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COMMENTARY

Economic Growth And Innovation

Lagging Behind:
Productivity and the Good Fortune of Canadian Provinces

Serge Coulombe

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In this issue...

When it comes to improving labour productivity, which is key to rising incomes, Canada's provinces are divided into winners and losers.

The Study in Brief

The Author of This Issue

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Rigorous external review of every major policy study, undertaken by academics and outside experts, helps ensure the quality, integrity and objectivity of the Institute's research.

The good fortune of bountiful natural resources is not enough to ensure rising incomes for Canadians in the long term. Growing labour productivity is the most important determinant of future economic welfare and on that measure, Canada is falling behind its major trading partners.

Increasing labour productivity does not mean workers working harder for less money, a common canard. It means more investment in one of three factors: 1) human capital (education or other learning); 2) physical capital (plants or other infrastructure); or 3) technology. This *Commentary* will show which provinces, in the last 25 years, have advanced the furthest in these components of labour productivity growth, and why. This *Commentary* finds that:

- The fastest productivity growth during the period occurred in Newfoundland and Labrador – because of improvements in education and better use of technology by shifting from low-yield fishing to high-yield oil production – followed by Saskatchewan and Ontario; and
- The slowest productivity growth was observed in British Columbia – mainly because of anemic physical capital accumulation – followed by New Brunswick.

Canadian policymakers can apply these lessons to two particular areas:

- Improving national research and development policy for the economy as a whole, while allowing provinces to apply research and development policy to province-specific issues in the natural resource sector; and
- For resource-boom provinces, saving non-renewable resource revenues in "rainy-day" funds is crucial. Provinces that benefit from high resource prices now should save and invest these revenues in ways that boost future growth, such as investments in education and productive physical capital.

Just as an individual's income is in the long-run dependent on how productive he or she is, so too is that of the nation as a whole. If Canada fails to improve its productivity, the incomes of both individual Canadians and the nation as a whole will fall behind those of other developed countries.

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Canada's natural resources have brought Canadians good fortune and economic bounty over the last few decades. However, such good fortune cannot last forever. In the long run, the most important determinant of national income is labour productivity growth, and on that score Canada has some catching up to do – Canada's labour productivity growth has been sorely lagging that of major trading partners in Europe and the United States.

How can this trend be reversed? Labour productivity growth can increase due to more investment in three factors: 1) human capital (education or other learning); 2) physical capital (plants or other infrastructure); or 3) technology, as measured here by multifactor productivity (MFP). Commonly used by economists, MFP is the technology component of productivity growth and is computed residually; that is, MFP is the productivity growth remaining after subtracting the effect of capital accumulation (both human and physical capital) from labour productivity growth. This *Commentary* will show which provinces, in the last 25 years, have advanced the furthest in each of these three measures and why.[1] Just as an individual's income is in the long-run dependent on how productive he or she is, so too is that of the nation as a whole. If Canada fails to improve its productivity, the incomes of both individual Canadians and the nation as a whole will fall behind those of other developed countries.

For each province, I measure growth in education levels and physical investment, and attribute the remaining growth to MFP – investment in technology and other efficiencies. The record of each province on these measures helps explain its overall performance in improving labour productivity, and has policy implications for resource-rich provinces seeking to ensure the long-term sustainability of their economies.

Highlights of the provinces' track records on improving labour productivity over the past 25 years include:

- Overall, labour productivity growth for Canadian provinces over the period is very low from an international perspective; behind the average of the United States and the Euro 15 area.
- The fastest productivity growth during the period occurred in Newfoundland and Labrador, followed by Saskatchewan and Ontario. The slowest productivity growth was observed in British Columbia, followed by New Brunswick.
- Newfoundland and Labrador has seen the largest improvement in its productivity because of 1) moving from a low-productivity natural resource – fish – to a higher-productivity natural resource – oil – and 2) recording the largest improvement in human capital.
- British Columbia clearly lags behind the other provinces in productivity growth, mainly because of anemic physical capital accumulation.
- In contrast to Newfoundland and Labrador, Alberta has had among the lowest growth rates for human capital and labour productivity, reflecting a growing reliance on extracting resources from the oil sands, which requires more labour and capital per dollar of output than did past oil and gas reserves.

Another question addressed is whether policies aimed at improving labour productivity are best implemented at the federal or provincial level. I

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1 A substantial literature has been published over the last 10 years on the Canada-US productivity gap. Contrary to this paper, the earlier analyses focus on aggregate productivity data, or industry-level data, for both countries. In a nutshell, it appears that the Canada-US productivity gap (in favour of the United States) is mainly accounted for by differences in multifactor productivity. For a recent study, and hints to earlier studies, refer to Tang, Rao and Li (2010). For a recent study of productivity growth by industry and provinces over the 1997-2007 period, refer to Sharpe and Thomson (2010).

find that for the broad economy, excluding resources, it appears that technology-led growth has mainly reflected national policies and external shocks such as currency movements. This suggests that national public policy is relatively more important than provincial policy in stimulating productivity growth from technology in the broad economy. However, when it comes to the resource sector, provincial policies aimed at encouraging research and development (R&D) in the sector appear to have stronger impact than similar national policies.

One of the key points of this analysis is that I separate the natural resource sector from the rest of the economy (manufacturing and services). There are three good reasons for this. First, Canada is a large country with a small population and is richly endowed in natural resources. Second, Canadian provinces are very heterogeneous with regard to their endowments of natural resources. Finally, good fortune is a more important driver of success in the natural resource sector than in the rest of the economy.

I distinguish between improved productivity and good fortune as drivers of income growth because the former is determined by factors that Canadian government policy can, to some extent, control, such as education, investment, and economic and trade policy. Our good fortune, however, cannot be controlled by our actions but rather is determined by the evolution of international prices and our supply of natural resources.[2] Canada's good fortune will not last forever. Policymakers should heed the lessons of past productivity growth to better understand how to improve productivity growth when our luck runs out.

