, 1997-2007
(Average Annual Growth Rates)



Source: CSLS Provincial Productivity Database, Appendix Tables, http://www.csls.ca/data/mfp_new.asp.

During the period, the industries that experienced the highest capital intensity growth rates in the province were professional, scientific and technical services (12.9 per cent per year), administrative and support, waste management and remediation services (11.4 per cent), and arts, entertainment and recreation (5.0 per cent). Conversely, the industries that had the lowest growth rates in the province were other services (-4.0 per cent per year), manufacturing (-1.9 per cent), and construction (-1.0 per cent).

As mentioned before, Saskatchewan's market sector ranked 4th in terms of capital intensity growth. However, the province ranked 9th according to its equally-weighted rank. This divergence between the two rankings indicates that despite having above average growth rates in its market sector, most of Saskatchewan's industries experienced low capital intensity growth relative to the other provinces during the 1997-2007 period. At the industry level, eight of the 15 two-digit NAICS industries ranked 7th or below. In particular, other services, retail trade, and transportation and warehousing ranked 10th place. Administrative and support, waste management and remediation services was the only industry in the province that ranked 1st in terms of capital intensity growth.

Table 5: Capital Intensity Levels and Growth Rates in Saskatchewan, 1997-2007

	Compound Annual Growth Rate, 1997-2007	Rank	Province's Capital Intensity Level Relative to Canada's, 1997	Province's Capital Intensity Level Relative to Canada's, 2007	Capital Intensity Level, 2007	Rank, 2007
	(per cent)		(Canada=100)	(Canada=100)	(1997 Dollars)	
Market Sector	**2.7**	**4**	**129.7**	**135.3**	**21.2**	**2**
Agriculture, Forestry, Fishing and Hunting	2.9	5	117.2	126.5	16.4	1
Mining, and Oil and Gas Extraction	0.4	7	180.7	131.0	133.2	2
Utilities	0.3	5	114.7	129.6	135.3	4
Construction	-1.0	7	146.2	128.1	6.0	2
Manufacturing	-1.9	9	126.8	98.7	17.3	4
Wholesale Trade	1.2	9	174.8	134.5	17.8	1
Retail Trade	0.3	10	86.3	58.1	2.8	10
Transportation and Warehousing	0.4	10	153.7	122.9	16.2	2
Information and Cultural Industries	5.6	3	65.2	88.4	31.5	8
FIRE*	4.2	4	74.4	88.2	37.8	10
Professional, Scientific and Technical Services	12.9	3	78.4	115.0	12.7	5
ASWMR**	11.4	1	76.2	163.2	10.5	2
Arts, Entertainment and Recreation	5.0	4	182.4	212.4	16.7	1
Accommodation and Food Services	0.8	9	117.7	110.1	3.5	3
Other Services (Except Public Administration)	-4.0	10	167.0	82.8	2.5	7
Absolute Equally-Weighted Average Rank		6.4				4.1
Equally-Weighted Market Sector Rank		**9**				**2**

Source: CSLS Provincial Productivity Database, Appendix Tables, http://www.csls.ca/data/mfp_new.asp.
*Finance, insurance, real estate, rental and leasing **Administrative and support, waste management and remediation services

