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A DETAILED ANALYSIS OF THE PRODUCTIVITY PERFORMANCE OF MINING IN CANADA

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A Detailed Analysis of the Productivity Performance of Mining in Canada

Abstract

In recent years, the productivity performance of mining in Canada has been very poor. Based on official real GDP and labour input estimates from Statistics Canada, labour productivity in mining fell by 2.21 per cent per year between the 2000 cyclical peak and 2007, with capital productivity down 0.28 per cent per year and total factor productivity (TFP) off 1.07 per cent per year between 2000 and 2006. Among the various hypotheses put forward to explain these trends, the most robust seems to be that higher output prices have suppressed productivity growth through two effects: increased exploitation of low-productivity marginal resource deposits, and business decisions based on profitability rather than productivity. Despite the decline in productivity in mining, it is not necessarily true that Canadians are worse off. In fact, increased relative output prices for mining products as well as a high productivity level in the mining sub-sector, have resulted in positive contributions to Canada's aggregate labour productivity growth from 2000 to 2006 and an offsetting effect on the post-2000 aggregate labour productivity slowdown.

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Executive Summary

In recent years, the productivity performance of mining in Canada has been very poor. Based on official real GDP and labour input estimates from Statistics Canada, labour productivity in mining fell by 2.21 per cent per year between the cyclical peaks in 2000 and 2007, with capital productivity down 0.28 per cent per year and total factor productivity (TFP) off 1.07 per cent per year between 2000 and 2006. This situation reflects the faster growth of inputs relative to output in mining. While real GDP in mining increased 9.6 per cent over the 2000-2007 period, hours worked grew 28.2 per cent and the real capital stock grew by 11.8 per cent. Hence, the key to explaining the slump in productivity in mining is to shed light on why inputs are growing faster than output.

Mining is relatively less important in the United States than in Canada in terms of both output and employment. In the 1990s labour productivity in mining grew faster in Canada than in the United States, but from 2000 to 2006 labour productivity in mining continued to grow, albeit more slowly, in the United States, while it declined in Canada. On this basis, labour productivity (per worker) in mining in the United States has been higher than in Canada since 1995, however, the labour productivity gap in mining between Canada and the United States is smaller than the all industries average. Finally, Canada performed better in terms of capital and total factor productivity, both of which exhibited similar trends. In both cases, Canada experienced significantly faster growth than the United States in the 1990s, and less dramatic declines in the 2000-2006 period. Overall, the comparison with the United States suggests that the factors driving productivity trends in mining in Canada are also affecting mining south of the border.

Mining exerted a small negative effect on aggregate labour productivity growth in Canada in the 1989-2000 period. Mining is an activity with a high level of labour productivity. Over this period, labour productivity in mining grew faster than other sectors. In spite of this growth and in spite of high prices for mining outputs, the contribution of mining was still negative. The reason for this counterintuitive result is that a smaller share of the Canadian labour force worked in mining in 2000 than in 1989, and a larger share worked in other, lower-productivity, activities. The situation reversed from 2000 to 2006. Mining accounted for around 10 per cent of aggregate labour productivity growth, due largely to an increase in the relative prices of mining outputs.

Canada experienced a significant slowdown in labour productivity growth between the 1996-2000 and 2000-2006 periods, from an average annual rate of labour productivity growth of 2.35 per cent to 1.02 per cent. Without higher output prices and labour productivity levels in mining after 2000, this slowdown would have been more severe.

There are a number of possible explanations for the observed declines in all three measures of productivity (labour, capital, and total factor) in mining in Canada: declining capital intensity; higher mining output prices; compositional shifts within the industry; lagging innovation and technological progress; deterioration of the average quality of the workforce; greater environmental regulation; deterioration of the average quality of resources exploited independent of price effects; labour relations; and taxation.

Upon examining various hypotheses put forward to explain falling productivity in mining, the strongest seems to be the effect of higher prices on both capital intensity and TFP. When the price of a natural resource increases it becomes profitable to increase extraction rates at existing deposits and to extract from marginal resource deposits that were previously unprofitable due to high costs of extraction.

Another seemingly robust explanation is that profitability trumps productivity as an objective for firms. While the objectives of productivity and profitability normally coincide, they diverge when commodity prices are extremely high. As a result, the productivity growth of an industry, measured in constant prices, may suffer due to greater inefficiency in operations. This is reflected in a fall in TFP growth. Data on TFP and capital intensity suggest that falling capital intensity growth rates can explain a large part of the productivity slowdown in mining between the 1996-2000 and 2000-2006 periods. Yet, it also suggests that the decline in labour productivity in mining is also due to sustained declines in TFP. These findings reinforce the idea that higher prices were the main driver of both the post-2000 labour productivity slowdown and the negative productivity growth in mining.

Since productivity growth is the key driver of increases in living standards, the deceleration in labour productivity growth in Canada after 2000 implies a slower rate of increase in living standards. But improving terms of trade are also a source of real income increases. The higher commodity prices that Canada has enjoyed until 2008, in addition to the negative effect on mining productivity, have boosted the real income of Canadians.

This report does not recommend any industry-specific policies to improve productivity growth in mining above and beyond general public policies to improve productivity, such as investments in human capital and innovation. Despite the decline in productivity in this industry, it is not true that Canadians are worse off. In fact, the increases in prices and employment share in mining, together with the high productivity level of the sub-sector, have resulted in a positive contribution to aggregate labour productivity growth over the 2000-2006 period, and to an offsetting effect on the post-2000 aggregate labour productivity slowdown.

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A Detailed Analysis of the Productivity Performance of Mining in Canada[1]

I. Introduction

A. Motivation

In recent years, the productivity performance of mining in Canada has been very poor. According to official real GDP and labour input estimates from Statistics Canada, labour productivity in mining fell by 0.94 per cent per year between the cyclical peaks of 2000 and 2007, with capital productivity down 0.28 per cent per year and total factor productivity (TFP) off 1.07 per cent per year between 2000 and 2006.[2] The three questions that this report seeks to answer are

- Why has productivity in mining fallen?
- What has been the effect of this poor performance on aggregate labour productivity growth? and,
- What, if anything, should be done about this falling productivity?

Summary Table 1: The Importance of Mining in Canada, 2007

	Real GDP			Jobs		
	Millions of Chained 2002 Dollars	As a Share of Mining Sub-Sector Total (per cent)	As a Share of All Industries Total (per cent)	Thousands of Jobs	As a Share of Mining Sub-Sector Total (per cent)	As a Share of All Industries Total (per cent)
Mining	9,676	100.0	0.79	64,173	100	0.38
Coal Mining	980	10.1	0.08	5,741	8.9	0.03
Metal Ore Mining	3,994	41.3	0.33	32,721	51.0	0.19
Non-Metallic Mineral Mining and Quarrying	4,883	50.5	0.40	25,712	40.1	0.15

Source: Appendix Tables 1 and 6

Note: GDP shares should not be calculated using chained dollars, so the figures presented in this table should be interpreted with caution. Chained dollar were used because neither constant nor current dollars were available. Figures are rounded.

[1] The authors would like to thank Industry Canada for financial support and Jianmin Tang from Industry Canada for useful comments and suggestions. We would also like to thank officials from Natural Resources Canada for their comments, as well as Souleima El-Achkar, Jean-François Arsenault, Peter Harrison, Alexander Murray, and Christopher Ross for assistance.

[2] All data used in the report can be found in the extensive set of Appendix Tables posted alongside this report on the CSLS website (www.csls.ca). In general, the report will make direct reference to the relevant appendix table when discussing specific trends or results. The set of Appendix Tables covers both the oil and gas extraction and the mining sub-sectors. For an analysis of the oil and gas sub-sector, see Bradley and Sharpe (2009).

Mining is a relatively important sector of the Canadian economy. In 2007, mining accounted for 0.79 per cent of real GDP in Canada and provided 64,173 jobs, or 0.38 per cent of all jobs (Summary Table 1). Coal mining produced 10.1 per cent of mining output and provided 8.9 per cent of all mining jobs (5,741 jobs). Metal ore mining accounted for about 40 per cent of all mining output and 51.0 per cent of mining jobs (32,721 jobs) in 2007. Non-metallic mineral mining and quarrying was the largest industry group in the mining sub-sector. It accounted for just over one-half of output and 40.1 per cent of the jobs in mining in Canada in 2007 (25,712 jobs).

Since the 1980s mining has been in decline in terms of its share of GDP and jobs in Canada. This decline has been centered in coal mining and metal ore mining; non-metallic mineral mining and quarrying has seen an increase in both its share of total mining output and employment. This increase was driven by increased employment in stone mining and quarrying and sand, gravel, clay, and ceramic and refractory minerals mining and quarrying.

B. Organization of the Report

This report is divided into eight major parts. After the introduction, definitions, data sources, concepts, and measurement issues relevant to the analysis of productivity in mining are discussed. The third part of the report reviews trends in indicators related to mining productivity in Canada. Trends in real GDP, hours worked, capital stock, labour productivity, capital productivity, and total factor productivity (TFP) are analyzed. The fourth part of the report reviews trends in mining productivity in the United States. The fifth part assesses the contribution of changes in labour productivity in mining to aggregate labour productivity growth in Canada. The contribution of mining to the overall productivity slowdown that occurred between the periods 1996-2000 and 2000-2006 is assessed. The sixth part presents hypotheses for the observed decline in productivity in mining since 2000. Hypotheses examined are changing capital intensity; higher prices for energy and materials; lagging innovation and technological progress; deterioration in the average quality of the workforce; greater environmental regulation; deterioration in the average quality of resources independent of price effects; labour relations; and taxation. The seventh part assesses the implications of falling productivity mining for the Canadian economy. The eighth and final part summarizes the findings of the report and concludes.

II. Definitions, Data Sources, and Measurement Issues

This part discusses definitions that are relevant for analyzing productivity in the mining sub-sector, key productivity concepts, data sources, and measurement issues associated with productivity in the mining sub-sector.

A. Definitions

Statistics Canada classifies establishments[3] according to the North American Industry Classification System (NAICS, pronounced "nakes"). NAICS classifies establishments into industries based on the similarity of their production processes. NAICS has a hierarchical structure which divides the economy into 20 sectors, identified by 2-digit codes. Below the sector level, establishments are classified into 3-digit sub-sectors, 4-digit industry groups, and 5-digit industries. At all levels the first two digits always indicate the sector, the third digit the subsector, the fourth digit the industry group, and the fifth digit the industry. The mining sub-sector is part of the mining and oil and gas extraction sector, NAICS code 21.

Exhibit 1: The Mining Sub-Sector and its industry groups according to the North American Industry Classification System

212 Mining (except Oil and Gas)

2121 Coal Mining
2122 Metal Ore Mining
2123 Non-Metallic Mineral Mining and Quarrying

Source: Statistics Canada, 2007.
Note: See Appendix for a complete description of the industries that make up the mining sub-sector.

Mining (NAICS code 212)[4] is a sub-sector composed of establishments primarily engaged in mining, beneficiating[5] or otherwise preparing metallic and non-metallic minerals, including coal. The coal mining industry group (2121) consists of establishments primarily engaged in mining bituminous coal, anthracite and lignite by underground mining, and auger mining, strip mining, culm bank mining and other surface

[3] "The establishment is the level at which all accounting data required to measure production are available. The establishment, as a statistical unit, is defined as the most homogeneous unit of production for which the business maintains accounting records from which it is possible to assemble all the data elements required to compile the full structure of the gross value of production (total sales or shipments, and inventories), the cost of materials and services, and labour and capital used in production. Provided that the necessary accounts are available, the statistical structure replicates the operating structure of the business. In delineating the establishment, however, producing units may be grouped. An establishment comprises at least one location but it can also be composed of many. Establishments may also be referred to as profit centres." (Statistics Canada, 2007)
[4] This paragraph and the next are drawn from the official NAICS handbook (Statistics Canada, 2007).
[5] Beneficiation is the process of crushing and separating ore into valuable substances or waste by any of a variety of techniques.

mining. It also includes mining operations and preparation plants (also known as cleaning plants and washeries), whether or not such plants are operated in conjunction with mine sites. The metal ore mining industry group (2122) comprises establishments primarily engaged in mining metallic minerals (ores). Also included are establishments engaged in ore dressing and beneficiating operations, whether performed at mills operated in conjunction with the mines served or at mills, such as custom mills, operated separately. These include mills that crush, grind, wash, dry, sinter, calcine or leach ore, or perform gravity separation or flotation operations. Finally, the non-metallic mineral mining and quarrying industry group (2123) comprises establishments primarily engaged in mining or quarrying non-metallic minerals, except coal. Primary preparation plants, such as those engaged in crushing, grinding and washing, are included.

It is worth noting that two industries excluded from the analysis conducted in this report; in both cases the exclusion is the result of the absence of data. This report does not analyze productivity in the “other support activities for mining” industry (NAICS code 213119), because data are not available. This industry includes establishments primarily engaged in performing mining services, for others, on a contract or fee basis. Establishments engaged in the exploration for minerals are also included in this industry. Such exploration is often accomplished using purchased services of specialty businesses, such as contract drilling services to obtain core samples. Another exclusion is the “contract drilling (except oil and gas)” industry (NAICS code 213117) which includes establishments primarily engaged in diamond, test, prospect and other types of drilling, for minerals, other than oil and gas. These two industries are part of the support activities for mining and oil and gas extraction sub-sector (213) and not the mining sub-sector (212).[6]

B. Data Sources

This report largely relies on official estimates of real GDP, labour, and capital provided by Statistics Canada. At the time of writing this report, official Statistics Canada estimates of productivity in the mining sub-sector were only available for the period 1961-2004. Furthermore, official productivity estimates are only available in index form, which allows for the analysis of growth rates but not of levels. In order to provide more detailed analysis of productivity trends in mining, calculations from the Centre for the

[6] These exclusions are only important to the following analysis if these industries have experienced a different productivity performance than the mining sub-sector, a proposition that is explored herein. In 2007, the support activities for mining and oil and gas sub-sector (NAICS code 213), the lowest level for which data are available, represented approximately 40 per cent of hours worked in the mining and oil and gas sector as a whole (NAICS code 21). Its productivity level, however, was only about one-third that of the mining sub-sector. Over the 1987-2007 period, support activities exhibited trends similar to those of the mining and oil and gas sector. In both cases, labour productivity was negative on average over the period (-0.49 per cent per year for the support activities sub-sector and a decline of 0.11 per cent per year for the sector as a whole). Moreover, in both cases labour productivity growth was positive during the 1990s, and then turned negative after 2000. Given that the support activities sub-sector covers activities in both the mining and the oil and gas fields, it is not surprising that its labour productivity growth rate has in general been in-between that of either sub-sector over the 1987-2007 period and within sub-periods (see Appendix Table 15). These trends suggest that the inclusion of the portion of the support activities sub-sector relevant to mining would not alter in any significant way the trends and conclusions discussed in this paper.

Study of Living Standards productivity database are used.[7] These calculations are based on Statistics Canada data and are provided for the 1987-2007 period (1987-2006 for TFP measures).[8]

For the United States, we use official productivity estimates for mining produced by the Bureau of Labor Statistics, supplemented by productivity estimates constructed from real output and labour and capital input data compiled by the Bureau of Economic Analysis.[9]

C. Productivity Concepts[10]

Productivity is the key factor behind growth in living standards. Without increasing the amount each worker can produce there would be no increase in real wages and incomes (CSLS, 2004). It is therefore productivity growth which drives increases in living standards, defined as real GDP per capita. When discussing productivity there are two important factors to consider: whether productivity is measured using partial productivity or total factor productivity, and whether productivity is measured in current or constant dollars.

Productivity can be measured in various ways. There is a fundamental distinction between partial and total factor productivity (TFP).[11] Partial productivity refers to the relationship between output and a single input, such as labour or capital. This report will provide estimates of both labour productivity (the most commonly used measure of productivity) and capital productivity. It is important to note that growth in labour productivity is not attributed solely to changes in labour effort. Other factors that can affect labour productivity include technical change and the amount of capital each worker has to work with. TFP attempts to measure how efficiently all factors are used in the production process. TFP growth is measured as the difference between output growth and combined input growth, and thus captures the effects of all elements of the production

[7] The CSLS productivity database used in this report is available online at http://www.csls.ca/data/ptabln.asp. These estimates and Statistics Canada's official estimate for total factor productivity (TFP) are not entirely consistent; TFP estimates between the two sources differ as Statistics Canada uses capital services instead of capital stock when measuring the contribution of capital inputs and also because CSLS estimates do not account for changes in labour composition. The most recent update of the CSLS productivity database provides estimates consistent with those provided by Statistics Canada. It provides estimates of labour, capital and multifactor productivity for Canada and the provinces with estimates for two-digit NAICS sectors (www.csls.ca/data/mfp.asp). No data for sub-sectors (three-digit) are yet available. See Sharpe and Arsenault (2009) for more details on this database.