Canadian policymakers can apply these lessons to two particular areas: 1) research and development policy; and 2) saving non-renewable resource revenues in "rainy-day" funds. In the general economy, technology-led productivity growth is similar across provinces, suggesting that research and development incentives are best left to federal policy. However, significant differences in technology-led productivity growth in the resource sector, across provinces, suggest that research and development policy targeted to the resource sector is best left to individual provinces.

Further, provinces that benefit from high resource prices should save and invest these revenues in ways that boost future growth. This *Commentary* aims to identify the areas of productivity growth where the provinces have fallen behind – such as technology, physical capital, or education – as a starting point for knowing where to invest in the future.

Methodology

Labour Productivity

Labour productivity is the starting point of my analysis. It is the straightforward measure of living standards that is widely used in international comparisons. I define labour productivity as the real provincial gross domestic product (GDP) in the economy divided by the quantity of hours worked. Three points are worth mentioning regarding the usefulness of labour productivity as a proxy for living standards.

1) Labour productivity is a measure for GDP data and does not capture all determinants of living standards. Other determinants include environmental quality, location amenities, and personal perception of well-being.
2) I use GDP per hour worked, not GDP per worker. Consequently, workers can increase their income by working more hours per day, or by having fewer holidays. Labour productivity remains a good proxy of living standards over time for one country as long as the average work/leisure decision does not change too much.

2 This distinction applies only to a developed economy such as Canada since, generally speaking, a country needs to be well governed and organized to exploit natural resources efficiently. Without the intervention of a democratic government that cares about the welfare of the overall population, the exploitation of natural resources often leads to conflicts, war, and rent seeking behaviour. Sachs and Warner (2001) have labelled the negative effect of natural resources abundance on economic growth in less-developed countries as the Natural Resource Curse. In the paper, the good governance of our natural resource sector is taken for granted.

3) Labour productivity is also directly related to living standards if the proportion of workers in the total population remains constant. This is not, however, the case in a period of demographic changes. According to demographers, economic development is often associated with falling mortality and fertility rates and a rising female participation rate; a phenomenon known as a demographic transition. In this situation, for a period of many decades following the start of the demographic transition, output per capita will increase faster than labour productivity simply because the proportion of workers in the total population is increasing. This transitional positive growth effect in known as the demographic dividend (Bloom, Canning and Sevilla 2003).
4) A demographic dividend can also follow from a babyboom period such as the one encountered in Canada after World War II. In this case, for a period of about three decades, the growth in per capita GDP was larger than the growth in labour productivity. This period has ended for Canada. Consequently, and more so than in the last few decades, Canada will now have to count on labour productivity growth to increase its living standards.

Growth Accounting and Multifactor Productivity

As discussed above, labour productivity can come from one of three sources: human capital investment, physical capital investment, or multifactor productivity (MFP). The purpose of calculating MFP is to separate the effects of technological improvement from those of capital accumulation (human and physical) on labour productivity growth. Technological improvements increase the production and income of an economy for a given level of capital and labour. Physical or human capital accumulation increases living standards by providing more capital or education to workers, which raises labour productivity. Box 1 explains how MFP growth is computed residually by subtracting the effect of capital accumulation from labour productivity growth.

Diagnosing the causes of economic growth can be useful for economic policy purposes. For example, if an economy is growing faster than others because of rapid capital accumulation (also referred to as capital deepening), MFP growth in this economy will be low and the long-run prospect for living standards improvements are reduced. The reason is that capital deepening, without technological improvements, will eventually face decreasing returns since the productivity of capital goods decreases when the quantity of capital per unit of labour increases. Rapid labour productivity growth originating from capital accumulation is then perceived as temporary. Consequently, the appropriate economic policy response to low MFP growth is to promote research and development, to adopt new technology, and to stop protecting and subsidizing low-productivity industries.

In contrast, in modern economic theory, economic growth resulting from MFP improvements is usually perceived as more sustainable than growth originating from capital deepening. The reason why MFP growth is more sustainable than capital deepening is that technological progress does not face decreasing returns: there are always new ideas and processes to be discovered that would improve the production of goods and services.

It is important to note that what is temporary in economic growth might last many decades. Germany or Japan after World War II, for example, counted on capital accumulation (reconstruction) to fuel productivity growth for two or three decades.

Important potential problems regarding the growth accounting exercises are worth mentioning.

1) MFP growth is a concept that is more subject to measurement errors than labour productivity. The precision of MFP growth measurement relies on good measures of capital accumulation (investments in machinery, equipment, structures, and human capital) and the measure of capital accumulation's impact on output (see technical box). Further, MFP growth measures produced by different statistical agencies cannot be used for cross-country comparisons because of methodological differences. For this reason, labour productivity is more often used as a measure of economic growth for international comparison.

Box 1: 1The Measure of Multifactor Productivity

The starting point of the measure of multifactor productivity (MFP) is the production function F by which labour L is combined with physical capital K, human capital H and technology A for producing output Y: $Y = F(L,K,H,A)$. The purpose of multifactor productivity is to measure the contribution of technology A in the production process. Since I don't have data on technology, the contribution of technology is measured residually by subtracting the contribution of other inputs (K,H, and L) to the production process. Formally, the growth of technology $g(A)$ equals the growth of labour productivity $g(Y/L)$ minus the contribution of physical capital accumulation $c(K/L)$ and the contribution of human capital $c(H/L)$ to labour productivity growth:

$$g(A)=g(Y/L)-c(K/L)-c(H/L) \quad \text{B1}$$

Following standard practices in growth accounting, I measure the contribution of physical capital by the product of the share of profits in national income times the growth of the capital-labour ratio. The share of profits is assumed to be 1/3 but the relative measure of MFP growth across provinces is not sensitive to this assumption.[a]

Also following standard practices, the contribution of human capital is measured as the macroeconomic return to education times the increase in the mean years of schooling of the population 15 years and over. The macroeconomic return to education is assumed to be 5 percent which is the estimate found by Coulombe and Tremblay (2007) of the mean macroeconomic returns to education for the 10 Canadian provinces in the 1951-2001 period. This number is the annual return in terms of labour productivity increase in Canadian provinces of one extra year of schooling for the population 15 years and over.