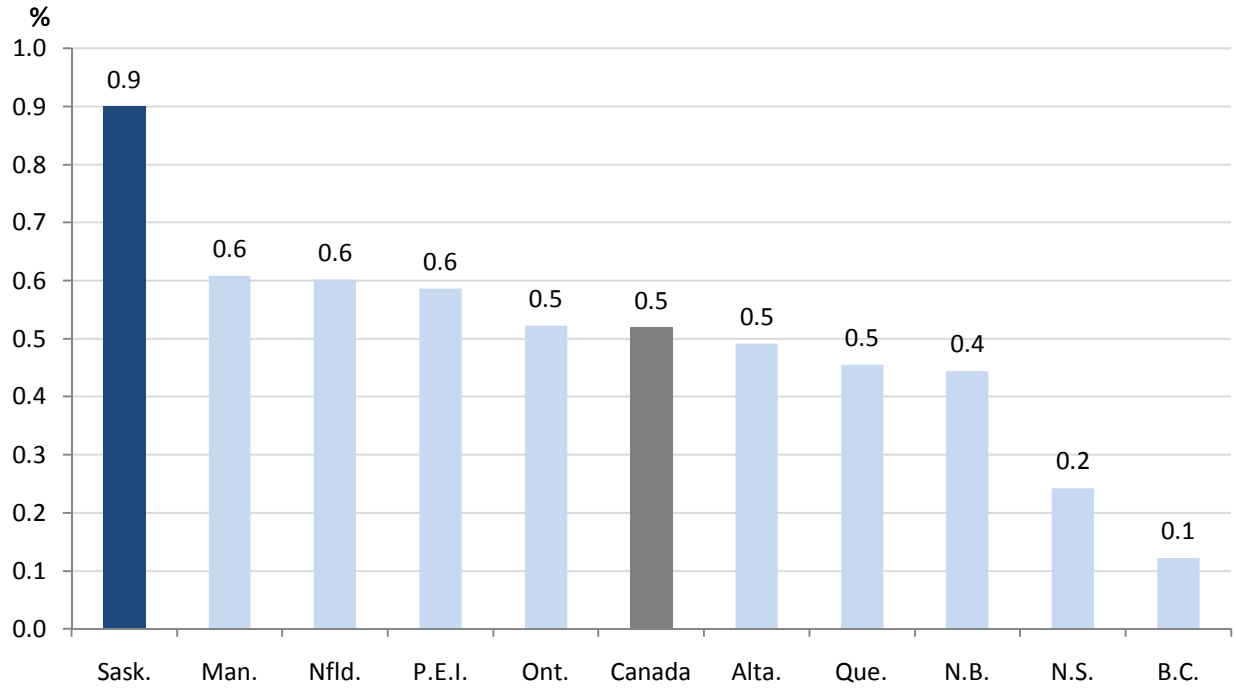
Saskatchewan's capital intensity level was 135.3 per cent of the Canadian level in 2007, up from 129.7 per cent in 1997. Of the 15 two-digit NAICS industries, 10 had levels above the national average in 2007. The industries with the highest capital intensity levels in the province were arts, entertainment and recreation (212.4 per cent of the Canadian level), administrative and support, waste management and remediation services (163.2 per cent), and wholesale trade (134.5 per cent).

In terms of capital intensity levels, Saskatchewan's market sector ranked 2nd in Canada in 2007 (the province also ranked 2nd according to the equally-weighted market sector ranking). 10 of the 15 two-digit NAICS industries in the province ranked 4th or above, with arts, entertainment and recreation, wholesale trade, and agriculture, forestry, fishing and hunting ranking 1st in Canada. The only two industries that ranked 10th place in terms of capital intensity levels were retail trade, and FIRE.

VII. Labour Quality

Saskatchewan's labour quality grew at an average rate of 0.9 per cent per year during the 1997-2007 period, above the national average, which grew at an average annual rate of 0.5 per cent. The province ranked 1st in Canada in terms of labour quality growth (Chart 5).

Chart 5: Labour Quality Growth in Canada and the Provinces, Market Sector, 1997-2007
(Average Annual Growth Rates)



Source: CSLS Provincial Productivity Database, Appendix Tables, http://www.csls.ca/data/mfp_new.asp.

During the period in question, the industries that experienced the highest labour quality growth rates in the province were professional, scientific and technical services, FIRE, and transportation and warehousing (all of which grew at 0.5 per cent per year). The industries that had the lowest labour quality growth rates were retail trade (-0.2 per cent per year), and construction (-0.1 per cent).