[8] In general, the sub-periods used in the report to support the analysis are 1989-2000 and 2000-2007. Both these periods are peak-to-peak periods, and as such they are cyclically neutral. While we could have attempted to include 2008 in our analysis, consistent data on hours worked for the mining sub-sector were not yet available. Moreover, data for 2008 would likely not show any significant change in trend, as the mining and oil and gas sector as a whole experienced labour productivity growth of -5.7 per cent, in line with the trend over the 2000-2007 period (-4.4 per cent).

[9] Official estimates of capital input and total factor productivity growth in Canada and the United States are not entirely comparable, because Statistics Canada changed its methodology for measuring capital stocks in 2006. Yet, internationally comparable sources such as the Groningen Growth and Development Centre (GGDC) and the OECD only provide estimates up to 2003 and do not provide industry detail beyond the mining sub-sector. As such, data from Statistics Canada and the Bureau of Economic Analysis (BEA) are used for comparisons between the two countries.

[10] This section draws on CSLS (2003), CSLS (2004), and Sharpe (2007).

[11] Total Factor Productivity (TFP) is also referred to as Multi Factor Productivity (MFP). The difference is purely semantic as both measures attempt to capture the growth in value added that is not accounted for by growth in measured inputs, in particular labour and capital inputs (CSLS, 2005).

process such as skill of the workforce, compositional shifts, improvements in technology and organization, and increasing returns to scale.

In Canada, at the time of writing this report TFP estimates by industry were limited to the 1961-2004 period. In the United States, the Bureau of Labor Statistics does not provide TFP estimates for mining. The CSLS has therefore calculated its own TFP estimates for the United States based on official labour, capital and value added (GDP) estimates. These indexes are calculated with fixed 1997 factor shares according to a Cobb-Douglas production function that exhibits constant returns to scale (CSLS, 2005). In this framework, if the strong assumption of short-run profit maximization is made, the elasticity of output with respect to the labour input is identical to the share of total output paid to labour. The labour share in 1997 is calculated by multiplying average weekly earnings by employment and dividing by current-dollar value added, all for 1997. There are a number of limitations with this approach. Therefore the interpretation of TFP growth must be very broad and it is not possible to simply ascribe changes in TFP to technological change.

Productivity can be expressed either in growth rates or in levels. Economists most often focus on productivity growth rates, which should be based on constant price output and productivity measures to reflect increases in the real volume of output produced per hour worked or per unit of capital stock. In contrast, business analysts most often focus on productivity levels expressed in current dollars as this estimate will capture increases in relative prices. Often, current-dollar productivity levels and real productivity growth rates can move in opposite directions. This is especially true of the mining sub-sector which has experienced relatively volatile prices, and in recent years rapidly rising energy prices.

D. Measurement Issues

The reliability of estimated productivity trends is highly dependent on the quality of the underlying data on current-dollar output, industry price deflators, capital input, and labour input (CSLS, 2003). Since the mining sub-sector produces a marketed output, there is no ambiguity concerning the appropriate measure of output as there often is in non-market sectors such as health care and national defence. In addition, the output of the mining sub-sector can be measured in physical terms, for example, tonnes of coal. Price data is also relatively reliable due to the physical nature of the output.

In 2007, Statistics Canada rated the quality of input and GDP data from the input-output tables for each NAICS industry for the 2002-2003 period (Statistics Canada, 2007).[12] GDP data for the sub-divisions of mining were rated as reliable with output from metal ore mining and output from the non-metallic mineral mining and quarrying industries rated as "most reliable." Input data was rated "most reliable" for the metal ore

[12] The highest quality rating of 'A' - *most reliable* - was assigned to data sets with the largest sample size and smallest under-coverage requiring indirect estimation of missing data. A *reliable* rating of 'B' was assigned to data sets that had some, but not all, of the attributes of an 'A' rating. The lowest quality rating 'C' is assigned to data sets that required significant indirect estimation techniques and relied on source data from small samples.

mining industries and the non-metallic mineral mining and quarrying industries, and reliable for the coal mining and support activities industries. This report assumes that output, price, capital, and labour data are generally reliable and that the productivity estimates therefore capture the true productivity trends. However, there are some issues that may affect productivity estimates that should be noted.

First, it is often difficult to accurately capture quality changes of outputs over time. The quality of mining output refers to factors such as ease of extraction, grade and purity of the deposit, and the size of the deposit. Therefore, quality deterioration of a natural resource base is often correlated with higher costs of extraction.

Second, the treatment of exploration and on-site construction could have significant effects on productivity estimates. Over time, as larger and more easily recoverable deposits of a resource are found and exploited, resources allocated by mining firms to exploration may increase. If there is no measure of exploration in the output of the mining sub-sector, this will show up as a slump in productivity. According to Statistics Canada’s implementation of the International System of National Accounts in 1993, expenditures on mining exploration, whether successful or not, are treated as gross fixed capital formation (Statistics Canada, 1995).

III. Productivity Trends in Mining in Canada

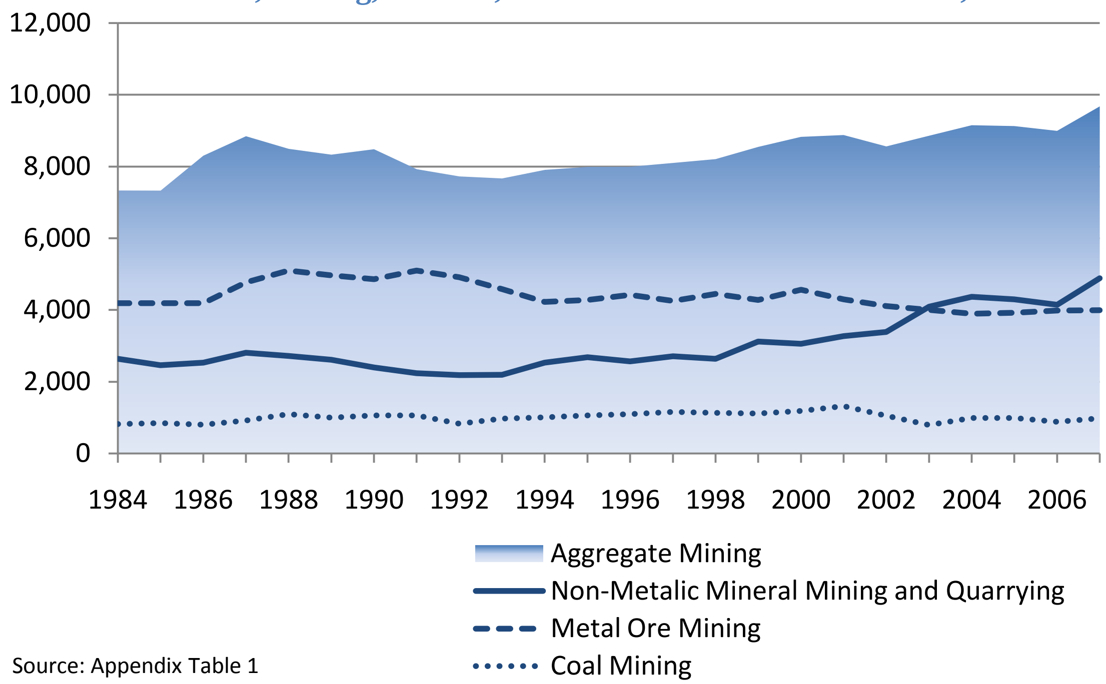
This part of the report explores productivity trends in mining in Canada and in each of its three constituent industry groups: coal mining, metal ore mining, and non-metallic mineral ore mining and quarrying. Each of the elements of productivity estimates, *i.e.* real GDP, hours worked, and real capital stock, are examined. Then, trends in labour productivity, capital productivity, and total factor productivity are explored.[13]

A. Real GDP

As was noted earlier, real GDP in mining accounted for about 0.8 per cent of total real GDP in Canada in 2007. Real GDP in mining in Canada has grown much less rapidly than real GDP in the economy as a whole (Summary Table 2). From 1989 to 2007 real GDP in mining grew at an average annual rate of 0.84 per cent, while real GDP in the economy as a whole expanded by a healthy 2.64 per cent per year. The 1990s were a period of particularly slow growth in mining real GDP (0.53 per cent per year), while the 2000s have seen a small acceleration in real GDP growth, to an average of 1.32 per cent per year between 2000 and 2007.

For the entire 1989-2007 period, coal mining and metal ore mining have generally seen declining real GDP, while non-metallic mineral mining and quarrying experienced relatively strong real GDP growth spurred by the expansion of the diamond industry, especially since 2000 (Chart 1).

Chart 1: Real GDP, Mining, Canada, Millions of Chained 2002 Dollars, 1984-2007



Source: Appendix Table 1

[13] There are gaps in the labour and capital input data at the provincial level for mining. Consequently productivity estimates for mining at the provincial level are not available.

Summary Table 2: Real GDP, Mining, Canada, Chained Dollars, Compound Annual Growth Rates, per cent, 1989-2007

	1989-2007	1989-2000	2000-2007
All Industries	2.64	2.70	2.55
Aggregate Mining	0.84	0.53	1.32
Coal Mining	-0.09	1.58	-2.68
Metal Ore Mining	-1.21	-0.76	-1.90
Non-Metallic Mineral Mining and Quarrying	3.53	1.43	6.92
Stone Mining and Quarrying	..	..	3.96
Sand, Gravel, Clay, and Ceramic and Refractory Minerals Mining and Quarrying	..	..	3.14
Other Non-Metallic Mining and Quarrying	..	..	8.70
Salt Mining	..	..	-0.35
Potash Mining	..	..	2.94
Miscellaneous Non-Metallic Mineral Mining and Quarrying (including diamonds)	..	..	18.71

Source: Appendix Tables 1 and 1a

Note: .. means that data are not available

B. Hours Worked

The number of hours worked in mining has fallen an average of 1.82 per cent per year in the 1989-2007 period (Appendix Table 8). Hours worked fell rapidly in the 1990s, declining by 5.13 per cent per year from 1989 to 2000. The 2000-2007 period saw a turnaround, and hours worked increased at an average annual rate of 3.61 per cent. This pattern of declining hours worked in the 1990s followed by growing hours worked after 2000 was in evidence in all three industry groups. Coal mining was the industry group with the largest average annual decline in hours worked in the 1990s (8.91 per cent) of any of the three industry groups, and also experienced the smallest increase in hours worked after 2000 (1.98 per cent).

C. Real Capital Stock

The real capital stock in mining fell by 1.65 per cent per year from 1989 to 2000 and increased by 1.61 per cent per year from 2000 to 2007 (Appendix Table 10). The increase in real mining stock after 2000 is attributable to the rising capital stock in the non-metallic mineral mining and quarrying industry group, which saw real capital increase by 9.68 per cent per year between 2000 and 2007. The capital stock in the coal mining industry group experienced the largest rate of decline between 1989 and 2000, falling by 6.48 per cent per year on average.

D. Labour Productivity

Labour productivity, defined as real GDP per hour worked, in mining grew rapidly in the 1990s, but has performed very poorly in the period 2000-2007 (Summary Table 3). From 1989 to 2000 labour productivity in mining grew by 5.96 per cent per year, while after 2000, it declined at an average annual rate of 2.21 per cent. This aggregate performance masks significant diversity among the industry groups that make up the mining sub-sector. Nonetheless, all three constituent industry groups experienced robust labour productivity in the 1990s, and saw significant slowdowns after 2000.

The level of labour productivity in mining and its three industry groups exceeded the all industries average level of labour productivity over the entire period. Given that labour productivity growth in mining was considerably higher than the all industries average over the 1989-2007 period, the labour productivity gap in levels between mining and the all industries average widened over the period.

Summary Table 3: Labour Productivity, Mining, Canada, 1989-2007

	1989-2007	1989-2000	2000-2007
	Compound Annual Growth Rate, Per Cent		
All Industries	1.45	1.77	0.96
Aggregate Mining	2.70	5.96	-2.21
Coal Mining	4.97	11.53	-4.56
Metal Ore Mining	1.39	5.43	-4.64
Non-Metallic Mineral Mining and Quarrying	2.60	3.10	1.82
	1989	**2000**	**2007**
	Level, Chained 2002 Dollars		
All Industries	31.82	38.57	41.23
Aggregate Mining	44.98	85.02	72.70
Coal Mining	33.70	111.88	80.68
Metal Ore Mining	46.93	83.93	60.20
Non-Metallic Mineral Mining and Quarrying	56.30	78.80	89.44

Source: Appendix Table 15
Note: Labour productivity is chained 2002 dollars per hour worked.

E. Capital Productivity

Capital productivity in mining grew faster than the all industries average in the 1990s, but fell in the 2000-2007 period (Summary Table 4). All three mining industry groups saw capital productivity growth slow after 2000. The slowdown was especially dramatic in coal mining, which enjoyed capital productivity growth of 8.63 per cent per year from 1989 to 2000, but capital productivity declines averaging 1.85 per cent per year after 2000. In terms of capital productivity levels, mining has relatively low capital productivity, largely reflecting an above average capital intensity. In 2007, mining capital productivity was less than half the all industries average.

Summary Table 4: Capital Productivity, Mining, Canada, 1989-2007

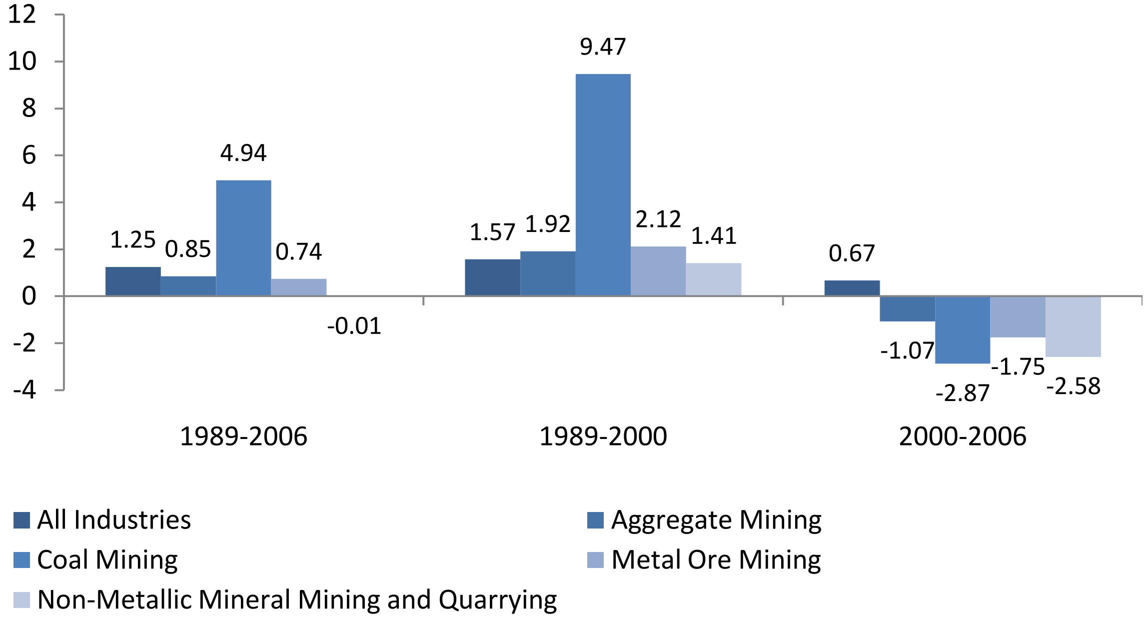
	1989-2007	1989-2000	2000-2007
	Compound Annual Growth Rates, Per Cent		
All Industries	0.86	1.37	0.07
Aggregate Mining	1.23	2.21	-0.28
Coal Mining	4.43	8.63	-1.85
Metal Ore Mining	-0.30	0.28	-1.22
Non-Metallic Mineral Mining and Quarrying	-0.50	0.79	-2.51
	1989	**2000**	**2007**
	Level, Chained 2002 Dollars		
All Industries	826	959	964
Aggregate Mining	335	426	418
Coal Mining	200	498	437
Metal Ore Mining	301	310	285
Non-Metallic Mineral Mining and Quarrying	776	846	708

Source: Appendix Table 11
Note: Capital productivity is real GDP per $1,000 of capital stock, both measured in chained 2002 dollars.

F. Total Factor Productivity

TFP in mining grew at an annual average rate of 0.85 per cent between 1989 and 2006, below the all industries average of 1.25 per cent (Chart 2). Mining experienced a significant TFP growth slowdown in 2000-2006 relative to 1989-2000. During the 2000-2006 period, TFP declined by 1.07 per cent per year while during the 1989-2000 period annual TFP growth had averaged 1.92 per cent per year. Most of the growth over the 1989-2006 period was attributed to coal mining, which saw TFP grow by 4.94 per cent per year. After a significantly above-average growth rate from 1989 to 2000 of 9.47 per cent per year, TFP in coal mining fell by 2.87 per cent per year between 2000 and 2006. Metal ore mining also experienced a similar trend, with annual TFP growth of 2.12 per cent per year from 1989-2000 and a negative growth rate of 1.75 per cent per year from 2000-2006.