After having measured MFP growth using equation B1, this equation can be rewritten as:

$$g(Y/L)=c(K/L)+c(H/L)+g(A) \quad \text{B2}$$

Labour productivity growth can be accounted for by three factors: the contribution of physical capital accumulation, the contribution of human capital, and MFP growth.

An important caveat of my analysis is that, due to data limitation, natural resources are not introduced as inputs in the production function. Consequently, my MFP measures include the effects of resource discovery and the exhaustion of non-renewable resources. MFP growth measured in this paper does not just capture technological changes.

a I followed the usual practice in cross-country growth accounting by assuming a common capital share across provinces. See for example, Caselli (2005).

2) For the purpose of this *Commentary*, the measurement error problems are minimized since I use data from a common source (Statistics Canada) and apply the same methodology to all provinces.[3]

3) I also correct capital data supplied by Statistics Canada to produce capital data changes that are consistent with labour changes. In the data supplied by Statistics Canada, the capital/labour ratio was decreasing over the medium run for most

3 I am using Statistics Canada data from special tabulations supplied by the Investment and Capital Stock Division (capital stock), and by the Income and Expenditure Account Division (output and labour). I am also using Census (educational attainment) and Conference Board of Canada nominal GDP data (for the 2007-2009 period). These were the best data at the time the analysis was conducted.

provinces. This implies that the growth rate of multifactor productivity (plus that of human capital accumulation) is larger than the growth rate of labour productivity. This fact is inconsistent both with economic theory and previous empirical evidence of a growing economy and I thus correct this problem.[4]

Good Fortune and Terms of Trade Changes

The determinants of living standards that I attribute to good fortune are related to the evolution of prices in international markets, which economists have labelled terms-of-trade changes.[5] The evolution of real GDP excludes, by definition, changes in terms of trade since changes in the prices of export and import goods are removed by transforming nominal data to real data. Consequently, if following an increase in oil price, Alberta is selling the same quantity of oil at a higher price, the nominal income of Alberta will be larger even if real GDP is unchanged.[6]

A well-diversified economy will not be that affected by terms-of-trade changes. However, Canadian provinces, perhaps with the exception of Quebec and Ontario, are more likely to be affected by terms-of-trade changes than the overall Canadian economy because they are less diversified.

In this paper, I separate the effects on economic growth of good fortune from higher natural resource prices from productivity to assess the extent to which provincial economic growth is based on factors partly within the control of government policy.[7]

Results for the Overall Economy

Labour Productivity Growth and Level

The distribution of productivity levels across provinces appears relatively stable throughout the whole 1985-2009 period (Figure 1).[8] This observation appears on the surface to contrast with the findings of Coulombe and Lee (1995, 1998) and Lee and Coulombe (1995), which showed that the evolution of a variety of living standard indicators across Canadian provinces from the 1950s to the early 1990s was characterized by convergence; i.e., living standard indicators were growing at a faster pace in the poorer provinces than in the rich ones and their

4 The correction increases the growth rate of the capital stock for the 10 provinces. In theory, the capital/labour ratio should be growing at the same rate as technological progress in a balanced growth path. This prediction is consistent with most stylized facts and a variety of models. Since the capital/labour ratio was decreasing in all provinces, I corrected Statistics Canada capital stock data in order to have capital/labour ratio on average across provinces growing at the same rate as MFP growth. The capital/labour ratio is allowed to grow at a different rate across provinces. Errors in the measurement of capital are the most common source of measurement error for multifactor productivity. On this topic, refer to Pritchett (2000) as well as (Coulombe 2002). In a recent study, Tang, Rao, and Li (2010) show that, using the same methodology for computing the capital stock (instead of using Statistics Canada data) the capital/labour ratio in Canada is growing at a faster pace than in the United States.

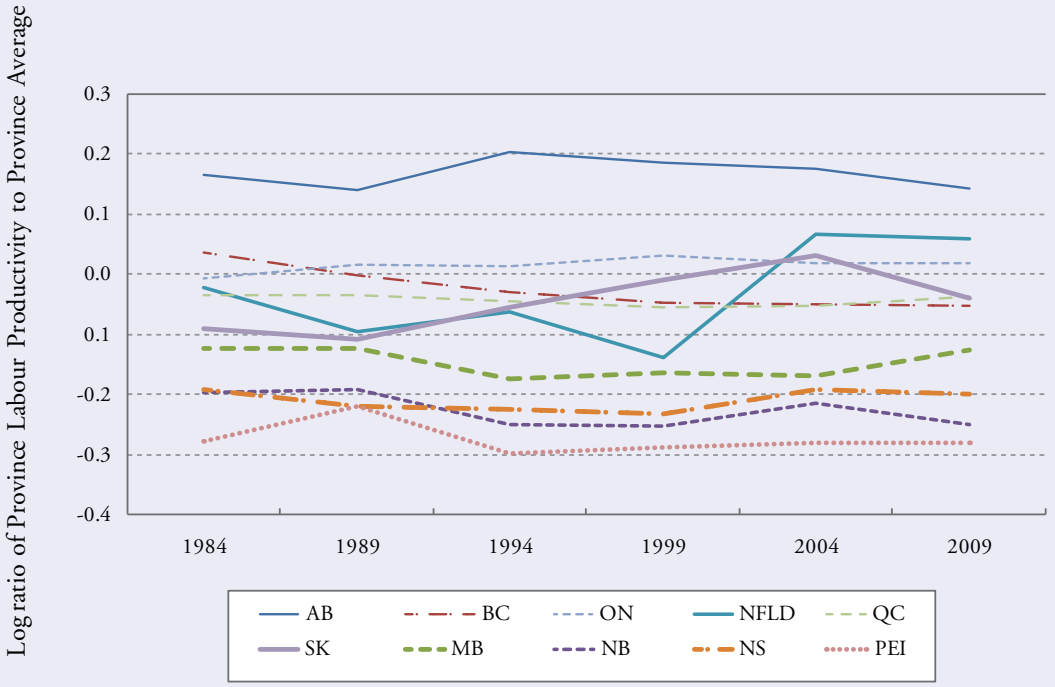
5 For an open economy, terms of trade refer to the prices of its exports relative to the price of imports, both measured in the national currency. Consequently, terms-of-trade developments are determined by the evolution of goods trade in international markets and by the exchange rate.