Despite ranking 1st according to its market sector rank, Saskatchewan ranked 6th in terms of its equally-weighted market sector rank. This difference between the two ranking s can be understood by noticing that a significant number of industries in Saskatchewan had average performances in terms of labour quality growth. Indeed, looking at the industry level, none of Saskatchewan's industries ranked 1st place in Canada, only construction ranked 10th place, and seven industries ranked between 4th and 6th place. In addition to the two divergent rankings, the fact that Saskatchewan's labour quality growth in the market sector was significantly higher than the growth experienced by any single industry in the province seems to indicate that changes in industry composition were the main driver behind the province's substantive labour quality growth.

Table 6: Labour Quality Levels and Growth Rates in Saskatchewan, 1997-2007[10]

	Compound Annual Growth Rate, 1997-2007	Rank
	(per cent)	
Market Sector	**0.9**	**1**
Agriculture, Forestry, Fishing and Hunting	0.1	8
Mining, and Oil and Gas Extraction	0.1	3
Utilities	0.1	6
Construction	-0.1	10
Manufacturing	0.1	8
Wholesale Trade	0.3	4
Retail Trade	-0.2	9
Transportation and Warehousing	0.5	6
Information and Cultural Industries	0.3	7
FIRE*	0.5	3
Professional, Scientific and Technical Services	0.5	4
ASWMR**	0.3	6
Arts, Entertainment and Recreation	0.1	6
Accommodation and Food Services	0.3	3
Other Services (Except Public Administration)	0.4	4
Absolute Equally-Weighted Average Rank		5.8
Equally-Weighted Market Sector Rank		**6**

Source: CSLS Provincial Productivity Database, Appendix Tables, http://www.csls.ca/data/mfp_new.asp.
*Finance, insurance, real estate, rental and leasing **Administrative and support, waste management and remediation services

[10] Labour quality levels are not shown here because they are assumed to be the same (and equal to 100.0) across all provinces and in Canada in the base year, 1997 (Sharpe and Thomson, 2010a). They differ after 1997, incorporating the different labour quality growth rates experienced by the provinces and Canada. For example, labour quality in Saskatchewan's market sector grew at an average annual rate of 0.9 per cent over the 1997-2007 period, while Canada's labour quality grew at an average annual rate of 0.5 per cent. As a consequence, Saskatchewan's labour quality level was 103.8 per cent of the Canadian level in 2007.

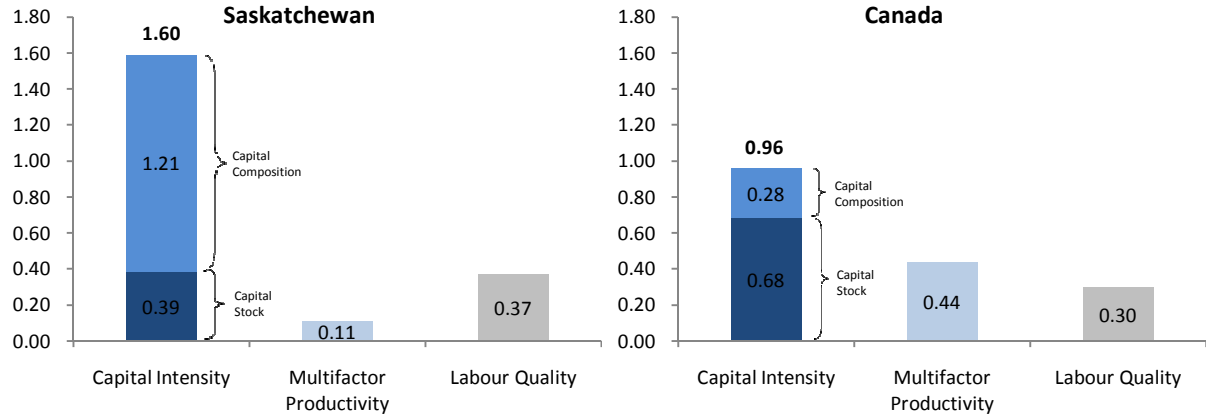
VIII. Sources of Labour Productivity Growth in the Market Sector

Saskatchewan's labour productivity grew at an average rate of 2.1 per cent per year during the 1997-2007 period, slightly higher than the national average, which grew at an average annual rate of 1.7 per cent. Charts 6 and 7 show both the percentage point and per cent contributions to labour productivity growth by the sources of growth for Saskatchewan and Canada over the 1997-2007 period.