Chart 2: Total Factor Productivity, Mining, Canada, Compound Annual Growth Rate, Per Cent, 1989-2006



Source: Appendix Table 17

IV. Productivity Trends in Mining in the United States

Due to the proximity of Canada and the United States many of the factors that influence mining productivity in the United States are also important in Canada. As well, many mining firms operate in both countries, and therefore have access to similar technologies and processes. Comparing inputs, outputs, and productivity measures between Canada and the United States provides context for analyzing Canada's productivity performance and can help explain the productivity slowdown in mining after 2000.

A. The Relative Importance of Mining in the United States and Canada

Mining is relatively less important in the United States than in Canada in terms of both GDP and employment. According to nominal GDP estimates from the Bureau of Economic Analysis (BEA), mining accounted for only 0.26 per cent of total economy nominal GDP in 2004 in the United States, only one-quarter the share of mining in Canada, which generated 1.06 per cent of total nominal GDP in 2004. Employment in mining accounted for 0.15 per cent of all industry employment in 2007 in the United States, less than one-half the level of Canada, 0.38 per cent. In Canada, between 1989 and 2006, real GDP in mining grew by 0.45 per cent per year, while in the United States real GDP growth has been much more rapid, growing at an average annual rate of 3.44 per cent (Appendix Table 22). On the other hand, over the 2000-2006 period, real GDP fell 0.25 per cent per year in the United States, while it rose 0.31 per cent per year in Canada (Appendix Table 1 and Chart 3).

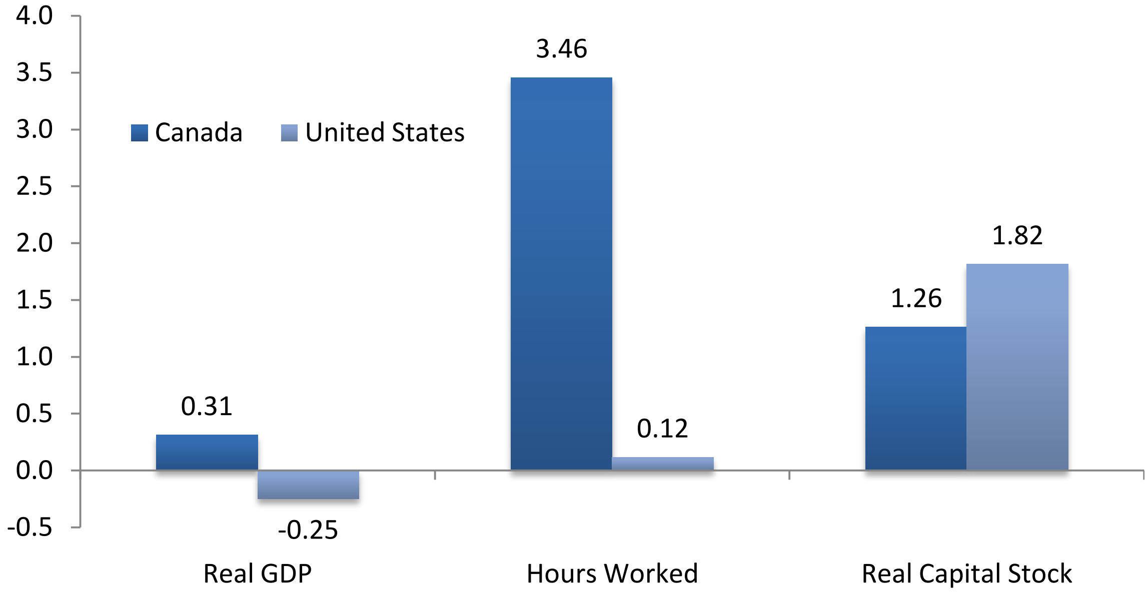
B. Labour and Capital Inputs

In the United States, the number of hours worked in mining fell over the 1989-2006 period by 1.46 per cent per year while total industry hours worked increased by 0.91 per cent per year (Appendix Table 26). During the 2000-2006 period, hours worked in mining increased by 0.12 per cent per year, faster than the all industries average, which saw an annual decline of 0.08 per cent. However, increases in hours worked in mining were much faster in Canada for that same period (3.46 per cent per year). Employment showed similar trends to the number of hours worked.

Real capital stock growth in mining in the United States has been weak over the 1989-2006 period, growing by 0.58 per cent per year, well below the 2.56 per cent annual increase for all industries (Appendix Table 30). Over the 2000-2006 period the real capital stock of mining grew by 1.82 per cent per year, still slower than the all industries growth rate of 2.40 per cent per year. Nonetheless, the real stock of mining capital increased faster in the United States than in Canada between 2000 and 2006. In Canada, the real capital stock grew by 1.26 per cent per year in mining and by 2.25 per cent per year for all industries (Chart 3).[14]

[14] As previously noted in the data sources section, capital input estimates between Canada and the United States are not entirely comparable since Statistics Canada change its methodology in 2006. Yet, BEA and Statistics Canada remain

Chart 3: Comparison of Mining, Canada and the United States, Average Annual Growth Rates, Per Cent, 2000-2006



Source: Appendix Tables 1, 8, 10, 22, 26, and 30

C. Productivity

Mining in the United States has exhibited a less dramatic labour productivity slowdown than in Canada (Appendix Table 28 and Chart 4). From 1989-2006 real GDP per hour worked increased by 2.14 per cent per year, slower than in Canada. Canada experienced stronger labour productivity growth over the 1989-2000 period than the United States. Over the 2000-2006 period labour productivity in the United States increased by 0.66 per cent per year,[15] while in Canada labour productivity fell by 1.34 per cent per year.

Hours worked are only provided in index form by the Bureau of Labor Statistics. Therefore, it is not possible to compare real GDP per hour worked in levels between Canada and the United States. We can, however, compare the levels of real GDP *per* worker across the two countries once the levels have been adjusted for total economy purchasing power parity (Appendix Table 43 and Chart 5). Over the 1990-2006 period, real GDP per worker in mining in Canada was initially above the US level, but fell below it in 1995 and has not exceeded the US level since. Real GDP per worker in mining in Canada was 83 per cent of the US level in 2006.

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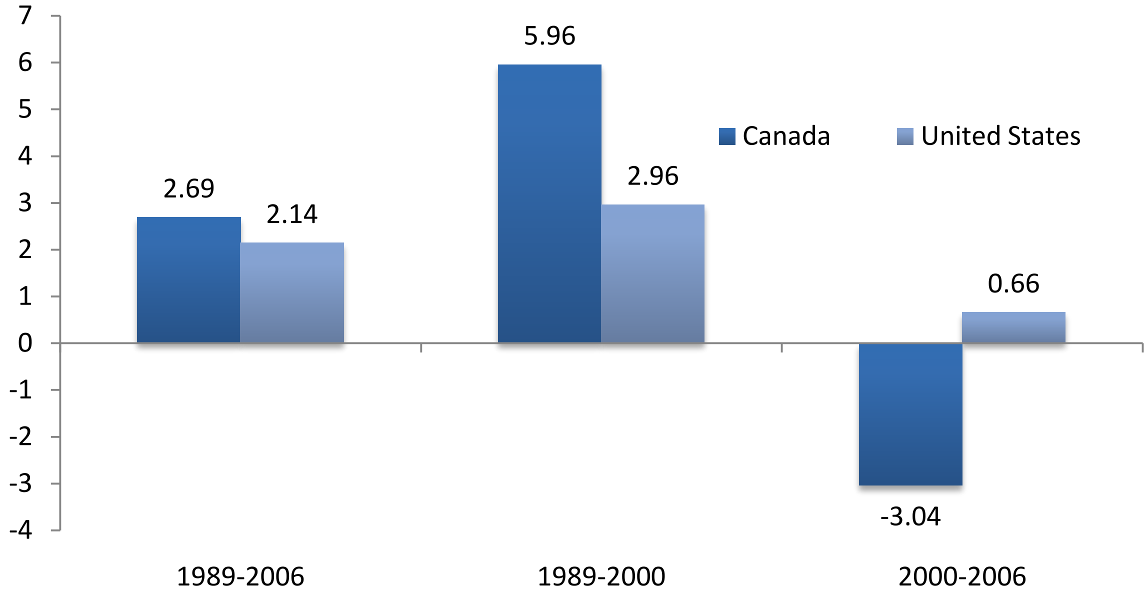
the only sources of data available for years beyond 2003 and will thus be used to provide a rough idea of differences between the two countries.

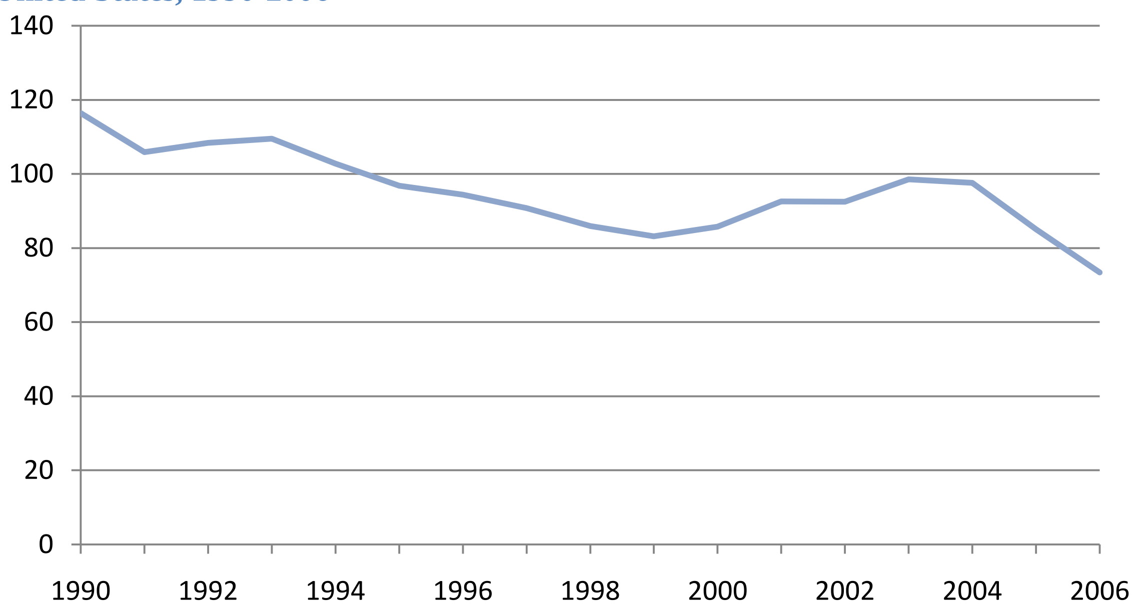
[15] We acknowledge that in the 2000-2006 period, Chart 3 shows rising hours worked and falling real GDP, implying falling labour productivity (-0.37 per cent per year), while Chart 4 shows increasing labour productivity. This inconsistency is a result of real GDP data being drawn from the Bureau of Economic Analysis (BEA), while data on hours worked and labour productivity are drawn from the Bureau of Labor Statistics (BLS). In other words, the output growth implicit in BLS labour productivity is much larger than that provided by BEA.

Chart 4: Real GDP per Hour Worked in Mining, Canada and the United States, Average Annual Growth Rate, Per Cent, 1989-2006



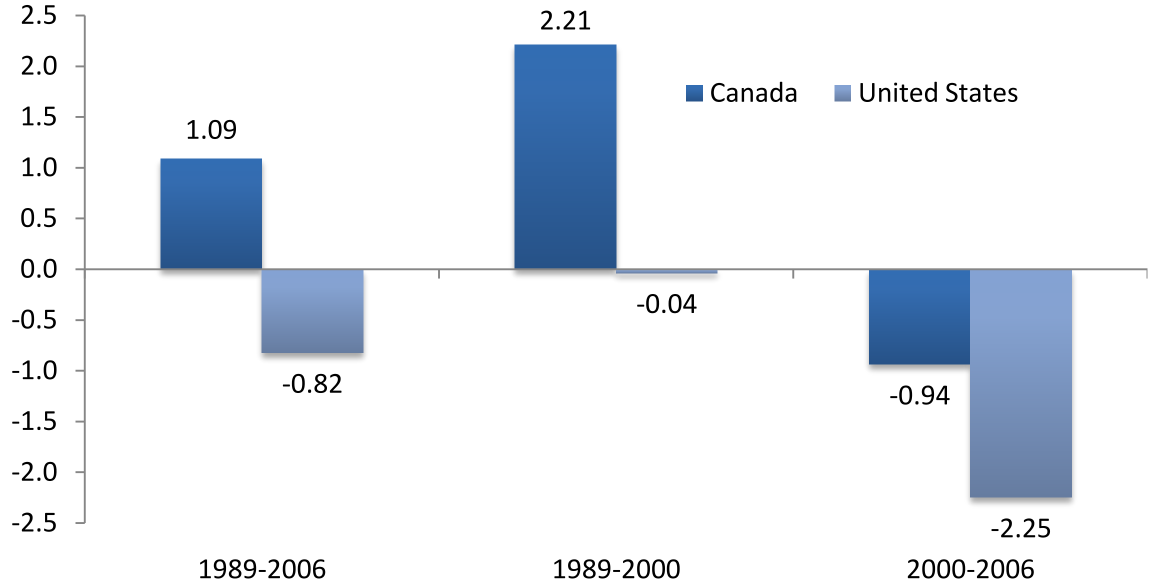
Source: Appendix Tables 15 and 28

Chart 5: Real GDP per Worker in Mining in Canada as a Percentage of that of the United States, 1990-2006



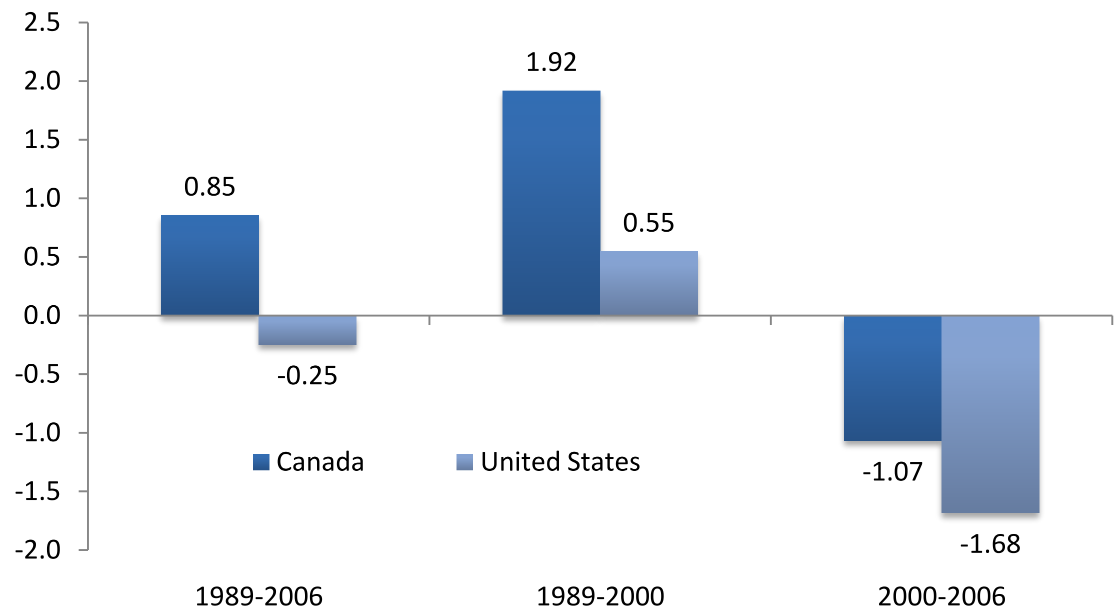
Source: Appendix Table 43

Chart 6: Capital Productivity in Mining, Canada and the United States, Average Annual Growth Rates, Per Cent, 1989-2006



Source: Appendix Tables 11 and 44

Chart 7: Total Factor Productivity in Mining, Canada and the United States, Average Annual Growth Rates, Per Cent, 1989-2006



Source: Appendix Tables 17 and 45

In terms of growth rates of capital productivity, the United States has performed worse than Canada over the 1989-2006 period (Appendix Table 44 and Chart 6). The average annual rate of change of capital productivity over the 1989-2006 period in the United States was -0.82 per cent per year compared to growth of 1.09 per cent per year in Canada. Over the 2000-2006 period, the United States experienced a significant contraction of capital productivity, 2.25 per cent per year, while Canada experienced a smaller average annual decline of 0.94 per cent.