6 Real GDP is a concept that is related to economic activity not to national income. Evolutions of terms of trade that affect national income are treated as price movements for the computation of real GDP. Terms-of-trade changes are related to the evolution of prices of exports and imports. The changes in those prices are treated as inflation in the transformation of nominal GDP into real GDP. For a excellent discussion of the issue, refer to Kohli (2004). I deflate nominal provincial GDP using a national CPI to get a proxy of real provincial income, which is necessary to determine the provincial terms of trade effects.

7 I include the effect of terms-of-trade changes by deflating nominal provincial GDP using a national Consumer Price Index (CPI). In a second step, I separate the effect of terms-of-trade changes by subtracting the growth of provincial real GDP from the growth of the CPI-deflated provincial nominal GDP. This intuitive procedure yields results that are good approximations to more sophisticated approaches such as the one proposed by Kohli (2004).

8 The standard deviation of the logarithm of the ratios, a measure of dispersion of labour productivity across the provinces, is roughly stable throughout the period at around 13 percent.

Figure 1: Labour Productivity Levels of Canadian Provinces, 1984-2009



Source: Author's calculations from Statistics Canada special tabulations.

Note: Data are the natural logarithm of the ratio of each province's labour productivity to Canadian labour productivity. Data are chained GDP $2002 per hour worked, from Statistics Canada System of National Accounts special tabulation.

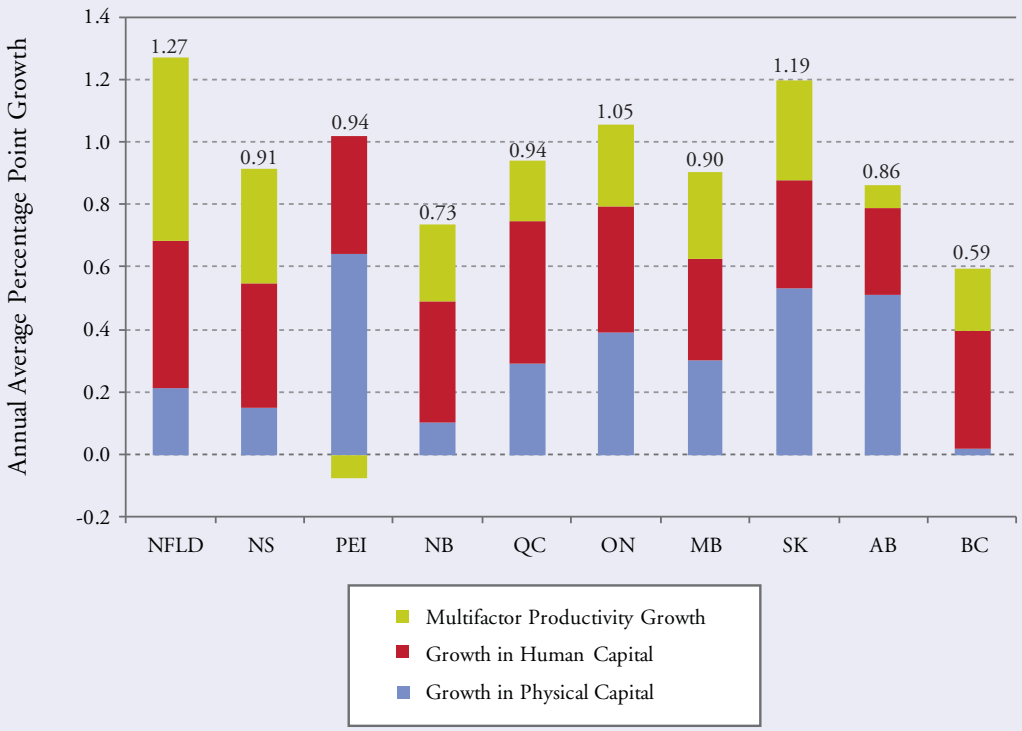
dispersion was decreasing. However, my finding concurs with the conjecture by Coulombe (2000) that, since the mid-1980s, the relative positions of Canadian provinces appear to be nearly in a long-run equilibrium: the catching-up process of the poor provinces appears to be completed and the distribution of relative labour productivity nationwide appears stable. The relative ranking of a few provinces is sometimes disturbed by region-specific shocks. An example is the beginning of production from Newfoundland's Hibernia oil field at the end of 1997. Between 1998 and 2007, labour productivity growth in Newfoundland averaged 4 percent a year, which is more than three times the Canadian average for the period.

In terms of levels of labour productivity, Alberta firmly stands in first place for the whole 1985-2009 period. Second place changed hands over the years. British Columbia stood in second place at the beginning of the period, Ontario did so in the middle years, and Newfoundland took second place by the end of the period. Notably, British Columbia lost four places, sliding from second to sixth, and the three Maritime Provinces remained in the last three positions for the whole period.

The average growth rates of labour productivity for the whole period range between 0.59 and 1.27 percent per year (Figure 2), which is between 0.45 and 0.70 percent below the average of the United States and the Euro 15 area.[9] Labour productivity growth for Canadian provinces is very low from an international perspective. The fastest productivity growth occurred in Newfoundland, followed by Saskatchewan, and Ontario. The slowest productivity growth was in British Columbia, followed by New Brunswick.

9 The numbers reported in the text are based on the period 1990-2004 for comparable productivity numbers presented and analysed in Maudos et al. (2008).

Figure 2: Components of Labour Productivity Growth of Canadian Provinces, 1984-2009



Source: Author's calculations from Statistics Canada special tabulations.

Mean productivity growth varies vary little across the other five provinces (between 0.86 and 0.94 percent).