Saskatchewan's labour productivity growth was driven mainly by capital intensity, which accounted for 1.60 percentage points of the overall labour productivity growth (or, alternatively, 76.2 per cent of total growth). The contribution of capital intensity to labour productivity growth can be broken down into two components: capital composition growth, which was responsible for 1.21 percentage points of labour productivity growth (57.7 per cent), and capital stock growth, which accounted for 0.39 percentage points of the latter (18.5 per cent).

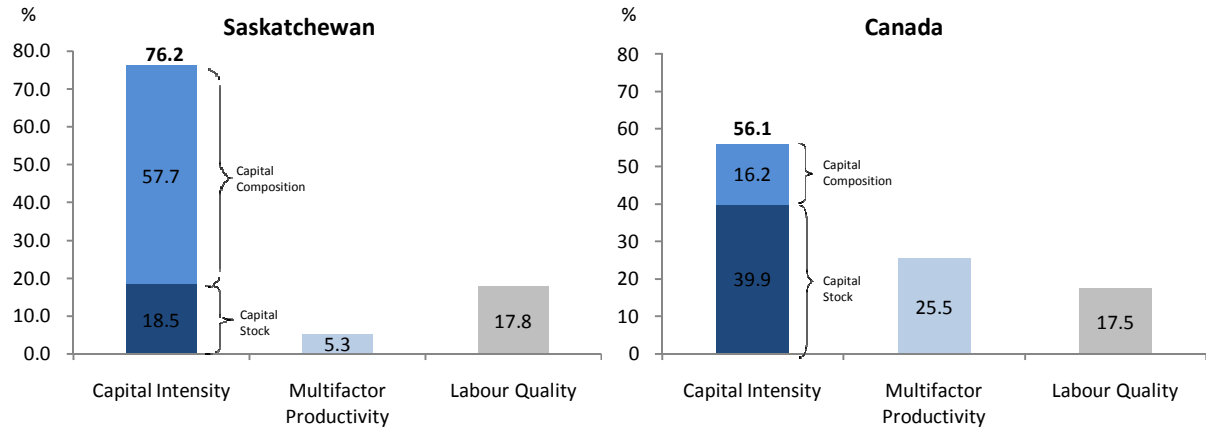
Comparing the two charts, it can be seen that labour quality had approximately the same relative contribution to labour productivity growth in Saskatchewan and in Canada (albeit slightly higher in Saskatchewan). The main difference between the two was in the role of multifactor productivity and capital intensity. Whereas multifactor productivity explained 25.5 per cent of labour productivity growth in Canada, it explained only 5.3 per cent of Saskatchewan's labour productivity growth. Conversely, capital intensity explained only 56.1 per cent of labour productivity growth in Canada, but 76.2 per cent in Saskatchewan.

Chart 6: Percentage Point Contribution to Labour Productivity Growth by the Source of Labour Productivity Growth in the Market Sector in Saskatchewan and in Canada, 1997 to 2007



Source: CSLS Provincial Productivity Database, Appendix Table 17, http://www.csls.ca/data/mfp_new.asp.

Chart 7: Per Cent Contribution to Labour Productivity Growth by the Source of Labour Productivity Growth in the Market Sector in Saskatchewan and in Canada, 1997 to 2007



Source: CSLS Provincial Productivity Database, Appendix Table 17, http://www.csls.ca/data/mfp_new.asp.
Note: Numbers may not sum to 100 due to rounding.