Over the 1989-2006 period, TFP in US mining declined 0.25 per cent per year (Table 45 and Chart 7). Compared to Canada, the United States experienced slower growth during the 1989-2000 period when TFP in mining in Canada increased by 1.92 per cent per year, while the TFP in US mining grew by 0.55 per cent per year. Since 2000, TFP in Canada has declined (by 1.07 per cent per year), but less rapidly than in the United States where TFP fell at an average annual rate of 1.68 per cent.

V. The Contribution of Mining to Aggregate Productivity Growth in Canada

This part of the report provides estimates of the contribution of mining to aggregate labour productivity growth in Canada.[16] In this analysis, we use the methodology developed by Tang and Wang (2004).[17] Tang and Wang's methodology can be applied to chained-Fisher index real GDP even though such measures are not additive across industries. Our analysis covers the 1987-2006 period and selected sub-periods.[18] This part of the report also estimates the contribution of mining to the aggregate productivity slowdown between the 1996-2000 and 2000-2006 periods.

A. The Contribution to Aggregate Labour Productivity Growth

The methodology developed by Tang and Wang (2004) provides a way to decompose aggregate labour productivity growth into industrial components.[19] Their method is based on the assumption that aggregate labour productivity growth attributed to a single industry can arise from three sources: improvements in labour productivity, increases in an industry's labour share, and increases in the real output price of the industry. The contributions of these three sources are quantified in three components: the pure productivity growth effect, the relative size change effect, and the interaction of the first two. The pure productivity growth effect is an industry's labour productivity growth rate weighted by its nominal output share at the beginning of the period. The relative size of an industry is defined as the labour share of the industry multiplied by the relative implicit deflator of the industry. The relative size change effect is weighted by the relative labour productivity of the industry at the beginning of the period. The interaction effect captures the interaction between industry labour productivity growth and the relative industry size, weighted by relative labour productivity.

It is important to note that according to Tang and Wang's methodology, even an industry experiencing negative productivity growth might contribute positively to aggregate productivity growth due to the relative size change effect. This effect captures the impact of the reallocation of labour from low productivity industries to high productivity industries, as well as changes in relative output prices across industries with

[16] Throughout this part, labour productivity is measured as real GDP per hour worked.
[17] Appendix tables also include more common labour productivity growth decompositions using labour input and real output shares as weights (Appendix Tables 55 and 57).
[18] Since nominal GDP data was only available up to 2004 at the time this report was prepared, the nominal GDP series is extended by applying the growth rate of the Bank of Canada Energy price index to the implicit price deflator series for the 2004-2006 period. It is then possible to calculate nominal GDP with the extended implicit price deflator series and real GDP data available to 2006.
[19] The methodology developed by Tang and Wang is similar to the one developed in Nordhaus *et al.* (1972) where aggregate labour productivity growth is decomposed to calculate industry contributions. The Nordhaus *et al.* method takes into account that an increase in the relative size of a highly productive industry, measured by both nominal output share and employment share, can result in an industry with negative productivity growth contributing positively to aggregate productivity growth. Nordhaus *et al.*, however, do not account for the non-additivity of the chained-Fisher index. Sharpe (2009) developed and applied a methodology similar to that of Nordhaus *et al.*, and found that the mining and oil and gas extraction sector did not contribute to productivity growth over the 2000-2007 period (-0.06 percentage points per year).

different productivity levels. To calculate the relative size change effect, the change in the relative size of an industry, which encompasses both the change in its employment share and the change in relative prices, is weighted by the relative labour productivity level of that industry. Since the of level labour productivity in mining is around twice the average level of all industries, and since prices in mining have been growing faster than in other industries in recent years, the relative size change effect is large and positive even though the industry exhibits falling productivity growth rates. In general, unless the economy exhibits a sustained structural shift across industries, the effect of changing relative sizes cannot be the main driver of productivity growth over long periods of time. Over shorter periods, however, shifts across industries can be strong drivers of productivity growth.

Summary Table 5: The Contribution of Mining to Aggregate Labour Productivity Growth, Canada, 1987-2006

	Average Annual Labour Productivity Growth (per cent)		**Average Annual Absolute Contribution Over the Period to Aggregate Labour Productivity Growth** (percentage points)				**Relative Contribution** (per cent)
	Total Economy	Mining	Pure Productivity Growth Effect	Relative Size Change Effect	Interaction Effect	Total Effect	Total Effect
	A	B	C	D	E	F=C+D+E	G=F/A*100
87-06	1.26	1.21	0.02	-0.05	-0.01	-0.04	-3.52
87-96	0.94	1.69	0.03	-0.03	-0.01	-0.01	-1.10
96-00	2.35	6.82	0.09	-0.09	-0.03	-0.03	-1.26
00-06	1.02	-3.04	-0.03	0.16	-0.03	0.10	10.07
Difference: 96-00 and 00-06 (percentage points)	-1.33	-9.86	-0.11	0.25	0.00	0.13	11.33

Source: Calculated by the Centre for the Study of Living Standards from Table 46b.
Note: Methodology based on Tang and Wang (2004).

According to Tang and Wang's methodology, mining made a negative contribution of 0.04 percentage points to aggregate Canadian labour productivity growth over the 1987-2006 period (Summary Table 5). Mining took away 0.01 and 0.03 percentage points from aggregate labour productivity growth over the 1987-1996 and 1996-2006 periods respectively.

Over the 2000-2006 period, labour productivity in mining declined by 3.04 per cent per year, while labour productivity in the entire Canadian economy increased by 1.02 per cent per year. However, mining made a positive contribution of 0.10 percentage points to total economy labour productivity growth, about ten per cent of aggregate labour productivity growth. This counter-intuitive positive contribution is due to the relative size change effect. That is, the size of the mining sub-sector increased due to rising real relative output prices and a high relative labour productivity level (which is used to weight the relative size of the industry). In terms of a pure productivity growth effect, ignoring changes in relative size, mining made a small negative contribution of 0.01percentage points over the 2000-2006 period.

B. The Contribution to the Post-2000 Productivity Slowdown

The contribution of mining to the post-2000 productivity slowdown can also be calculated using Tang and Wang's methodology. The total economy in Canada experienced a labour productivity slowdown of 1.33 percentage points between the 1996-2000 period and the 2000-2006 period.[20] Mining experienced a considerably larger labour productivity slowdown of 9.86 percentage points. Nonetheless, because of the above average increase in hours worked and output prices in the mining sub-sector, it has not contributed to the productivity slowdown, but rather increased its contribution to aggregate labour productivity after 2000. The final row of Summary Table 5 provides the estimates of the contribution of mining to Canada's aggregate post-2000 labour productivity growth slowdown.

From 1996 to 2000 mining made a negative contribution of 0.03 percentage points to the 2.35 annual aggregate labour productivity growth rate. Over the 2000-2006 period, the contribution became positive. Mining contributed 0.10 percentage points of the 1.02 annual aggregate labour productivity growth rate. Increasing relative prices coupled with a high relative productivity level in mining resulted in a total positive contribution to aggregate productivity growth between the 1996-2000 and 2000-2006 periods, resulting in a smaller post-2000 aggregate labour productivity growth slowdown than would otherwise have been the case. Ignoring relative size effects, mining made a negative pure productivity growth contribution of 0.10 percentage points. While mining has experienced rapidly declining productivity, this negative effect on aggregate productivity growth was more than offset by increasing prices and hours workers in this above average productivity level sub-sector.

[20] The measure of the aggregate productivity slowdown is sensitive to the base period. Aggregate labour productivity in Canada experienced uncharacteristically large growth over the 1996-2000 period. If the 1989-2000 period had been used as a base year, the productivity slowdown would have been 0.75 percentage points for the aggregate economy and 7.3 percentage points in mining.

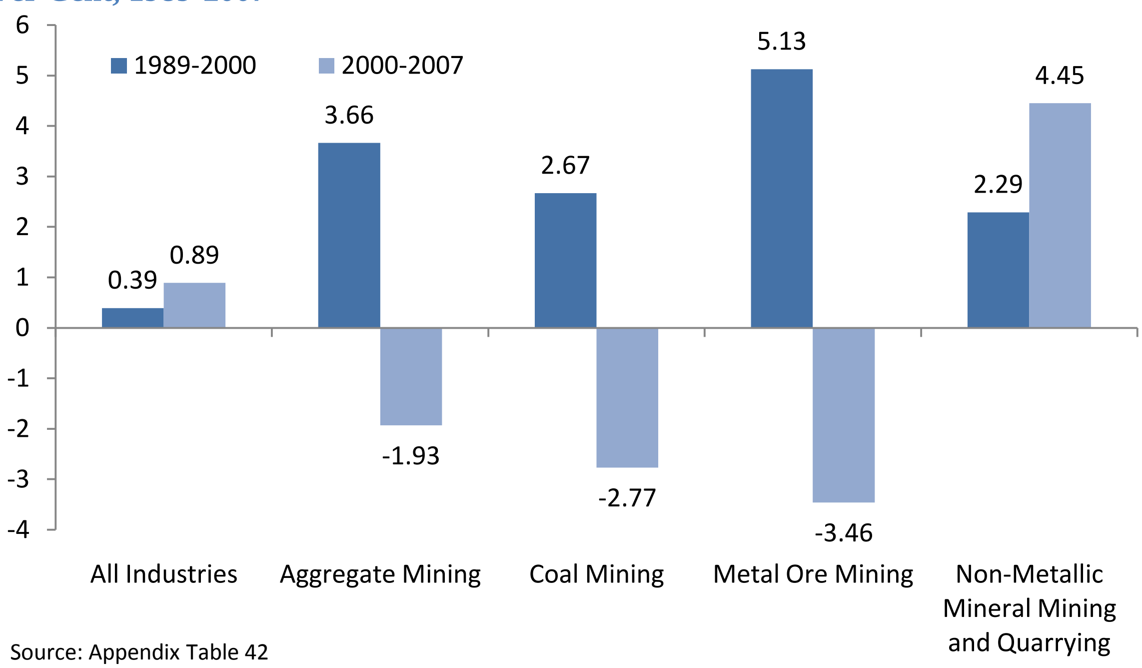
VI. Causes of Falling Mining Productivity in Canada

As discussed earlier, all three measures of productivity (labour, capital, and total factor) in mining in Canada have fallen since 2000. While the sector has not been a net contributor to the post-2000 productivity growth slowdown, these trends remain worrying. This part will provide a detailed examination of possible reasons for this falling productivity: declining capital intensity; higher mining commodity prices; compositional shifts within mining; lagging innovation and technological progress; deterioration of the average quality of the workforce; greater environmental regulation; deterioration of the average quality of resources exploited independent of price effects; labour relations; and taxation.

A. Capital Intensity

A key driver of labour productivity is the capital intensity of production, measured as the capital-labour ratio. An increase in capital intensity means that each worker has more capital with which to work. According to the neoclassical growth accounting framework, the growth rate of labour productivity is equal to the sum of the growth rate of TFP and the growth of capital intensity weighted by the share of capital income in GDP.

Chart 8: Capital-Labour Ratio, Mining, Canada, Compound Annual Growth Rate, Per Cent, 1989-2007



Source: Appendix Table 42

The average annual rate of growth of the capital-labour ratio in mining was much weaker over the 2000-2007 period than over the 1989-2000 period, -1.93 per cent per year compared to 3.66 per cent per year (Chart 8 and Summary Table 6). This slowdown was particularly notable because growth in capital intensity in mining was considerably above the average for all industries before 2000 (0.39 per cent per year between 1989 and 2000), and it fell to a rate that was significantly below the rate of growth for all industries after 2000 (0.89 per cent from 2000 to 2007).

Summary Table 6: Contribution of Capital Intensity Growth to Labour Productivity Growth, Mining, Canada, 1989-2007

	Average Annual Growth Rate				Contribution of Capital Intensity Growth to Labour Productivity Growth	
	Capital Stock	Labour Input	Capital Intensity	Labour Productivity	Absolute (percentage points)	Relative (per cent)
	A	B	C≈A-B	D	E=Capital Share*C	F=E/D*100
All Industries						
1989-2000	1.32	0.92	0.39	1.77	0.21	12.00
2000-2007	2.48	1.58	0.89	0.96	0.48	49.95
Difference	1.17	0.66	0.50	-0.81	0.27	37.95
Mining						
1989-2000	-1.65	-5.13	3.66	5.96	2.26	37.88
2000-2007	1.61	3.61	-1.93	-2.21	-1.19	53.86
Difference	3.26	8.74	-5.60	-8.17	-3.45	42.21

Source: Appendix Tables 8, 10, 15 and 42.
Note: The value used for the capital share of real GDP is from the CSLS productivity database and reflects 1997 values. For the mining sub-sector this value was 61.59 per cent. The all industry capital share in 1997 was 53.78 per cent.

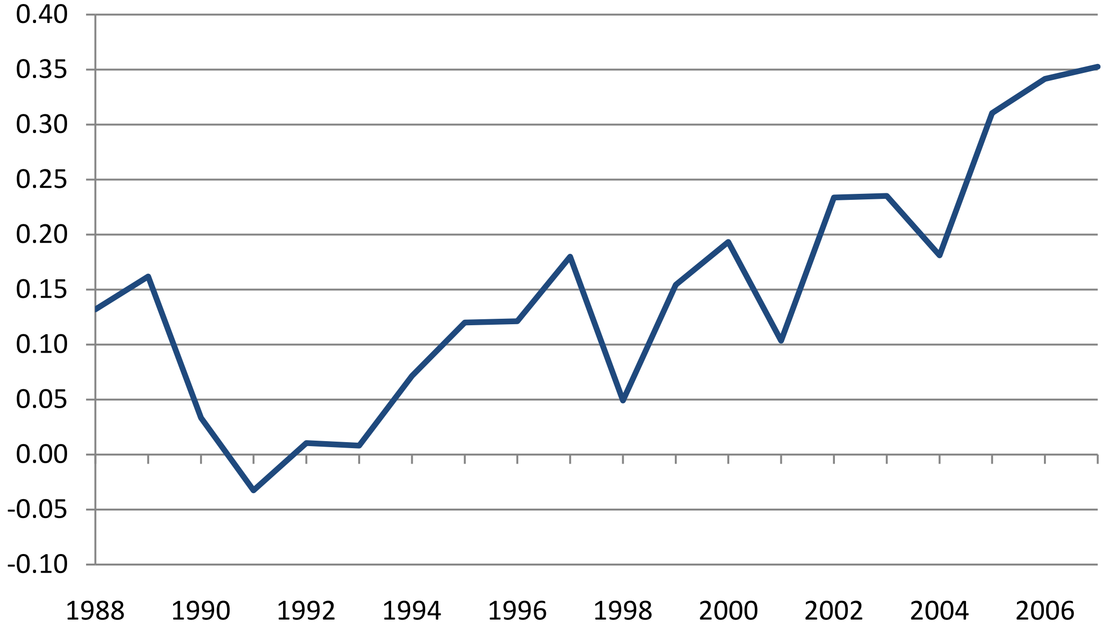
Summary Table 6 provides estimates of the contribution of the decline in capital intensity to the decline in labour productivity that occurred between the 1989-2000 and the 2000-2007 periods. In the 2000-2007 period, the decline in capital intensity in mining accounted for 54 per cent of the decline in labour productivity in mining. Moreover, the decline in capital intensity growth post-2000 explains about 43 per cent of the fall in labour productivity growth in mining. Falling capital intensity is an important explanation for falling labour productivity in mining. But why has capital intensity fallen? The likely reasons for this decline will be developed below.

B. Higher Prices for Energy and Minerals

Prices can have significant impacts on productivity since changing prices can alter the profitability and composition of a sector. The prices of mining outputs are likely driving the productivity performance of the mining sub-sector. When the price of a natural resource increases sharply there are two mechanisms which can act to reduce productivity: a Ricardian effect and a behavioural effect.