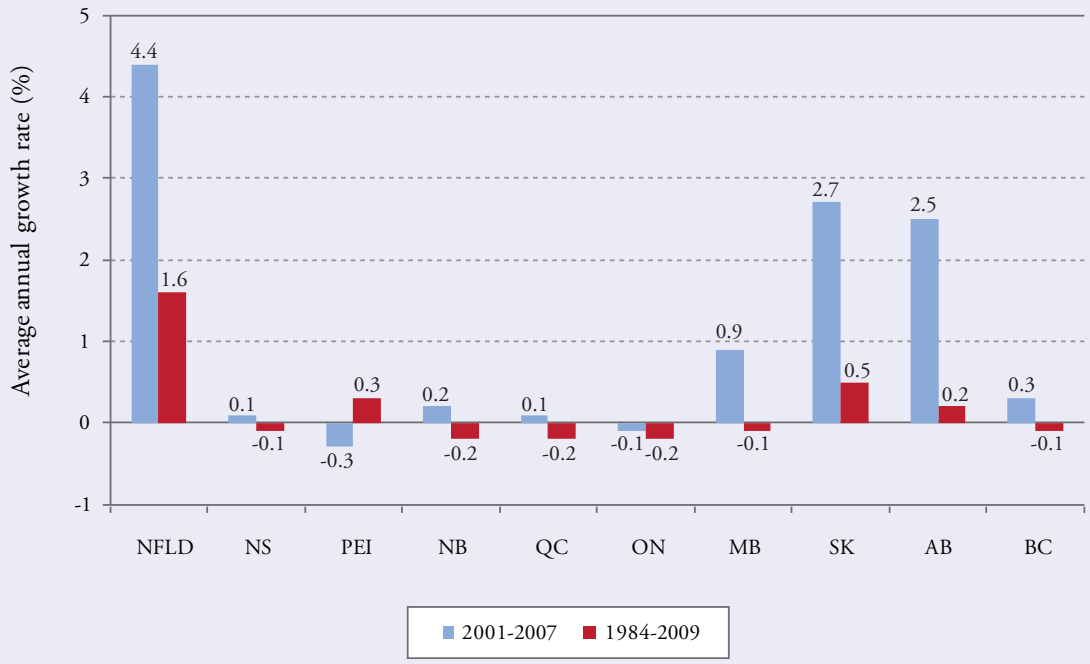
Good Fortune does not Last Forever

The evolution of terms-of-trade changes over the resource boom period 2001-2007 and the whole 1984-2009 period for the 10 provinces are shown in Figure 3. The number reported for each province is the average annual change for the period considered. A positive (negative) number implies that terms of trade have improved (deteriorated). For example, the +1.6 percent average for Newfoundland for the overall period implies that, terms-of-trade improvements have contributed to a 1.6 percent annual increase in living standards, on average, during the 25-year period. This represents a 50 percent cumulative increase in living standards over the period. Terms-of-trade changes over the whole period (Figure 3) can be added to those of Figure 2 to get the total improvement in living standards over the period.

It is important to point out first that, in general and over a very long period of time (say, 100 years), relative commodity prices movements have been characterized by a small decreasing trend and a lot of variability (Cashin and McDermott 2002). The 1990s were a time of decreasing commodity prices and the first decade of this century (the resource boom 2001-2007 particularly) was a time of increasing relative commodity prices.

During the resource-boom period, improvements in terms of trade have been a very substantial contributor to living standard improvements in Newfoundland, Saskatchewan and Alberta. For the whole period, terms-of-trade changes for the other nine provinces are relatively small; some being positive, some negative. The average for the other nine provinces for the whole period is virtually nil. Good fortune does not generally last forever.

Figure 3: Terms-of-Trade Changes in Canadian Provinces



Source: Author's calculations from Statistics Canada and Conference Board of Canada.

Finally, before moving to the growth accounting exercise in the next section, it is important to elaborate on the excellent performance of Newfoundland during the 1984-2009 period. Newfoundland clearly scores first across the 10 provinces in both productivity growth and growth due to good fortune. With a combined (terms of trade plus productivity) living standard improvement of 2.9 percent per year on average for more than two decades, Newfoundland's living standard will double every 24 years. This number is driven by the exceptional cumulative growth of 9.6 percent (4.4 for the terms of trade and 5.2 for productivity) during the resource boom 2001-2007 period.

Capital Deepening versus Technology

I provide estimates in Figures 2 of labour productivity growth from three sources: human capital accumulation, physical capital accumulation, and technological improvements (MFP growth). In this figure, a number of 0.5 percent, for example, means that for this province, a given factor has contributed to increased labour productivity by 0.5 percent per year on average during the period.

Human Capital Accumulation

Human capital accumulation has been less important in the four Western provinces than elsewhere in Canada (Figure 2). Newfoundland and Quebec are the clear leaders of human capital accumulation among the provinces over the period from 1984 to 2009, with Ontario in third place. Alberta is clearly in the last position. Newfoundland's faster pace is a catching-up process since the province was last in terms of the level of human capital for the whole period. Quebec's ranking improved from seventh to fourth place.

The contribution of human capital accumulation to productivity growth is substantial. On average, for the 10 provinces, human capital accumulation accounts for a 0.38 percentage point increase in labour productivity per year. This number is even larger than the average contribution of physical capital (0.31 percent per year). [10]

Schooling versus the Direct Measure of Human Capital

Two points are worth discussing regarding the measure of the contribution of human capital.[11] First, I am using a measure of human capital based on the years of schooling achieved instead of a direct measure based on the results of tests devoted to measuring skills such as the international Programme for International Student Assessment (PISA) and the International Adult Literacy Survey (IALS). A measure based on years of schooling is appropriate for analyzing the human capital of people that received education of comparable quality, such as within the same country (Coulombe and Tremblay 2006, 2009a).[12]

Second, the contribution of human capital in Alberta might appear disappointing especially since it is well-known that Alberta consistently outperforms the other Canadian provinces and most other countries in the world on PISA tests. PISA test scores are not appropriate for computing the effect of human capital accumulation on productivity since it is not available on a time-series basis and it measures only the skills acquired by 15-year-olds. It is important to bear in mind though that the contribution of human capital to labour productivity growth is measured by the increase in human capital. Alberta is still in second place in 2009 (after Ontario) for the level of schooling of the overall population in 2009. The larger contribution of human capital accumulation in poorer provinces results from a catching-up process.