Table 7 details the contributions in absolute and per cent terms of capital intensity, MFP, and labour quality growth to labour productivity growth in Saskatchewan over the 1997-2007 period at the two-digit NAICS industry level.

Table 7: Contributions to Labour Productivity Growth at the Industry Level by Source in Saskatchewan, 1997-2007

	Labour Productivity	Capital Intensity			MFP	Labour Quality
		Total	Capital Composition	Capital Stock		
	Percentage Point Contributions to Labour Productivity Growth					
Market Sector	**2.1**	**1.6**	**1.2**	**0.4**	**0.1**	**0.4**
Agriculture, Forestry, Fishing and Hunting	4.7	2.3	0.1	2.2	2.4	0.0
Mining, and Oil and Gas Extraction	-4.7	0.2	0.0	0.2	-4.9	0.0
Utilities	0.7	0.2	0.0	0.1	0.5	0.0
Construction	1.0	-0.6	-0.2	-0.3	1.7	-0.1
Manufacturing	0.1	-1.0	-5.4	4.4	1.0	0.1
Wholesale Trade	3.9	0.6	0.2	0.4	3.1	0.1
Retail Trade	4.0	0.1	0.0	0.2		-0.1
Transportation and Warehousing	2.3	0.1	0.1	0.0	1.9	0.2
Information and Cultural Industries	4.1	2.6	1.4	1.2	1.4	0.2
FIRE*	3.9	2.2	1.2	1.0	1.4	0.2
Professional, Scientific and Technical Services	2.0	2.4	0.2	2.2	-0.8	0.4
ASWMR**	1.7	3.2			-1.6	0.2
Arts, Entertainment and Recreation	-3.8	0.7			-4.5	0.0
Accommodation and Food Services	0.9	0.2	0.0	0.2	0.5	0.2
Other Services (Except Public Administration)	3.7	-0.9	0.6	-1.5	4.4	0.3
		Per Cent Contributions to Labour Productivity Growth				
Market Sector	**100.0**	**76.5**	**57.7**	**18.5**	**5.3**	**17.8**
Agriculture, Forestry, Fishing and Hunting	100.0	48.6	1.5	47.2	50.2	0.0
Mining, and Oil and Gas Extraction	100.0	-5.3	-0.4	-4.9	105.7	-0.7
Utilities	100.0	25.1	6.4	18.7	72.2	2.5
Construction	100.0	-55.0	-22.4	-32.5	165.8	-9.7
Manufacturing	100.0	-1658.2	-9215.2	7540.4	1670.2	104.3
Wholesale Trade	100.0	15.7	5.7	10.0	80.4	3.2
Retail Trade	100.0	3.2	-1.0	4.2		-3.7
Transportation and Warehousing	100.0	6.1	4.9	1.3	83.1	10.4
Information and Cultural Industries	100.0	61.7	33.0	27.9	33.4	3.9
FIRE*	100.0	57.5	30.9	26.1	35.7	5.7
Professional, Scientific and Technical Services	100.0	119.7	9.2	109.5	-39.6	20.5
ASWMR**	100.0	187.5			-95.7	11.1
Arts, Entertainment and Recreation	100.0	-17.9			117.9	-0.8
Accommodation and Food Services	100.0	21.6	-4.4	26.1	58.3	19.8
Other Services (Except Public Administration)	100.0	-25.1	15.7	-39.9	118.5	7.5

Source: CSLS Provincial Productivity Database, Appendix Tables, http://www.csls.ca/data/mfp_new.asp.
Note: Per cent contributions may not sum to 100 due to rounding.
*Finance, insurance, real estate, rental and leasing **Administrative and support, waste management and remediation services

IX. Sources of Labour Productivity Level Gap by Industry

Saskatchewan's labour productivity level was 98.1 per cent of the Canadian level in 2007, which implies a labour productivity gap of 1.9 percentage points. Table 8 makes it clear that this gap was caused by the market sector's below average multifactor productivity level, which was responsible for 19.6 percentage points of the gap. The above average levels of capital intensity and labour quality were able to offset a significant part of the gap, 15.9 and 1.8 percentage points, respectively.[11]

Saskatchewan had a labour productivity gap in 10 of the 15 two-digit NAICS industries. In most cases, the below average multifactor productivity level was the main culprit. The main exceptions were retail trade, and FIRE, where the below average capital intensity levels were responsible for the gaps.