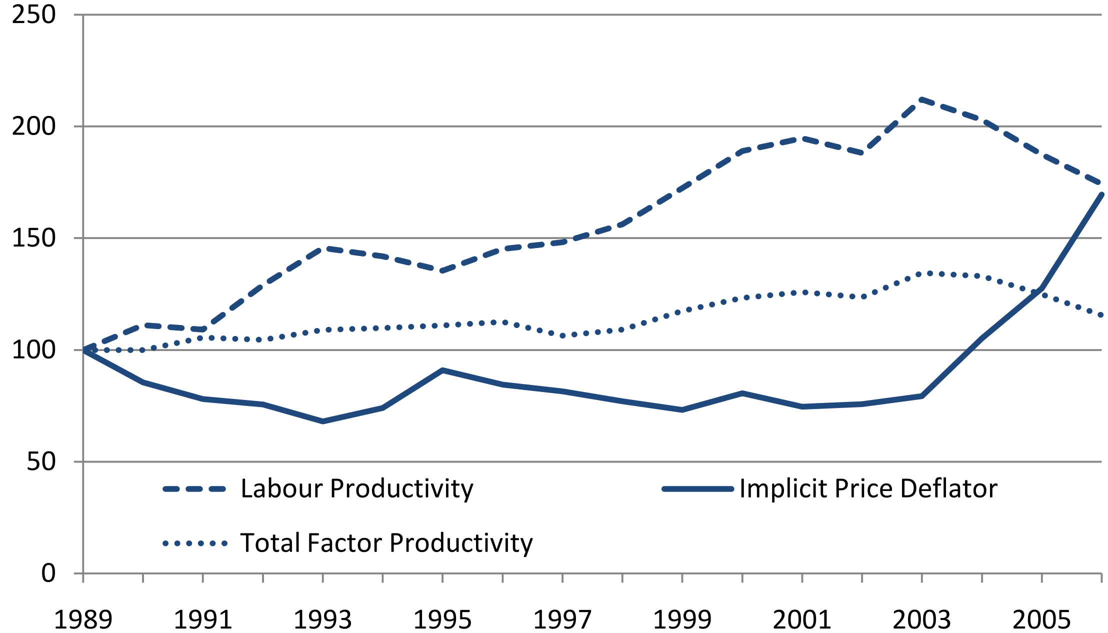
As prices rise it becomes profitable to increase extraction rates from existing deposits and to extract from marginal resource deposits that were previously unprofitable due to high costs of extraction, this is the Ricardian effect of higher prices. In the short-term, because labour is less rigid than capital, we expect this adjustment process to translate into falling capital intensity. Given different grades and pricing conventions for metallic and non-metallic minerals, there is no one single best price series to examine. This report will use the implicit price deflators for each industry group supplemented by commodity price indexes.

Chart 9: Net Profits, Mining, As a Share of Total Economy GDP, Current Dollars, Per Cent, 1988-2007



Source: Appendix Table 71

Chart 10: Prices and Productivity, Mining, Canada, Index 1989 = 100, 1989-2006



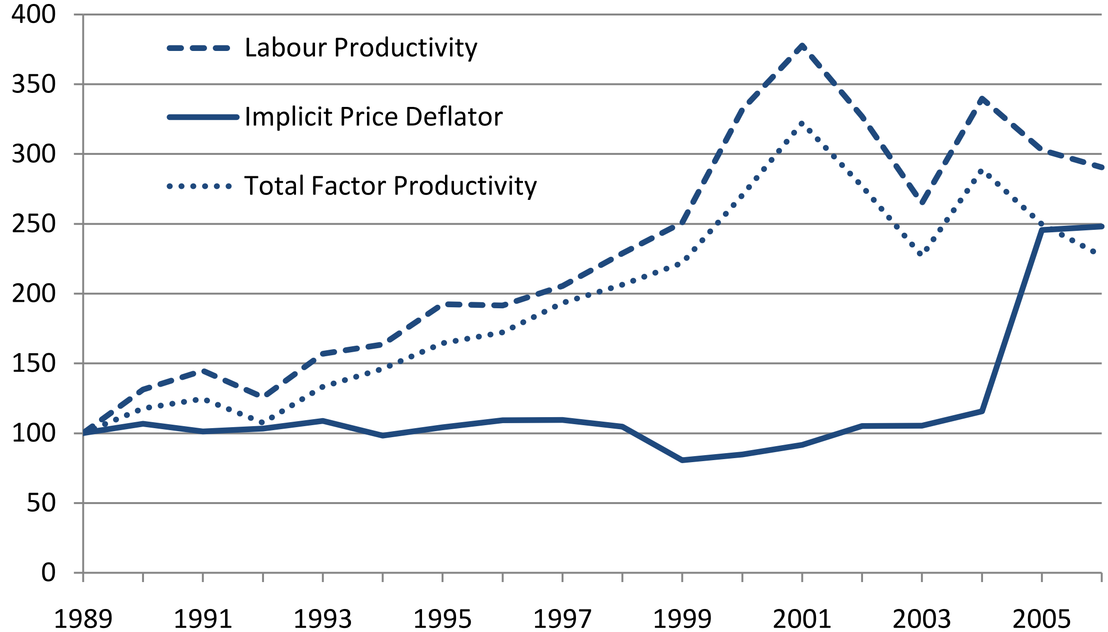
Source: Appendix Tables 5, 15, and 17.

The second effect of higher prices is behavioural. While economists place great weight on productivity, in general, profitability trumps productivity as an objective for firms (Chart 9). On this indicator, the mining sub-sector did very well after 2000. Indeed, mining profits rose from 0.19 per cent of total economy nominal GDP in 2000 to 0.35 per cent in 2007.

Normally the objectives of productivity and profitability coincide, but when they diverge, as for example when commodity prices are extremely high, the productivity growth of a firm, measured in constant prices, may suffer. High prices translate into less attention paid to cost reduction. Despite greater X-inefficiency in operations, the firm will continue to profit due to high prices.[21] As the data will show, mining output prices have risen quickly in recent years, especially since 2003. This inflation has led to poorer productivity growth for firms and the mining sub-sector as a whole (CSLS, 2004). In general, this fall in efficiency would largely be reflected in a fall in TFP growth.

[21] The term 'X-inefficiency' refers to inefficiency in production that cannot be explained with reference to standard economic theory. In the case of resource industries, for example, it is possible that high profitability as a result of high output prices may make firm managers less motivated to encourage productivity growth than they would be if productivity were more integral to their firms' profitability.

Chart 11: Prices and Productivity, Coal Mining, Canada, Index 1989 = 100, 1989-2006



Source: Appendix Tables 5, 15, and 17.

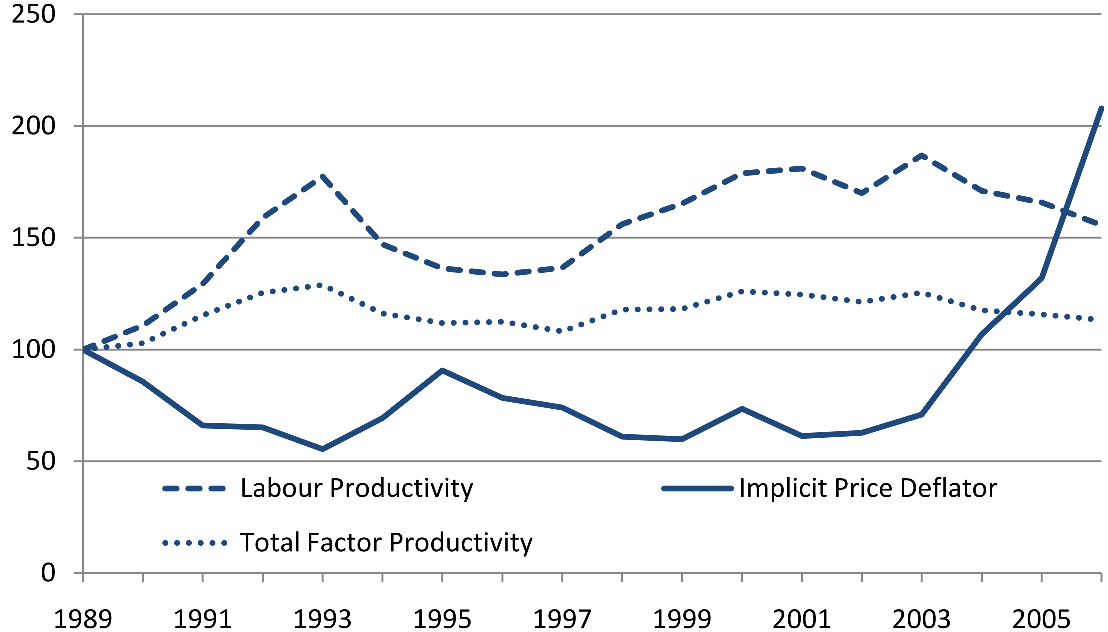
Indeed, between 2003 and 2006, as prices for mining outputs have started to increase significantly, there appears to be a downward trend in productivity (Chart 10).[22] These trends have varied across industry groups within mining.

The implicit price deflator for the coal mining industry group was stable from 1989 to 1997 (Chart 11). Between 1997 and 2000, the coal deflator dropped by 23 per cent and TFP in the coal mining industries increased by 40 per cent. Since 2000 the price of coal has increased sharply, especially since 2004, while TFP in coal mining declined between 2000 and 2006 after peaking in 2001.

Overall, metal ore mining has also seen productivity change in the opposite direction as prices (Chart 12). For instance, prices fell in the early 1990s, as measured by the implicit GDP deflator, while both TFP and labour productivity increased. This pattern has been replicated from 2003 to 2006 as prices have again increased, while productivity has fallen. Detailed data on the industries that make up the metal ore mining industry group allow us to develop a more detailed picture of trends.

[22] The implicit deflator for mining was available to 2004, calculated from National Accounts estimates of real and nominal GDP. The implicit deflator estimates have been extended to 2006 by applying the growth rate of mining value added (current dollars) from Statistics Canada CANSIM Table 152-0005 (*Principal Statistics of the Mining Industry*) for the 2004-2006 period to the nominal GDP estimates from Statistics Canada's national accounts. The level of total value added from Table 152-0005 is not consistent with the national accounts estimates, but the growth rates are similar.

Chart 12: Prices and Productivity, Metal Ore Mining, Canada, Index 1989 = 100, 1989-2006

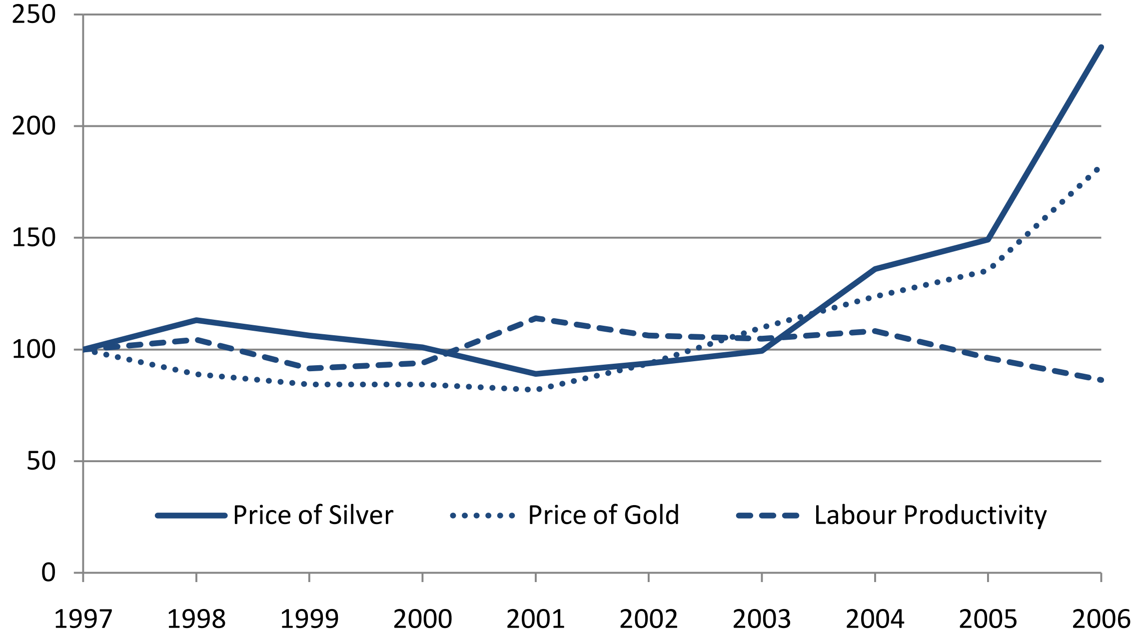


Source: Appendix Tables 5, 15, and 17.

For the gold and silver ore mining industry, real GDP per worker is calculated for the 1997-2006 period (Appendix Table 14a). There is a clear upward trend in the price of gold and silver between 2001 and 2007, each increasing by over seven per cent per year (Appendix Table 68). From a peak in 2001, real GDP per worker in the gold and silver ore mining industry declined by 5.38 per cent per year to 2006 (Chart 13). The peak in productivity in 2001 and the trough of gold and silver prices in that same year imply a strong relationship between prices and productivity in the gold and silver mining industry. The reason productivity levels were the highest when prices were lowest is likely due to a reduction in the exploitation of the least profitable gold and silver deposits at that time. Smith (2004b) concluded that rising prices were the cause of negative labour productivity growth in the gold mining industry between 1973 and 1981, and falling prices contributed to positive labour productivity growth between 1981 and 2000. His conclusion is consistent with our results, *i.e.* that the reversal in price trends in 2001, with prices increasing from 2001 to 2006, has resulted in declining labour productivity.

It is interesting to note that Canada, as one of the few mineral-rich countries with a stable investment environment, ranked first in mineral exploration spending in 2006 (Hoffman, 2008). Increased exploration activities, which generally have a lower level of productivity than extraction activities, generally follow price movements in the underlying commodity. In Canada, increased exploration in recent years would not have an impact on labour productivity in mining, because exploration activities are part of the other support activities for mining" industry (NAICS code 213119), for which data were not available.

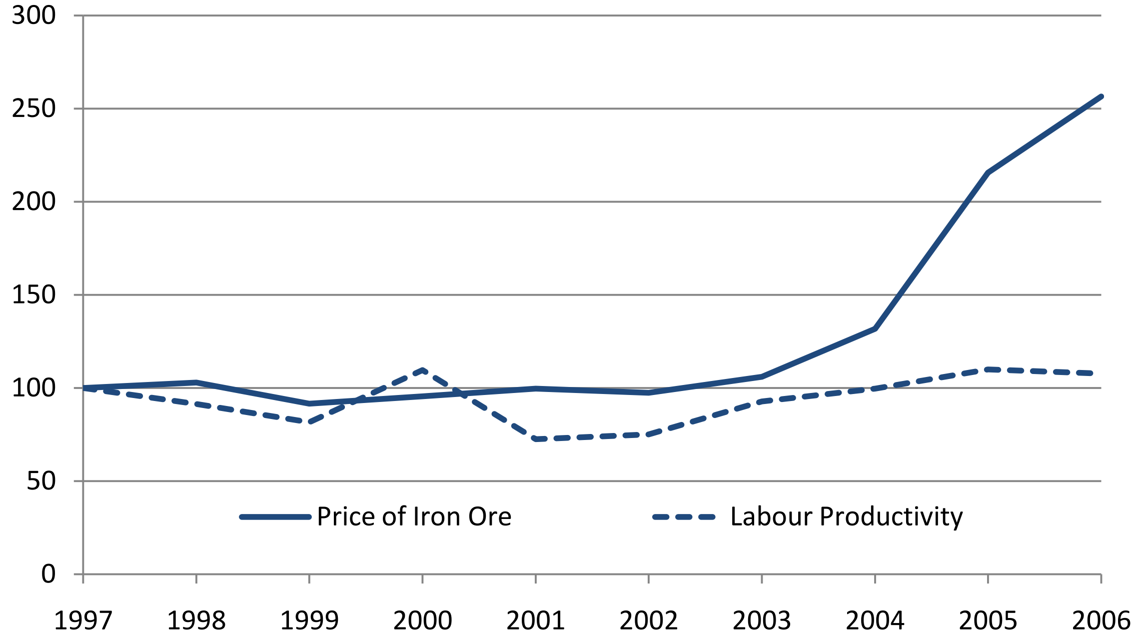
Chart 13: Prices and Productivity, Gold and Silver Ore Mining Industry, Canada, Index 1997 = 100, 1997-2006



Source: Appendix Tables 14a and 68.

The iron ore mining industry experienced a slight decrease in real GDP per worker between 2000 and 2006 of 0.28 per cent per year after rising 3.10 per cent per year between 1997 and 2000 (Appendix Table 14a and Chart 14). The price of iron ore could have had an effect on productivity in the iron ore mining industry as prices rose by nearly 18 per cent per year between 2000 and 2006, while iron ore prices fell 1.53 per cent per year between 1997 and 2000 (Appendix Table 68). Yet, the lack of significant productivity declines in the iron ore mining industry suggests that rising prices have resulted in increased output of constant cost and constant quality iron ore. There has likely not been a compositional shift towards marginal iron ore deposits.

Chart 14: Prices and Productivity, Iron Ore Mining Industry, Canada, Index 1997 = 100, 1997-2006



Source: Appendix Tables 14a and 68.

C. Compositional Shifts Related to the Development of New Mining Industries

An important compositional shift, which has increased productivity, is the rise of the diamond mining industry within the non-metallic mining industry group. Diamond mining is relatively new in Canada, beginning in 1998 with two mines, the Etaki and Diavik mines in the Northwest Territories. By 2003, the diamond mining industry accounted for 34 per cent of nominal value added in the non-metallic mineral mining and quarrying industry, and 15 per cent of nominal value added in mining overall.