Physical Capital Accumulation

The reliability of capital stock data for the Canadian provinces is weak, and the contribution of capital accumulation to labour productivity growth across provinces has to be interpreted with care. What really matters, and this point stands also for the interpretation of MFP growth in the next section, is that the relative contributions across provinces are measured with greater accuracy than the mean contribution across provinces.[13]

The contribution of physical capital accumulation varies considerably across provinces. Prince Edward Island, followed by Saskatchewan and Alberta, stand out favouriably whereas capital accumulation is anaemic in British Columbia and extremely small in New Brunswick, Nova Scotia, and Newfoundland. The performance of Prince Edward Island is surprising since capital accumulation peaked between 1989 and 1993, a period that preceded the construction of the Confederation Bridge.[14] This surprise could, however, be explained by measurement error, which can be exacerbated, in the case of Prince Edward Island, given the small size of the economy.

10 This result regarding the relative importance of human capital versus physical capital accumulation concurs with an earlier findings obtained from a completely different methodology such as in Coulombe and Tremblay (2006).

11 For a survey of the issue in a Canadian perspective, refer to Coulombe and Tremblay (2009).

12 However, years of schooling is a misleading measure of human capital accumulation for cross-country purposes since the quality of education varies considerably across countries. Coulombe and Tremblay (2007) show that when analysing provincial human capital stock, taking either years of schooling or a direct skill measure does not have any material effect on measuring human capital (contrary to cross-country analysis). This suggests that the quality of education does not vary much across provinces.

13 Relative measures of MFP growth across provinces are not affected by a common measurement error to the capital stock of provinces. If, for example, the measure of the capital for all provinces is growing at a slower pace because of measurement error, MFP growth will be overestimated for all provinces. The difference in MFP growth between the provinces will not be very affected by this common error however. Consequently, relative MFP measures of growth are more reliable than absolute values in case of common measurement errors.

14 The impact of building the Confederation Bridge on transport costs across the Northumberland straight should not be overestimated since the highly subsidized ferry services were already providing low-cost transportation.

MFP Growth

Three provinces stand out regarding the contribution of MFP to labour productivity growth. Newfoundland stands well above the other provinces with an annual MFP growth around 0.28 percentage points larger than the other provinces' mean. Prince Edward Island (with slightly negative MFP growth) and Alberta stand clearly at the bottom with MFP growth just around zero. The result for Prince Edward Island is intriguing given the capital accumulation was so fast during the period in this province. As mentioned earlier, measurement errors might be an explanation to this puzzle, especially given the very small size of Prince Edward Island. The weak MFP growth of Alberta comes from the weak performance of its natural resource sector, especially after 2000, as will be discussed in more detail below. MFP growth is remarkably close in the other seven provinces; between 0.19 and 0.35 percent per year.

Finally, the average MFP growth across provinces (excluding Newfoundland) is low and consistent with the low labour productivity growth observed earlier. Human capital accumulation appears substantial but the adoption of new technologies, which is an essential driver of MFP growth in normal circumstances, appears to be lagging behind.

Natural Resources and the Rest of the Economy

Labour productivity, MFP growth, and capital accumulation

The key trend in productivity growth in provincial natural resource sectors is the extraordinary performance of the natural resource sector in Newfoundland following the beginning of production at the Hibernia oil field on November 1997 (Table 1).[15] From a productivity point of view, this event is by far the single most important regional development in the period under study. Labour productivity growth in the Newfoundland resource sector peaked at 27 percent per year in the 2000-2004 period and averaged 8.3 percent for the whole period.[16] These developments in the poorest province were sufficient to end Newfoundland's status as a recipient of equalization payments from the federal government.

The comparative evolution of the resource sector in Alberta and Newfoundland illustrates well the impact of natural resource extraction on productivity. Labour productivity growth in the natural resource sector in Alberta between 2000 and 2009 has been negative on average. The two resource booms of Newfoundland and Alberta are different. The development of Newfoundland is characterized by the transformation from a fishing industry for which productivity improvements were held back by resource depletion, to the exploitation of new and highly productive off-shore oil fields. In Alberta, the 2001-2007 resource boom accelerated the exploitation of less productive oil sands at the same time that production of the traditional oil fields was decreasing because of exhaustion. The key lesson is that productivity growth and resource booms do not always go together.

Labour productivity growth in the resource sector was also spectacular in the resource intensive Saskatchewan economy. Labour productivity growth in the resource sector was negative and relatively substantial in Ontario and New Brunswick and virtually nil in Québec. Interestingly, these three provinces, which do not produce oil and gas, all have a large forestry industry.

15 For all provinces, the natural resource sector is defined as the aggregation of: Agriculture, forestry, fishing and trapping, mining, quarrying and oil-well industries.

16 Production at Hibernia was followed in 2002 with the beginning of production at Terra Nova in 2002 and White Rose in 2005.

Table 1: Labour Productivity Growth Excluding Natural Resources

	AB	BC	MB	NB	NFLD	NS	ON	PEI	QC	SK	Provincial Average
1985-1989	-0.2	-0.5	0.2	0.1	-1.1	-0.4	0.6	1.4	0.1	-1.0	**-0.1**
1990-1994	1.5	0.8	0.1	0.3	2.4	0.8	1.2	-0.5	1.1	0.5	**0.8**
1995-1999	1.7	1.6	2.0	1.9	-0.8	2.1	2.0	1.8	1.6	2.7	**1.6**
2000-2004	2.2	1.1	0.8	2.0	1.1	1.8	0.8	1.2	1.1	1.7	**1.4**
2005-2009	0.7	1.0	1.4	0.2	1.4	0.5	0.9	0.7	1.1	0.4	**0.8**
1985-2009 Average	**1.2**	**0.8**	**0.9**	**0.9**	**0.6**	**1.0**	**1.1**	**0.9**	**1.0**	**0.9**	**0.9**
1985-2009 Rank	1	9	5	7	10	4	2	6	3	8	

Source: Author's calculations from Statistics Canada special tabulations.