Table 8: Sources of the Labour Productivity Gap Relative to Canada for Saskatchewan at the Two-Digit Industry Level, 2007

			Percentage Point Contributions to Labour Productivity Gap			Percent Contributions to Labour Productivity Gap			
	Labour Productivity Relative Level	Labour Productivity Gap	Capital Intensity	Multifactor Productivity	Labour Quality	Labour Productivity	Capital Intensity	Multifactor Productivity	Labour Quality
Market Sector	**98.1**	**-1.9**	**15.9**	**-19.6**	**1.8**	**100.0**	**-844.5**	**1,037.4**	**-93.0**
Agriculture, Forestry, Fishing and Hunting	86.4	-13.6	14.3	-25.2	-2.7	100.0	-105.3	185.7	19.7
Mining, and Oil and Gas Extraction	120.2	20.2	25.7	-5.6	0.1	100.0	127.1	-27.8	0.7
Utilities	130.8	30.8	22.4	8.6	-0.2	100.0	72.6	28.0	-0.6
Construction	92.1	-7.9	8.0	-14.3	-1.6	100.0	-100.6	180.6	20.0
Manufacturing	86.9	-13.1	-0.5	-11.1	-1.4	100.0	4.1	85.3	10.7
Wholesale Trade	115.8	15.8	15.2	0.8	-0.2	100.0	96.1	4.8	-1.0
Retail Trade	91.5	-8.5	-14.2	7.8	-2.2	100.0	165.6	-91.2	25.6
Transportation and Warehousing	119.8	19.8	9.7	9.8	0.3	100.0	49.0	49.3	1.7
Information and Cultural Industries	87.1	-12.9	-5.7	-5.9	-1.3	100.0	44.4	46.0	9.7
FIRE*	95.2	-4.8	-6.6	1.4	0.3	100.0	135.6	-29.5	-6.0
Professional, Scientific and Technical Services	83.1	-16.9	2.5	-18.6	-0.9	100.0	-15.0	109.8	5.2
ASWMR**	90.9	-9.1	12.7	-23.5	1.7	100.0	-138.7	257.3	-18.7
Arts, Entertainment and Recreation	87.4	-12.6	16.9	-30.5	1.0	100.0	-134.7	243.0	-8.3
Accommodation and Food Services	91.8	-8.2	2.2	-10.7	0.3	100.0	-27.0	130.7	-3.6
Other Services (Except Public Administration)	113.6	13.6	-5.3	19.1	-0.3	100.0	-38.7	140.8	-2.1

Source: CSLS Provincial Productivity Database, Appendix Tables, http://www.csls.ca/data/mfp_new.asp.
*Finance, insurance, real estate, rental and leasing **Administrative and support, waste management and remediation services

[11] Again, it is important to bear in mind that labour quality levels were assumed to be equal to 100.0 in all provinces and in Canada for the base year of 1997. They differ after 1997, incorporating the different labour quality growth rates experienced by the provinces and Canada.

X. Conclusion

During the 1997-2007 period, Saskatchewan's average annual labour productivity growth rate was higher than the national average (2.1 per cent vs. 1.7 per cent). In contrast, the province's multifactor productivity growth was only one-fourth of the national average (0.1 per cent per year vs. 0.4 per cent per year), while its capital productivity growth rate was the same as the national average (-0.6 per cent).