The effect of the diamond mining industry on the overall mining sub-sector was surveyed in a CSLS report released in 2004 by Jeremy Smith "The Growth of Diamond Mining in Canada and Implications for Mining Productivity." Based on the limited data that are available, it appears that the knowledge and expertise developed by other mining industries in Canada has given the diamond mining industry a solid foundation (Summary Table 7). Labour productivity growth[23] in diamond mining over the 2000-2006 period was above average, 5.64 per cent per year. More impressive is the very high level of labour productivity, $666,152 (constant 1997 dollars) in 2006, reflecting the high degree of economic rent in the sale of rough diamonds. Since 1998 the level of real GDP per worker in the diamond mining industry has been at least three times as high as the level for the overall non-metallic mineral mining and quarrying industry.

[23] Labour productivity for the diamond industry refers to real GDP per worker as data on hours worked are limited.

Summary Table 7: Principal Statistics for the Diamond Mining Industry [NAICS 212392], Canada, 1997-2006

	Real GDP (millions of 1997 dollars)	Nominal GDP (millions of dollars)*	Nominal GDP as a Share of Non-Metallic Mining Nominal GDP (%)	Employment (persons)	Real GDP per Worker (constant 1997 dollars)	Real GDP per Worker as a Share of Non-Metallic Mining Real GDP per Worker (%)
1997	0	0	0	0	0	0
1998	52	54	1.88	93	559,140	414.9
1999	428.3	538.4	16.33	387	1,106,718	708.5
2000	303.9	459.7	14.93	634	479,338	296.3
2001	446.2	583.7	17.29	731	610,397	350.2
2002	545.4	615.4	18.16	899	606,674	329.6
2003	1,062.8	1,327.4	33.58	1,189	893,879	407.8
2004	1,454.6	1,816.7	36.58	1,591	914,264	420.7
2005	983.9	1,228.8	-	1,352	727,718	371.0
2006	914.6	1,142.3	-	1,373	666,152	383.1
Average Annual Growth Rate, Per Cent						
2000-06	20.16	16.38	-	13.74	5.64	-

Source: Statistics Canada CANSIM Table 152-0005
Note:
Real GDP measured in basic prices.
* Real GDP data not available from 2003-2006 at the five-digit NAICS level. The average of the implicit deflator over the 1998-2002 period was used to calculate an estimate of real GDP for the 2003-2006 period from total value added (current dollars) for the diamond mining industry which is available to 2006.

Summary Table 8: The Diamond Mining Industry's Contribution to Non-Metallic Mining Industry Productivity Growth, 2000-2005

	Diamonds [212392]			Non-Metallic Mining and Quarrying with Diamonds			Non-Metallic Mineral Mining and Quarrying without Diamonds		
	Real GDP	Workers	Real GDP per Worker	Real GDP	Workers	Real GDP per Worker	Real GDP	Workers	Real GDP per Worker
2000	304	634	479,338	2,780	20,300	136,946	2,476	19,666	125,908
2005	984	1,352	727,811	4,139	20,600	200,922	3,155	19,248	163,913
Average Annual Growth Rate, Per Cent									
2000-05	26.48	16.35	8.71	8.29	0.29	7.97	4.97	-0.43	5.42

Source: Summary Table 12 and Appendix Tables 1, 6 and 15.
Note: Real GDP in millions of constant 1997 dollars.

Given the very high level of output per worker in the diamond mining industry and the strong growth of the industry in recent years, the labour productivity growth of the non-metallic mineral mining and quarrying industry has been favourably affected by this compositional shift. Following Smith (2004c), real GDP per worker in the non-metallic mineral mining and quarrying industry would have grown 3.08 percentage points slower per year between 2000 and 2005 without the diamond mining industry (Summary Table 8). The level of real GDP per worker in this sector would have been nearly $40,000 (constant 1997 dollars) lower in 2005 in the absence of the diamond mining industry.

D. Lagging Innovation and Technological Progress

Innovation and technological progress are key drivers of productivity growth. In practice, however, it is difficult to assess the pace of innovation and technological progress. Innovation measures, such as the growth of research and development (R&D) can be used as indicators of the rate of change of technological progress. However, R&D trends within mining may not be relevant as the sub-sector can draw on international technological advances as well as progress in other sectors. For example, research undertaken by the higher education sector, government or other sectors which supply inputs (*e.g.* machinery) to mining will be excluded from R&D measures for mining despite being relevant. Further, R&D is neither a necessary nor sufficient condition for innovation or technological progress (CSLS, 2005). This section will first present estimates of R&D expenditures provided by Statistics Canada. It will then provide estimates from a 2006 study by the Council of Canadian Academies. The section will conclude with a brief look at innovation in mining from the Statistic Canada's Survey of Innovation.

i. R&D Expenditures and R&D Intensity

According to Statistics Canada's Business Enterprise Research and Development (BERD) expenditure estimates, in mining and related services (including NAICS industries 213117 (contract drilling) and 213119 (other support activities for mining)), intramural R&D expenditures decreased by 13 per cent between 2000 and 2007 in nominal terms. A 2001 study by Global Economics Limited, produced for the Mining Association of Canada, found that the majority of mining industry R&D expenditures was meant to improve processes or develop new processes to reduce extraction costs.

R&D intensity, measured as nominal R&D expenditures over nominal value added, stayed above one per cent for the business sector in Canada between 1994 and 2004 (Chart 15).[24] Mining and related support activities experienced falling R&D intensity from 1994 to 2004, dropping from 1.05 to 0.42.

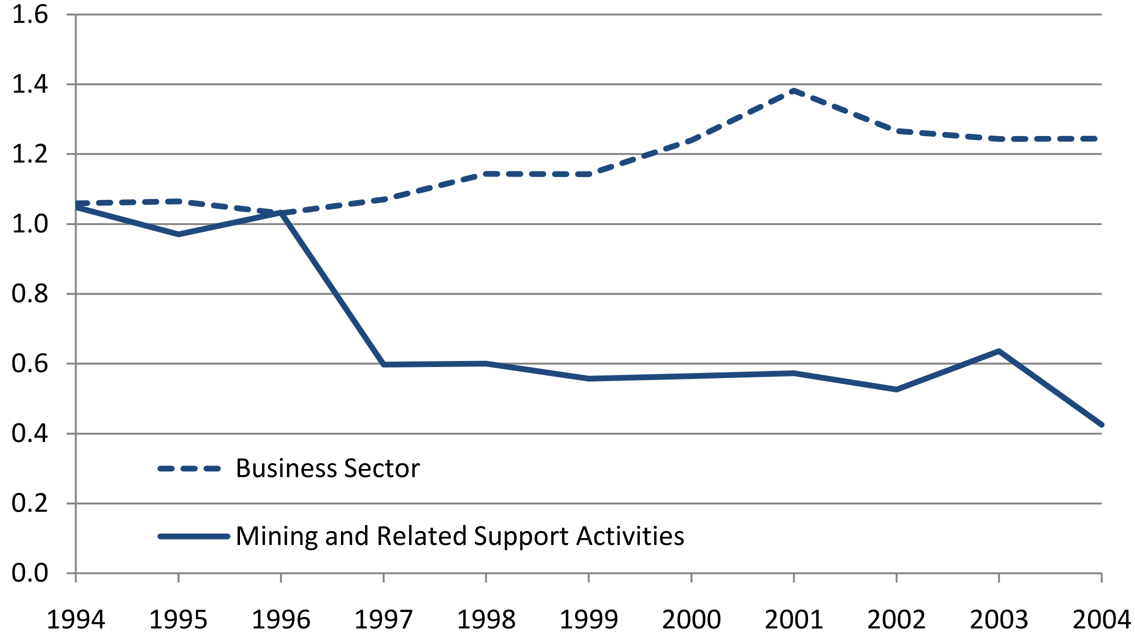
ii. Council of Canadian Academies Study

The Council of Canadian Academies published a study in 2006, *The State of Science & Technology in Canada* for Industry Canada. The report addressed the connection between science and technology (S&T) and innovation. Although there is no "linear progression" between S&T and innovation, the study noted that S&T is essential

[24] Available only to 2004 as nominal value added is only available up to 2004 while R&D intramural expenditures are available to 2007.

for an economy's capacity to innovate. The study undertook various approaches to identify the strengths and weaknesses of Canada's S&T system. The first approach was an opinion survey of Canadian S&T experts who were asked to rank the strength of S&T and its application in 50 areas. According to the survey, mining exploration ranked sixth, mineral extraction and primary processing ranked seventh, and mining and mineral processing ranked thirteenth. Survey respondents were also asked to rank federal government research institutions; Natural Resources Canada institutions as well as federal environmental regulation institutions were given high ranks in terms of S&T capacity and infrastructure.

Chart 15: Research and Development Intensity, Mining, Canada, R&D Expenditure as a Share of GDP, Per Cent, 1994-2004



Source: Appendix Table 61.

A second approach was a bibliometric perspective which measured the intensity of Canadian publications in various fields relative to the rest of the world. This analysis found that publication intensity was above the world average in the mining and mineral process engineering and in the geology. The study also included a review of the foreign perspective on Canada's S&T strengths in which natural resources, specifically mining and energy, were given high rankings consistent with the domestic survey results. The perception of Canada as a world leader in mining technology suggests that lagging technical progress does not explain the post-2000 mining productivity growth slowdown. However, there is no time series data to determine whether the pace of technological progress has fallen off since 2000 despite Canada's high rank in this area on the global stage.

iii. Statistics Canada Survey of Innovation

Statistics Canada released a report examining innovation in industries serving the mining and forestry industries based on the *2003 Survey of Innovation* (Lonmo and Schann, 2005). Their study looked at two industries specific to mining over the 2001-2003 period: “contract drilling (excluding oil and gas)” and “other support activities for mining” (NAICS codes 213117 and 213119 respectively). “Other support activities for mining” includes exploration activities that are often accomplished using purchased services of specialty businesses to obtain core samples. The report highlighted that 84 per cent of establishments in the “other support activities for mining” industry reported Canada-first innovations and 47 per cent reported world-first innovations. Of the establishments engaged in “contract drilling (excluding oil and gas),” 22 per cent reported both Canada-first and world-first innovations. A 2002 Statistics Canada paper focused on innovation in the mining industry based on the *1999 Survey of Innovation* (Schaan, 2002). This report found that less than one in ten mining establishments developed new technologies, but half of the mining establishments introduced new technologies. This indicates that most mining establishments in Canada purchase off-the-shelf technology, or customize and modify existing technologies.

Given these three studies there does not seem to be any evidence of deceleration in terms of innovation or technological progress in mining since 2000. Surveys of innovation indicate that new technologies that have been developed outside of the mining sub-sector are being implemented and adopted. Additionally, it seems plausible that mining is making progress in terms of extraction processes causing the real cost of extraction to fall (i.e. less inputs are needed). However, nominal costs of extraction are rising because of rising input prices.

E. Deterioration of the Average Quality of the Workforce

The quality of the labour force significantly affects labour productivity levels and growth. The level of skill and the ability to acquire new skills, proxied by educational attainment, can fuel labour productivity growth (CSLS, 2003). The level of advanced technology in mining requires a workforce that is highly educated and experienced in technical mining extraction and computer technology (Mining Association of Canada, 2007). Since mining has experienced rapid labour input growth some have suggested that this low rate of unemployment and subsequent hiring of low quality workers has caused the average quality of the workforce to deteriorate.

i. Rapid Employment Growth

Employment in mining increased 3.35 per cent per year between 2000 and 2007, while total economy employment increased by only 1.85 per cent per year over that same period (Appendix Table 6). Coal mining experienced slow employment growth of 1.24 per cent per year, metal ore mining had an increase in employment of 2.91 per cent per year, and the non-metallic mineral mining and quarrying industry experienced strong positive employment growth of 4.50 per cent per year. This rapid increase in employment, particularly in the non-metallic mineral mining and quarrying industry group, suggests that the quality of new hires could significantly affect the average quality of the workforce.

Summary Table 9: Employment by Highest Level of Educational Attainment in Mining, Canada, 2007

	All Industries*	Aggregate Mining	Coal Mining	Metal Ore Mining	Non-Metallic Mineral Mining and Quarrying
Average Years of Schooling	13.76	12.84	13.27	13.72	12.55
Employment by Highest Level of Educational Attainment as a Per Cent of Industry Employment					
0-8 Years	2.56	3.90	na	na	na
Some High School	10.36	14.26	na	13.31	16.97
High School Graduate	20.35	19.69	25.64	13.99	25.23
Some Post-Secondary	8.22	5.77	na	na	8.26
Post-Secondary Certificate or Diploma	35.02	44.65	44.87	50.51	36.70
University Degree or Above	23.48	11.71	na	15.70	na

Source: Tables Appendix 62-66.

ii. Educational Attainment

The average years of schooling in mining was below the all industries average in 2007; this was true of workers in the coal mining, metal ore mining, and non-metallic mineral mining and quarrying industries as well (Appendix Tables 62-66 and Summary Table 9). The industry with the lowest average years of schooling was the non-metallic mineral mining and quarrying industry, where an average worker had 12.55 years of schooling, a difference of 1.22 years from the all industry average. The percentage of workers with a post-secondary certificate or diploma was above 40 per cent in mining in 2001, slightly above the percentage for the Canadian labour force as a whole. Over 40 per cent of workers in the coal mining industries and the metal ore mining industries had a post-secondary certificate or diploma as their highest level of educational attainment. In the aggregate mining sub-sector, only 11.71 per cent of workers had a university degree in 2007. This situation likely reflects the high proportion of production workers in mining.

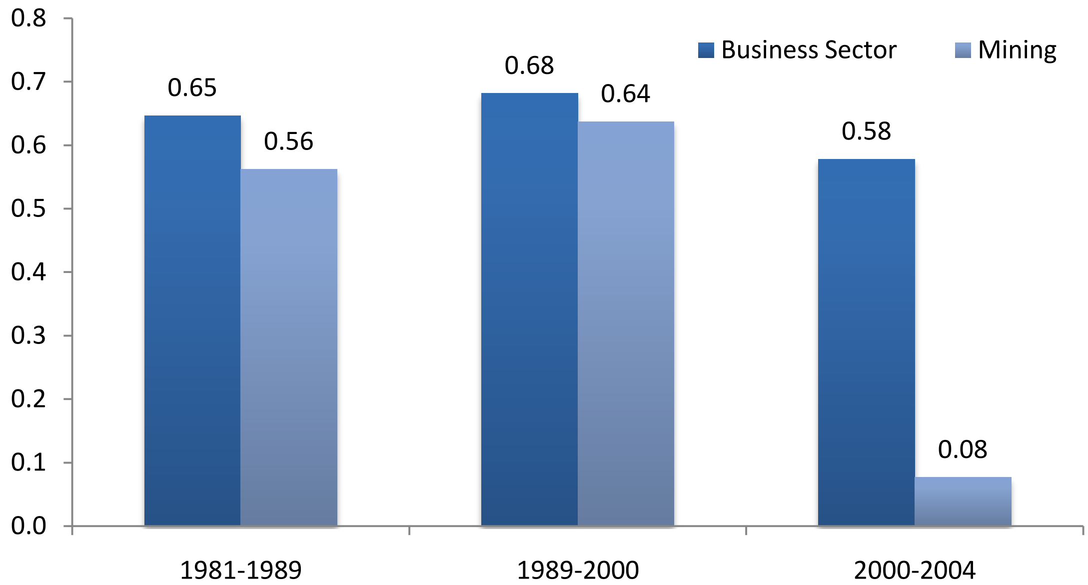
iii. Labour Composition

Statistics Canada estimates labour composition, the ratio of labour input[25] to hours worked, which can be used as a proxy for average quality of the workforce (Appendix Table 70 and Chart 16). An increase in labour composition reflects an increase in

[25] Labour input is a chained-Fisher index of aggregate hours worked adjusted for quality with workers classified by education, work experience, and employment category (self-employed or employee), aggregated using hourly compensation as weights.

educational attainment and work experience. While data were only available to 2004 at the time this report was prepared, it is apparent that growth in labour composition in mining since 2000 has slowed considerably from the pace observed in the 1980s and 1990s. This slowdown is evidence that the average quality of the workforce in mining may be deteriorating relative to other industries.

Chart 16: Labour Composition in the Business Sector and in Mining, Canada, Average Annual Growth Rates, Per Cent, 1981-2004



Source: Appendix Table 70

With high levels of labour input growth since 2000, there appears to have been deterioration in the quality of mining industry's workforce relative to other industries. The quality of the workforce will likely become a larger determinant of the productivity of the industry in the coming years as the Mining Association of Canada (MAC, 2007) identified human resources as a key challenge for the industry. In the next decade, MAC estimates that the Canadian mining industries' workforce will need to expand by 81,000 workers. Over this decade it is estimated that 65 per cent of Canadian geoscientists will reach age 65. Additionally, the number of workers over age 50 is two- to five-times greater than the number of workers under age 30 for all skill categories in mining. Finally, the number of mining engineers graduating from Canadian universities is below the requirements of the industry[26] and Canadian companies are facing competition from foreign firms recruiting Canadian graduates. Although most Canadian industries are experiencing an aging workforce due to Canada's aging population, the reality of an aging workforce is more pronounced in mining than in many other Canadian industries (MAC, 2007).