The picture for labour productivity growth in the rest of the economy for Alberta and Newfoundland is reversed (Table 2). Alberta has the fastest provincial productivity growth whereas Newfoundland has the slowest. Labour productivity growth for the rest of the economy does not vary much on average for the other eight provinces over time.

MFP growth for the resource sector (Table 3) and the rest of the economy (Table 4)[17] complement those obtained for labour productivity. For Newfoundland, the results are again spectacular. The adoption of new technology with the off-shore oil field industry accounts for this improvement. In Alberta, MFP growth is now slightly negative in the resource sector for the whole period and substantially negative for the resource boom period because production in the oil sands industry is dependent on massive physical capital investment.

For the whole period, MFP growth in the resource sector is also negative on average for Ontario, New Brunswick, Prince Edward Island, and Quebec and is virtually nil in British Columbia. For the rest of the economy, MFP growth is the highest in Alberta and the lowest in Prince Edward Island. In the other eight provinces, MFP growth in rest of the economy varies between 0.77 percent and 0.95 percent. Finally, it is worth noting that MFP growth in the rest of the economy was well above average in Ontario between 1995 and 1999. Thereafter, MFP growth in Ontario was lower than the average in the rest of Canada. These results concur with Sharpe and Thomson's (2010) findings that Ontario, given its size and poor relative performance, accounted for most of the decrease in provincial average for MFP growth after 2000. Interestingly, MFP in the non-resource component of the Ontario economy grew the

17 Comparable (across time and across provinces) schooling data for workers in the natural resource sector are not available.

Table 2: Labour Productivity Growth in the Natural Resource Sector

	AB	BC	MB	NB	NFLD	NS	ON	PEI	QC	SK	Provincial Average
1985-1989	0.0	-1.0	-0.6	2.8	-2.5	-0.2	0.5	0.3	3.5	2.2	**0.5**
1990-1994	5.2	3.3	0.5	-3.6	-0.1	5.2	-1.7	0.4	-1.4	6.4	**1.4**
1995-1999	2.9	0.9	-1.7	-4.3	7.0	-9.5	-2.9	0.3	-4.4	2.7	**-0.9**
2000-2004	-2.6	2.2	4.4	2.4	26.7	7.8	3.2	2.7	4.2	5.0	**5.6**
2005-2009	0.5	-1.0	3.6	-1.6	10.5	-0.3	-2.5	1.4	-2.1	-0.6	**0.8**
1985-2009 Average	**1.2**	**0.9**	**1.2**	**-0.8**	**8.3**	**0.6**	**-0.7**	**1.0**	**0.0**	**3.1**	**1.5**
1985-2009 Rank	4	6	3	10	1	7	9	5	8	2	

Source: Author's calculations from Statistics Canada special tabulations.

Table 3: Multifactor Productivity Growth Excluding Natural Resources

	AB	BC	MB	NB	NFLD	NS	ON	PEI	QC	SK	Provincial Average
1985-1989	-0.1	0.3	0.0	0.9	-0.5	-0.5	0.4	0.9	0.2	-1.4	**0.0**
1990-1994	1.6	0.8	-0.1	0.0	2.2	0.3	0.2	-1.6	0.4	0.2	**0.4**
1995-1999	2.3	1.5	1.9	2.0	-0.1	2.3	2.3	1.6	1.9	2.7	**1.8**
2000-2004	2.5	1.6	1.0	2.1	1.4	1.9	1.1	1.3	1.2	2.1	**1.6**
2005-2009	-0.3	0.6	1.0	-0.4	1.3	0.4	0.3	0.0	0.5	0.4	**0.4**
1985-2009 Average	**1.2**	**1.0**	**0.8**	**0.9**	**0.9**	**0.9**	**0.9**	**0.4**	**0.8**	**0.8**	**0.9**
1985-2009 Rank	1	2	9	3	5	4	6	10	7	8	

Source: Author's calculations from Statistics Canada special tabulations.

Table 4: Multifactor Productivity Growth in the Natural Resource Sector

	AB	BC	MB	NB	NFLD	NS	ON	PEI	QC	SK	Provincial Average
1985-1989	0.6	0.6	0.3	3.4	-2.5	1.3	0.4	0.5	3.2	2.6	**1.0**
1990-1994	4.8	2.6	0.1	-1.5	-4.1	5.8	-0.9	0.0	-1.0	6.1	**1.2**
1995-1999	0.0	-0.3	-1.8	-4.7	5.7	-11.5	-3.4	-0.5	-4.8	0.3	**-2.1**
2000-2004	-4.4	1.0	3.3	2.4	23.5	6.7	2.0	1.2	3.4	2.9	**4.2**
2005-2009	-1.8	-3.8	2.4	-3.7	6.8	0.9	3.3	1.1	-2.5	-2.9	**-0.7**
1985-2009 Average	**-0.2**	**0.0**	**0.9**	**-0.8**	**5.9**	**0.7**	**-1.0**	**0.5**	**-0.4**	**1.8**	**0.7**
1985-2009 Rank	7	6	3	9	1	4	10	5	8	2	

Source: Author's calculations from Statistics Canada special tabulations.

fastest during a period of exchange rate depreciation and grew more slowly during the period of appreciation.

MFP Growth: National versus Regional Components

The standard policy response to low MFP growth would be to promote R&D and the adoption of new technology. One relevant issue in a federation as decentralized as Canada is to know if this policy action, if needed, should be done at the provincial and/or at the federal level. If most MFP developments at the provincial level are independent of the national trend, one can assume that economic policy should be designed at the provincial level in order to adequately accommodate the idiosyncratic regional performances. If, however, national developments in MFP growth dominate regional ones, centralized action might be required in order to generate balanced regional growth patterns.