Saskatchewan's labour, capital, and multifactor productivity levels were below the national levels in 2007. The province's labour productivity level, in particular, was only 98.1 per cent of the Canadian level, which implies a labour productivity gap of 1.9 percentage points. This gap was caused by the below average multifactor productivity level in the province's market sector.

Table 9 provides a summary of both levels (in 1997 and 2007) and growth rates (for the 1997-2007 period) for the productivity measures discussed in this report, along with rankings that show how Saskatchewan fared in comparison to the other provinces. A key observation is that, despite lagging multifactor productivity growth, the province's labour productivity was able to grow more than the national average because of its strong capital intensity growth, which explains 76.2 per cent of the labour productivity growth experienced over the period.

Table 9: Summary of Saskatchewan's Productivity Performance in the Market Sector

	Market Sector Growth, 1997 to 2007			Per Cent of the Canadian Level		Level Rankings, 2007	
	Compound Annual Growth Rate	Market Sector Rank	Equally-Weighted Market Sector Rank	1997	2007	Market Sector Rank	Equally-Weighted Market Sector Rank
Labour Productivity	2.1	3	2	94.5	98.1	5	4
Capital Productivity	-0.6	7	2	72.9	72.5	9	9
Multifactor Productivity	0.1	8	2	84.8	82.1	8	5
Capital Intensity	2.7	4	9	129.7	135.3	2	2
Labour Quality	0.9	1	6				

Source: CSLS Provincial Productivity Database, Appendix Tables, http://www.csls.ca/data/mfp_new.asp.

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Appendix – A Growth Accounting Framework

The growth accounting framework used in this report assumes a Cobb-Douglas production function such that

$$Y = AK^{\alpha}L^{1-\alpha} \tag{1}$$

where *Y* is real output, *K* stands for capital services, *L* for labour input (quality adjusted hours), *A* for multifactor productivity and α is the share of output that takes the form of capital compensation. The labour input *L* can be decomposed into hours (*H*) and labour quality (*QL*):

$$L = H * QL \tag{2}$$

Capital services can be decomposed into capital stock (*SK*) and capital composition (*QK*):

$$K = SK * QK \tag{3}$$

Capital intensity (*KI*) is defined as:

$$KI = \frac{K}{H} \tag{4}$$

Using (1), (2), and (4), the components of labour productivity *growth* can be decomposed as follows:

$$\Delta LP = \Delta Y - \Delta H = [\Delta QL * (1-\alpha)] + [\Delta KI * \alpha] + \Delta A \tag{5}$$

where *LP* stands for labour productivity and Δ is the percentage change. This equation was used in section eight.

The province's MFP levels relative to the Canadian levels (*Relative MFP*$_{p,i}$) were calculated using the equation below:

$$\ln\left(Relative\ MFP_{p,i}\right) = \ln\left(\frac{A_{p,i}}{A_{c,i}}\right) = \ln\left(\frac{Y_{p,i}}{Y_{c,i}}\right) - k_{p,c} * \ln\left(\frac{K_{P,i}}{K_{c,i}}\right) - \left(1-k_{p,c}\right) * \ln\left(\frac{L_{p,i}}{L_{c,i}}\right) \tag{6}$$

where $k_{p,c}$ is the average share of capital input between Canada and the province, and the subscripts *c, p* and *i* stand for Canada, province and industry, respectively.

Finally, the contributions to the relative labour productivity levels between the province and Canada (*Relative LP*$_{p,i}$) can be found using the following formula:

$$\ln\left(Relative\ LP_{p,i}\right) = \ln\left(\frac{A_{p,i}}{A_{c,i}}\right) + k_{p,c} * \ln\left(\frac{KI_{P,i}}{KI_{c,i}}\right) + \left(1-k_{p,c}\right) * \ln\left(\frac{QL_{p,i}}{QL_{c,i}}\right) \tag{7}$$

This equation was used in section nine. For a detailed discussion about the growth accounting framework used here, refer to Sharpe and Thomson (2010a).