[26] In 2005, it was estimated that 100 mining engineers graduated from Canadian universities, a third fewer than what was required by the industry (MAC, 2007).

F. Greater Environmental Regulation

It is unclear whether more burdensome environmental regulation has an overall detrimental effect on productivity. Increased resources allocated towards processes needed to meet environmental standards that do not improve the efficiency of the production process will certainly decrease productivity. These resources, however, may indirectly lead to improved productivity-enhancing processes (CSLS, 2004). Despite rising costs associated with environmental regulations, a 2002 study identified strong federal and provincial government support for the mining and oil and gas extraction sector compared to governmental support for environmental protection (Winfield *et al.*, 2002). This governmental support may have dampened the effect of environmental regulation on the sector's productivity. Another issue to consider is that the value of improvements in the state of the environment arising from environmental expenditures is not captured in conventional measures of productivity despite enhancing living standards. Alternatively, if the state of the environment is worse due to mining, a productivity measure which accounts for environmental degradation would indicate that this industry is doing far worse than the conventional measures indicate (Gollop and Swinand, 2001).

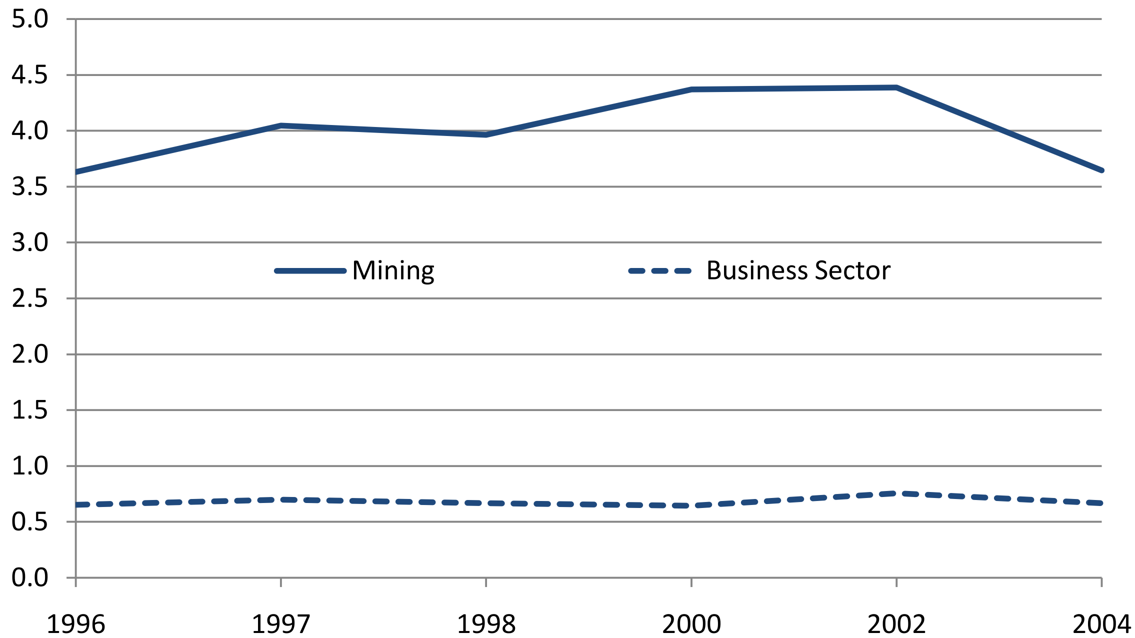
Statistics Canada (2004) provides estimates of total expenditures on environmental protection (EP) by sector and sub-sector for the 1996-2004 period (Appendix Table 69).[27] The mining sub-sector spent an estimated $463 million dollars on EP in 2004, representing 3.7 per cent of mining current dollar value added. In 2004, the entire business sector spent an estimated $6,754 million dollars on EP, or 0.7 per cent of total current dollar business sector value added.

In 2004, irrespective of the industry, about 36 per cent of total expenditure on pollution abatement and control (PAC), and pollution prevention occurred in the western provinces and territories.[28] Operating expenditures on PAC and pollution prevention were highest in Ontario, which accounted for more than one-third of total operating expenditures, while Alberta accounted for nearly one-quarter. Capital expenditures on PAC and pollution prevention were highest in Alberta, which accounted for over 40 per cent of total expenditures, Ontario accounted for 23 per cent (Statistics Canada, 2004).

The estimates of EP expenditures suggest mining faces a greater environmental regulation burden than other sectors and sub-sectors. Expenditures on EP have increased by 43 per cent in mining and by 62 per cent in the business sector between 1996 and 2004. The share of total business sector EP expenditures undertaken in mining has not changed significantly over that period, remaining around seven per cent. Similarly, EP expenditures as a share of nominal GDP in mining remained around 4 per cent over the period (Appendix Table 69 and Chart 17).

[27] Environmental Protection includes the following activities: environmental monitoring, environmental assessments and audits, reclamation and decommissioning, wildlife and habitat protection, pollution abatement and control processes (end-of-pipe), pollution prevention processes, and fees, fines and licenses.
[28] Western province and territories includes Manitoba, Saskatchewan, Alberta, Yukon Territory, Northwest Territories, and Nunavut.

Chart 17: Environmental Expenditures as a Share of Nominal GDP, Canada, 1996-2004



Source: Appendix Table 69.

Despite the fact that mining faces a greater environmental regulatory burden, it does not appear that this burden has changed significantly since 2000. While the level of EP expenditures increased dramatically between 2000 and 2004 in mining (from $410 millions to $463 millions), as a percentage of nominal GDP, the EP expenditures actually decreased (4.37 per cent versus 3.65 per cent). Therefore, it does not appear as though environmental regulation is a likely cause of the post-2000 productivity slowdown.

G. Deterioration of Average Quality of Resources Independent of Price Effects

Independent of price effects, the geological characteristics of resources extracted by miners may have contributed to the productivity slowdown. In the natural resources literature, a decline in the quality of a resource is associated with a rise in the cost of extraction. The quality of an extractive resource is determined by various characteristics: geographical location, size of resource deposit, ease of extraction, and grade and purity of deposit. Over time, independent of price movements, the quality of extractive resources tends to decline since large, easily accessible resources are often the first to be located and extracted. However, the deterioration of resource quality independent of price effects is not easily identifiable as mining activity is often determined by resource prices. There are often many forces affecting the quality of a resource, notably: price, transportation costs, and geological characteristics.

In mining, the average grade of ore mined is an indicator of the quality of the resource. An ore grade is a measure of the concentration of a mineral in the surrounding volume of ore in a mineral deposit. The grade of a specific ore is measured according to deposit type, a categorization based on geological characteristics of a deposit such as how the deposit was formed. Lydon *et al.* (2006) provide historical data on the average grade of ores mined in Canada from 1977 to 2003 for various deposit types. Lode gold deposits, the largest producing deposit type of gold, show an increase in the average grade of gold ores mined. Volcanogenic massive sulphide (VMS) ore deposits, Canada's prime source for silver and zinc ore, have shown constant average grades of silver and zinc as well as copper and gold. Magmatic nickel-copper deposits, from which the majority of nickel deposits are extracted, show a slight increase in the average grade of nickel over the time period. The average grade of copper ore mined from this type of deposit has stayed constant over the period after spiking in the mid 1990s. Uranium deposits have produced a constant high grade of uranium ore despite price fluctuations. SEDEX deposits, which allow for large tonnage mining of zinc, lead and silver, have shown constant average grades of lead and silver ore and a gradual increase in the grade of zinc ore. Overall, the data do not support the hypothesis that there has been deterioration in the quality of various mainstay ores mined in Canada.

H. Labour Relations

According to Statistics Canada, the unionization rate is declining in some natural resource industries. The unionization rate in the forestry, fishing and mining and oil and gas extraction sector fell from 30.9 per cent in 1997 to 22.6 per cent in 2007 (Appendix Table 72). These are much lower rates than in the 1970s and 1980s. In 1976, 43.2 per cent of natural resource industry employees (including the utilities industry) were unionized, (Galarneau, 1996). This figure fell to 33.5 per cent in 1986. The total number of strikes in Canada fell from 1,028 in 1980, to 379 in 2000 and to 293 in 2005.[29]

There is an extensive literature on unionization and labour relations, most in relation to coal mining. The implications of this literature can be extended to the aggregate mining sub-sector due to similar work conditions and production processes. Much of the literature on unionization and workplace safety regulation focuses on the 1970s, when safety regulations became more stringent and there was increased strike activity in the coal mining industry (Naples, 1998; Darmstadter. 1999; and Ellerman *et al.*, 2001).

Naples (1998) found that labour unrest and strike activity had a more noticeable effect on the productivity slowdown of the 1970s than did unionization. It is not surprising that a negative relationship between unionization and mining productivity has been identified in the 1970s; unions were the first to call for safety regulations, which required firms to make considerable adjustments to their production process. Chezum and Garen (1998) investigate the possible effect of unionization on productivity in US coal mining in the early 1980s. They conclude that the positive relationship between productivity levels and unionization in coal mining in that period is likely spurious since unions tended to be more prevalent in mines that had favourable geological attributes

[29] These figures are not specific to mining, and should be viewed as suggestive of broad trends.

(Smith, 2004a). Their work implies that the effect of unionization on productivity in coal mining is likely minor.

I. Taxation

The taxation policies facing the industry could have productivity effects since such policies affect the incentives to invest.[30] Brewer, Bergevin and Arseneau (1999) and Dahlby (1999) provide detailed reviews of the tax policies facing Canadian mining industries. Mining companies face both corporate taxes and resource royalties; the latter are designed to capture the economic rent of mineral extraction, or in other words the return over and above the cost of extracting the resource. There are, however, special provisions in the corporate tax code for mining, including deductibility of exploration expenses and accelerated depreciation on some capital investments. Overall Dahlby (1999) finds that the taxation burden for Canadian mining industries is below that of other Canadian industries and comparable to that for mining industries in other countries. Therefore, the Canadian taxation system does not appear to be impeding innovation in mining.[31]

Profit data from Statistics Canada show that net profits have risen in mining, increasing from $2,081 million in 2000 to $5,414 million in 2007. In addition to rising profits, investment has increased from $3.2 billion in 2000 to $4.5 billion in 2007 (real $2002 dollars). Rising profits and investment since 2000 indicate that the Canadian taxation system does not seem to be a cause of the post-2000 productivity slowdown.

J. Summary of Causes of Falling Mining Productivity Growth in Canada

This section examined nine possible explanations of falling mining productivity in Canada: declining capital intensity; higher mining commodity prices; compositional shifts within the sub-sector; lagging innovation and technological progress; deterioration of the average quality of the workforce; greater environmental regulation; deterioration of the average quality of resources exploited independent of price effects; labour relations; and taxation. Summary Table 10 provides a summary of the evidence and conclusions regarding these nine potential drivers.

[30] This discussion is taken from Smith (2004b).
[31] An earlier study by Boadway *et al.* (1987) found that some mining taxation provisions may be biasing investment towards exploration and development and away from other types of investment, such as innovation in the extraction process (although this does not conflict with the proposition that the disincentives to innovate are less in mining than in other Canadian industries). They argue that a tax on pure profits, as opposed to the corporate tax with special provisions, would remove this distortion. More recently and not specific to Canada, Andrews-Speed and Rogers (1999) also suggest that directing taxes only at mining companies' profits would be best for innovation, since this would provide a joint incentive to companies and governments to reduce mining costs (*i.e.* through the adoption of new technologies and processes) (Smith, 2004a).

Summary Table 10: Summary of Causes of Falling Mining Productivity Growth in Canada

Hypothesis	Evidence	Conclusion
1. Capital Intensity	Capital intensity (capital-labour ratio) fell over the 2000-2007 period by 1.93 per cent per year while it grew over the 1989-2000 period by 3.66 per cent per year.	The falling growth in capital intensity between the 1989-2000 and 2000-2006 periods accounted for 42 per cent of the post-2000 slowdown in mining productivity growth. For the 2000-2007 period, declining capital intensity accounted for 54 per cent of the negative growth in labour productivity.
2. High Prices for Energy and Minerals	Prices in the mining sub-sector nearly doubled between 2000 and 2006, increasing economic rents and profitability.	Profitability appears to have trumped productivity.
a. Ricardian Effect / Price Related Compositional Shift	More intensive exploitation of current deposits and exploitation of marginal resource deposits were driven by higher commodity prices.	Higher usage of labour at the margin and higher costs of extraction have resulted in declining labour productivity.
b. Behavioural Effect	Profits in the mining industry increased from 0.19 of nominal GDP in 2000 to 0.35 in 2007.	Significant increases in economic rents have likely resulted in an increase in X-inefficiency, resulting in declining total factor productivity.
3. Compositional Shifts Related to the Development of New Mining Industries	New mining industries, particularly the diamond mining industry, have developed significantly due to the discovery of new deposits. The level of labour productivity in the diamond mining industry in 2005 was 4 times greater than the average for the mining and oil and gas extraction sector.	The rise of the diamond industry over the 1998-2005 period has resulted in a positive effect on output and productivity in the non-metallic mining industry. This composition effect resulted in positive productivity growth in the non-metallic mining industry over the 2000-2006 period.
4. Lagging Innovation and Technological Progress	R&D Intensity in mining is below the Canadian business sector average, but has been increasing since 2000. Evidence shows that most mining establishments do not develop their own new technologies, but rather introduce new "off the shelf" technologies.	The Canadian mining industry is at the forefront of the technological frontier and does not appear to be lagging in terms of innovation.
5. Deterioration of the Average Quality of the Workforce	The educational attainment of the average worker in mining is below that of the overall economy. Moreover, a large influx of new workers may have created downward pressure on the average quality of the workforce.	Because of a rapid increase in labour input, there appears to be a slight downward trend in the growth rate of the average quality of the workforce in the mining sub-sector relative to the Canadian business sector.
6. Greater Environmental Regulation	Environmental protection expenditures, as a share of nominal value added, are much higher in the mining industries than in the Canadian business sector.	Mining faces a higher environmental regulation burden than the average industry in the business sector. However, this burden does not appear to have increased since 2000.
7. Deterioration of Average Quality of Resources Independent of Price Effects	The average grade of ores mined in Canada has remained relatively stable over the 1977-2005 period.	There is no evidence of decreasing quality of resources independent of price effects.
8. Labour Relations	The level of unionization has fallen in the forestry, fishing, and mining and oil and gas extraction industries between 1997 and 2007.	There is no evidence that strikes or unionization have affected productivity growth.
9. Taxation	Investment and profits in mining have increased substantially between 2000 and 2006.	There is no evidence that the Canadian taxation system is a cause of the industry's productivity slowdown.

Upon examining various hypotheses put forward to explain falling productivity in mining, both in terms of growth and levels, the most robust seems to be the effect of higher prices and its effect on both capital intensity and TFP. As prices rise it becomes profitable to increase extraction rates at existing deposits and to extract from marginal resource deposits that were previously unprofitable due to high costs of extraction. In the short-term, because labour is less rigid than capital, we can expect this adjustment process to translate into a falling capital-labour ratio. In general, profitability trumps productivity as an objective for firms. Normally the objectives of productivity and profitability coincide, but when they diverge, as for example when commodity prices are extremely high, the productivity growth of a firm, measured in constant prices, may suffer due to greater X-inefficiency in operations. This would be reflected in a fall in TFP growth.

Data on TFP and capital intensity suggest that falling capital intensity growth rates can explain a large part of the productivity slowdown in mining between the 1989-2000 period and the 2000-2006. Yet, it also suggests that the decline in labour productivity (negative growth) in mining is largely due to sustained negative TFP growth. These findings imply that while more intense extraction at the margin has driven the recent slowdown, it is an increase in X-inefficiency which is a key explanation behind falling labour productivity growth in the sector. These findings reinforce the idea that higher prices were the main driver of both the post-2000 labour productivity slowdown.

VII. Implications of Falling Mining Productivity for the Canadian Economy

Since productivity growth is the key driver of increases in living standards, the deceleration in labour productivity growth in Canada after 2000 implies a slower rate of increase in living standards. But improving terms of trade are also a source of real income increases. The higher commodity prices that Canada has enjoyed in recent years, in addition to the negative effect on mining productivity, have boosted the real income of Canadians (Kohli, 2006 and Macdonald, 2007). This development has offset some of the shortfall in real income growth from lagging productivity growth in mining. This part of the report will first describe the implications of falling productivity in mining on living standards, and will then explore the offsetting effects of improved terms of trade. The final section will outline a suggested policy response to the falling mining productivity.