To address these issues, I developed a simple methodology to separate the contribution of regional and national developments in MFP growth. I regressed my MFP estimates between 1984 and 2009 for the 10 provinces on time dummies.[18] In such a framework, the regression identifies the percentage of the evolution of MFP growth, across provinces and over time, that is

18 Estimations are performed using pooled least-squares. The pooling of the 10 provinces in five periods (of five years each) allows using 50 observations in each regression. The time dummies capture the common (or national) component of the growth rates across provinces. Since only time dummies are included in the regression, the R-squared captures the percentage of the growth rates that are explained by the common factors. The pooling in five-year periods is common in empirical analysis of economic growth since it overcomes business-cycle considerations.

explained by a common or a national component such as national policies and external shocks like exchange-rate movements. The rest is explained by idiosyncratic regional evolutions.[19]

The results show that for MFP growth in the natural resource sector, for the 10 provinces, the national components explains a little less than 20 percent of overall MFP growth developments during the 1985-2009 period. As I have shown above, MFP growth in Newfoundland has been very different from the other provinces during the period. Excluding Newfoundland from the regression analysis, I found that only 37 percent of overall MFP growth was explained by the national component. In sum, provinces have different resource endowments at different stages of development, and a one-size-fits-all federal resource policy is likely not best suited to the needs of provinces.

The results differ substantially for MFP growth in the rest of the economy. For the 10 provinces, the national component explains 53 percent of overall MFP growth during the period. Excluding Newfoundland from the analysis increases the contribution of the national components to 68 percent.

Policy Considerations: Natural Resources, Capital Accumulation, and the Hartwick Rule

Before concluding this analysis, a word on the direct policy implications of these results is in order. One clear policy implication is that an economy predicated on extracting natural resources will need to invest in other means of enhancing labour productivity to prepare for when natural resources have been exhausted or their productivity has declined. This is a rule of thumb known as the Hartwick Rule, which states that to sustain a constant flow of consumption, an economy that produces an exhaustible resource should invest the totality of the resource rents in reproducible capital. A resource rent is the difference between the market price of the resource and the cost of production. In other words, an economy that produced oil and gas should save and invest more than an economy that produces resources that are not exhausted after a single use, such as harvesting wheat and manufacturing goods. If the accumulation of capital (both physical and human capital) is not sufficient to compensate for the exhaustion of the resource, then the exhaustible resource economy's living standards will inexorably decline.

The Hartwick rule is an important concept in the economy of natural resources and it has been developed and analysed by well-known economists such as Solow (1986). This rule, however, is often forgotten in discussions about Canada's economic policy agenda during resource-boom periods.

What type of investment should be done for meeting the Hartwick rule? Fundamentally, a booming economy predicated on extracting exhaustible resources should broadly favour investment spending rather than consumption. Investing in human capital is probably the first candidate for an economy such as Newfoundland and Labrador that is in the early stages of exploiting highly productive oil fields. The lifetime of current off-shore projects is limited and preparation for the post-production period should begin now. Investment in human capital is also a very good idea for all developed natural-resource intensive economies since modern resource extraction activities are more human-capital intensive than they were in the past. Shifting to more knowledge-intensive resources industries will also enhance productivity growth and living standards, as illustrated by the case of Newfoundland in the last 20 years.

19 The common, or the national, component of my results that may be from measurement error is common to all provinces. If, for example, capital stock data tend to decelerate through time due to a common problem to all provinces in computing depreciation in Statistics Canada data, this will appear as a common to all provinces productivity shock and that would raise the R-squared of the regression with time dummies. The reason is that the time dummies capture the effect of the common deceleration in the capital stock. The results are available from the author.

Eliminating the provincial public debt should also be high on the priority list of provinces with a resource boom. Other candidates also include investment in capital goods that cannot be easily financed abroad such as public infrastructure. Once capital investment possibilities are exhausted, the economy should follow Norway's path and invest in financial assets. Alberta's heritage and saving fund is a small step in this direction, but has not been used to the extent necessary to appropriately save Alberta's oil and gas revenues (Shiell and Busby 2008). Indeed, the value of Norway's fund is 33 times larger than that of Alberta's at the end of 2010, for a population only 40 percent larger.

Finally it is worth mentioning that the policy prescription of the Hartwick rule is, in my view, very pertinent for other Canadian provinces with intensive exploitation of exhaustible resources (mining, potash, gas) such as Saskatchewan. However, the prescription does not apply to the case of the vast hydroelectric resource of Quebec. Contrary to oil and gas, hydroelectric power is not an exhaustible resource Consequently, Quebec's small Fond des Générations should not be viewed as an attempt to keep consumption constant in Quebec since the province's hydroelectric power will likely not run out.

Conclusion

A clear leader comes out of my analysis of productivity growth across Canadian provinces in the last 25 years. Newfoundland's performance has been spectacular. Thanks to its new off-shore oil industry, Newfoundland's labour productivity growth has outperformed the other provinces. The province has also been blessed with terms-of-trade improvements, the fastest growth in human capital, and the acquisition of new and highly productive technology.

Royalties and various tax revenues from oil extraction should be invested wisely if the off-shore successes are to spread inland. This is the key to balanced economic development for this province since my analysis illustrates that productivity gains in the natural resource sector do not easily spread from off-shore oil rigs to the rest of the economy. Continuing to invest in human capital is certainly a wise economic development avenue for Newfoundland since the province is still lagging behind other provinces in terms of educational achievements.

As for the other major regional resource boom in Canada, Alberta's development of the oil sands, has not fuelled productivity growth there. The production of oil from bituminous sands is a capital-intensive, high-cost, and low-productivity economic activity.[20] It is worth reiterating here that productivity levels in the natural resource sector are already high and that the poor productivity growth results from this province's exhaustion of traditional oil fields and that rising oil prices stimulate the exploitation of increasingly marginal resources. However, and again contrary to Newfoundland, Alberta's productivity performance in the rest of the economy is very good. The resource boom in Alberta appears to spread more easily to the other sectors of the economy than in Newfoundland.

Finally, the results of the analysis suggest that the regional dimension is crucial in explaining productivity developments in the natural resource sector, whereas the national component dominates the developments in the rest of the economy. This suggests that national policies to encourage MFP growth will be most important for the non-resource economy. However, provincial policies are more likely to be most appropriate in encouraging productivity in region-specific resource sectors.

20 The production of oil from bituminous sand is a highly valuable activity and fully justifies the billions of dollars that have been invested in it. However, it is not an economic activity that enhances multifactor productivity growth for the reasons given in the text.

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