A. Implications of Falling Mining Productivity and the Post-2000 Aggregate Productivity Slowdown

Economic well-being is best defined as a country's standard of living, which can be proxied by the level and growth of a country's per capita income (Sharpe, 1998). In the short run, per capita incomes can be increased by increases in the employment/population ratio, average hours worked, and the terms of trade (price of exports relative to price of imports). The growth of these factors, however, is limited. In the long run, the only way to sustain increases in per capita income is through productivity growth. Productivity growth provides resources to invest in areas that can improve the quality of life for individuals such as education, the environment, infrastructure, and health (Rao *et al.*, 2005).

As the fifth part of this report has shown, mining did not contribute to the labour productivity slowdown in Canada after 2000. This was due to increasing relative output prices, an increasing share of hours worked, and higher relative levels of labour productivity in the mining sub-sector. These factors offset declines in productivity growth in the sub-sector. Rao *et al.* (2005) attribute much of the post-2000 productivity slowdown to the ICT-producing sector, which experienced a productivity collapse in 2000. They hypothesize that the productivity slowdown in Canada is a return to trend productivity growth of the 1973-1996 period after experiencing abnormally high growth in the 1996-2000 period. Over that 23-year period, labour productivity in the Canadian total economy grew 1.06 per cent per year. During the 1996-2000 period, aggregate labour productivity grew more than twice as fast, 2.35 per cent per year. Over the 2000-2007 period aggregate labour productivity grew 0.98 per cent per year, which supports the hypothesis that the post-2000 slowdown is a return to the 1973-1996 trend. While it is important to be aware of how mining has affected aggregate productivity growth, it is also important to recognize the boost in the real incomes of Canadians due to high commodity prices has dampened the effect of lagging productivity on real income growth.

B. Can Improved Terms of Trade Offset the Negative Impact of Falling Mining Productivity on Real Incomes?

High commodity prices have coincided with and indeed produced falling productivity growth in mining, and potentially contributed to a decline in the rate of growth of the real income of Canadians. However, there is a positive impact from high commodity prices on the incomes of Canadians: improved terms of trade. As a country's terms of trade improve, the volume of imports a country can purchase for a given volume of exports increases. An improvement in terms of trade has a similar effect on real incomes as that of productivity growth: consumers are able to consume more goods and services from their available resource base.

Summary Table 11: Real GDP and Real GDI Growth in Canada and Selected Provinces, 2002-2005

	Total Real GDP Growth (per cent)	**Total Real GDI Growth** (per cent)	**Trading Gains** (percentage points)
	A	**B**	**C=B-A**
Canada	8.3	13.4	5.1
Newfoundland and Labrador	5.7	23.2	17.5
Nova Scotia	3.6	9.3	5.7
Quebec	6.3	7.8	1.5
Manitoba	6.7	8.4	1.7
Saskatchewan	10.8	18.9	8.1
Alberta	13.5	38	24.5

Source: Macdonald (2007b).

Macdonald (2007b) quantified the gains due to improvements in terms of trade in Canada and the provinces over the 1981-2005 period (Summary Table 11). According to his calculations, real Gross Domestic Income (GDI), which is a measure of the real purchasing power of income, grew at the same rate as real GDP over the 1981-2002 period. However, real GDI increased by 13.4 per cent in Canada between 2002 and 2005, while real GDP increased by only 8.3 per cent over the same period.[32] The difference between real GDP and real GDI growth is due to trading gains which arise from fluctuations in the terms of trade and in the real exchange rate. According to Macdonald, the terms of trade was the dominant factor affecting trading gains in Canada over the 2002-2005 period.

[32] Kohli (2006) also estimated the average annual growth rate of real GDP and real GDI over the 2002-2005 period. His estimates are consistent with those of Macdonald (2007b), with real GDP growth of 8.2 per cent over the period and real GDI growth of 13.4 per cent. More recently, Ross (2009) defined, estimated and discussed trends for eight measures of income and product for Canada and the United States for the 1980-2008 period. He found that in Canada, income measures have grown faster than product measures between 1980 and 2008, while this was not the case in the United States. This trend was even more apparent over the 2000-2008 period.

It seems unlikely that the booming mineral prices can be sustained in the long run. As the rate of growth of prices declines and possibly turns negative, Canada's terms of trade will stabilize and possibly deteriorate, as indeed happened in late 2008 and in 2009. However, there may be an offsetting effect of slower, or negative, growth in commodity prices: an improvement in productivity growth given the negative relationship that appears to exist between prices and productivity in mining.

C. Should There be a Policy Response to Falling Mining Productivity?

This report does not recommend any industry-specific policies to improve productivity growth in mining above and beyond general public policies to improve productivity, such as investments in human capital and innovation (e.g. Sharpe, 2007). Despite the rapid decline in the growth rate of productivity in mining, it is not necessarily true that Canadians are worse off. Falling mining productivity is a result of business decisions driven by profits and the exploitation of marginal deposits. Therefore, falling productivity is not a public policy issue. Further, the landscape of the mining business is determined largely by commodity prices, over which policy-makers have very limited control.

Another reason why a policy response to falling mining productivity growth is not necessary is that there does not appear to be technological stagnation within the sub-sector. The decline in mining productivity is largely a composition effect. Additional resources have been allocated to less productive operations which are now profitable due to high commodity prices. Further, Canada is considered to be on the frontier of technological developments in mining. In contrast, other industries, such as manufacturing, face intense cost competition and productivity growth is necessary in order to maintain competitiveness. In mining, the high economic rent, therefore, makes productivity less important compared to other industries, although certainly still desirable.

VIII. Conclusion

In recent years, the productivity performance of mining in Canada has been very poor. According to official real GDP and labour input estimates from Statistics Canada, labour productivity in mining fell by 0.94 per cent per year between the 2000 cyclical peak and 2007, with capital productivity down 0.28 per cent per year and total factor productivity (TFP) off 1.07 per cent per year between 2000 and 2006.

Canada as a whole experienced a significant slowdown in labour productivity growth between the 1996-2000 and 2000-2006 periods, from an average annual rate of labour productivity growth of 2.35 per cent to 1.02 per cent. Without higher output prices and hours worked in the high-productivity level mining sub-sector which translated into a positive contribution from this sub-sector, this slowdown would have been more severe.

There are number of possible explanations for the observed declines in all three measures of productivity (labour, capital, and total factor) in mining in Canada: declining capital intensity; higher mining output prices; compositional shifts within mining; lagging innovation and technological progress; deterioration of the average quality of the workforce; greater environmental regulation; deterioration of the average quality of resources exploited independent of price effects; labour relations; and taxation.

Upon examining various hypotheses put forward to explain falling productivity in mining, the most robust seems to be the effect of higher prices on both capital intensity and TFP. When the price of a natural resource increases, it becomes profitable to increase extraction rates at existing deposits and to extract from marginal resource deposits that were previously unprofitable due to high costs of extraction. In the short term, because labour is less rigid than capital, we can expect this adjustment process to translate into a falling capital-labour ratio.

Another seemingly robust explanation is that profitability trumps productivity as an objective for firms. While the objectives of productivity and profitability normally coincide, they may diverge when commodity prices are extremely high. As a result, the productivity growth of an industry, measured in constant prices, may suffer due to greater X-inefficiency in operations. This would be reflected in a fall in TFP growth.

Data on TFP and capital intensity suggest that falling capital intensity growth rates can explain a large part of the productivity slowdown in mining between the 1996-2000 and 2000-2006 periods (42 per cent). Yet, it also suggests that the decline in labour productivity in the mining is largely due to sustained declines in TFP. These findings reinforce the idea that higher prices were the main driver of both the post-2000 labour productivity slowdown and the negative productivity growth in mining.

Since productivity growth is the key driver of increases in living standards, the deceleration in labour productivity growth in Canada after 2000 implies a slower rate of increase in living standards. But improving terms of trade are also a source of real income increases. The higher commodity prices that Canada has enjoyed in recent years, in addition to the negative effect on mining productivity, have boosted the real income of Canadians (Kohli, 2006 and Macdonald, 2007).

This report does not recommend any industry-specific policies to improve productivity growth in mining above and beyond general public policies to improve productivity, such as investments in human capital and innovation. Ironically, the poor productivity performance of mining does not appear to be an indication of crisis, but rather an indication of the strength and vitality of a sub-sector on the technological frontier.

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Appendix: Definition and Description of the Mining Sub-Sector

This report uses the definition of the mining sub-sector from the North American Industry Classification (NAICS) 2002. For statistical purposes, NAICS classifies all establishments into two-digit sectors, such as mining and oil and gas extraction (NAICS code 21) or manufacturing (NAICS codes 31 through 33). Two-digit sectors are further subdivided into three-digit sub-sectors, such as mining (212). These three-digit subsectors are then divided into four-digit industry groups and five-digit industries. The remainder of this appendix is a detailed description of the three-, four-, five-, and six-digit industries that make up the forest products sector. This description is drawn from Statistics Canada (2007) and can be accessed at http://www.statcan.ca/english/Subjects/Standard/naics/2002/naics02-menu.htm.

The superscript at the end of NAICS titles indicates comparability:

CAN Canadian industry only,
US Canadian and United States industries are comparable,
[blank] Canadian, Mexican and United States industries are comparable.

212 Mining (except Oil and Gas)

This subsector comprises establishments primarily engaged in mining, beneficiating or otherwise preparing metallic and non-metallic minerals, including coal.

Exclusion(s): Establishments primarily engaged in providing support services, on a contract or fee basis, required for the mining and quarrying of minerals (21311, Support Activities for Mining and Oil and Gas Extraction)

2121 Coal Mining

This industry group comprises establishments primarily engaged in mining bituminous coal, anthracite and lignite by underground mining, and auger mining, strip mining, culm bank mining and other surface mining. Mining operations and preparation plants (also known as cleaning plants and washeries), whether or not such plants are operated in conjunction with mine sites, are included.

21211 Coal Mining

This industry comprises establishments primarily engaged in mining bituminous coal, anthracite and lignite by underground mining, and auger mining, strip mining, culm bank mining and other surface mining. Mining operations and preparation plants (also known as cleaning plants and washeries), whether or not such plants are operated in conjunction with mine sites, are included.

Exclusion(s): Establishments primarily engaged in producing coal fuel briquettes and packaged fuel (32419, Other Petroleum and Coal Products Manufacturing)

212114 Bituminous Coal Mining [CAN]

This Canadian industry comprises establishments primarily engaged in mining bituminous coal. Mining operations and preparation plants (also known as cleaning plants and washeries), whether or not such plants are operated in conjunction with mine sites, are included.

Exclusion(s): Establishments primarily engaged in producing coal fuel briquettes and packaged fuel (324190, Other Petroleum and Coal Products Manufacturing)

212115 Subbituminous Coal Mining [CAN]

This Canadian industry comprises establishments primarily engaged in mining subbituminous coal. Mining operations and preparation plants (also known as cleaning plants and washeries), whether or not such plants are operated in conjunction with mine sites, are included.

Exclusion(s): Establishments primarily engaged in producing coal fuel briquettes and packaged fuel (324190, Other Petroleum and Coal Products Manufacturing)

212116 Lignite Coal Mining [CAN]

This Canadian industry comprises establishments primarily engaged in mining lignite coal. Mining operations and preparation plants (also known as cleaning plants and washeries), whether or not such plants are operated in conjunction with mine sites, are included.

Exclusion(s): Establishments primarily engaged in producing coal fuel briquettes and packaged fuel (324190, Other Petroleum and Coal Products Manufacturing)

2122 Metal Ore Mining

This industry group comprises establishments primarily engaged in mining metallic minerals (ores). Also included are establishments engaged in ore dressing and beneficiating operations, whether performed at mills operated in conjunction with the mines served or at mills, such as custom mills, operated separately. These include mills that crush, grind, wash, dry, sinter, calcine or leach ore, or perform gravity separation or flotation operations.

21221 Iron Ore Mining

This industry comprises establishments primarily engaged in mining, beneficiating or otherwise preparing iron ores, and manganiferous ores valued chiefly for their iron content. Establishments engaged in the production of sinter and other agglomerates, except those associated with blast furnace operations, are included.

Exclusion(s): Establishments primarily engaged in operating blast furnaces to produce pig iron from iron ore (33111, Iron and Steel Mills and Ferro-Alloy Manufacturing)

212210 Iron Ore Mining

This Canadian industry comprises establishments primarily engaged in mining, beneficiating or otherwise preparing iron ores, and manganiferous ores valued chiefly for their iron content. Establishments engaged in the production of sinter and other agglomerates, except those associated with blast furnace operations, are included.

21222 Gold and Silver Ore Mining

This industry comprises establishments primarily engaged in mining, beneficiating or otherwise preparing ores valued chiefly for their gold and/or silver content.

212220 Gold and Silver Ore Mining [CAN]

This Canadian industry comprises establishments primarily engaged in mining, beneficiating or otherwise preparing ores valued chiefly for their gold and/or silver content.

21223 Copper, Nickel, Lead and Zinc Ore Mining

This industry comprises establishments primarily engaged in mining, beneficiating or otherwise preparing ores valued chiefly for their copper, nickel, lead or zinc content.

212231 Lead-Zinc Ore Mining [US]

This Canadian industry comprises establishments primarily engaged in mining, beneficiating or otherwise preparing lead ores, zinc ores or lead-zinc ores.

212232 Nickel-Copper Ore Mining [CAN]

This Canadian industry comprises establishments primarily engaged in mining, beneficiating or otherwise preparing nickel and/or nickel-copper ores.

Exclusion(s): Establishments primarily engaged in mining copper ores combined with zinc or any mineral other than nickel (212233, Copper-Zinc Ore Mining)

212233 Copper-Zinc Ore Mining [CAN]

This Canadian industry comprises establishments primarily engaged in mining, beneficiating or otherwise preparing copper and/or copper-zinc ores. Establishments engaged in the recovery of copper concentrates by the precipitation and leaching of copper ore are also included.

Exclusion(s): Establishments primarily engaged in

- mining nickel-copper ores (212232, Nickel-Copper Ore Mining)
- the recovery of refined copper by leaching copper concentrates (331410, Non-Ferrous Metal (except Aluminum) Smelting and Refining)

21229 Other Metal Ore Mining

This industry comprises establishments, not classified to any other industry, primarily engaged in mining, beneficiating or otherwise preparing metallic ores, such as uranium-radium-vanadium ores, molybdenum ores, antimony ores, columbium ores, illmenite ores, magnesium ores, tantalum ores and tungsten ores.

Exclusion(s): Establishments primarily engaged in

- mining, beneficiating or otherwise preparing iron ores (21221, Iron Ore Mining)

- mining, beneficiating or otherwise preparing ores valued chiefly for their gold and/or silver content (21222, Gold and Silver Ore Mining)
- mining, beneficiating or otherwise preparing ores valued chiefly for their copper, nickel, lead or zinc content (21223, Copper, Nickel, Lead and Zinc Ore Mining)

212291 Uranium Ore Mining [US]

This Canadian industry comprises establishments primarily engaged in mining, beneficiating or otherwise preparing uranium-radium-vanadium ores.

Exclusion(s): Establishments primarily engaged in mining, beneficiating or otherwise preparing molybdenum ores, antimony ores, columbium ores, illmenite ores, magnesium ores, tantalum ores and tungsten ores (212299, All Other Metal Ore Mining)

212299 All Other Metal Ore Mining [US]

This Canadian industry comprises establishments, not classified to any other Canadian industry, primarily engaged in mining, beneficiating or otherwise preparing metallic ores.

Exclusion(s): Establishments primarily engaged in mining, beneficiating or otherwise preparing uranium-radium-vanadium ores (212291, Uranium Ore Mining)

2123 Non-Metallic Mineral Mining and Quarrying

This industry group comprises establishments primarily engaged in mining or quarrying non-metallic minerals, except coal. Primary preparation plants, such as those engaged in crushing, grinding and washing, are included.

Exclusion(s): Establishments primarily engaged in:
- manufacturing brick and other structural clay products (32712, Clay Building Material and Refractory Manufacturing)
- manufacturing cement (32731, Cement Manufacturing)
- manufacturing lime (32741, Lime Manufacturing)
- cutting and finishing stone and stone products (32799, All Other Non-Metallic Mineral Product Manufacturing)

21231 Stone Mining and Quarrying

This industry comprises establishments primarily engaged in mining or quarrying dimension stone, rough blocks or slabs of stone, and crushed and broken stone.

212314 Granite Mining and Quarrying [CAN]

This Canadian industry comprises establishments primarily engaged in mining or quarrying dimension granite, rough blocks or slabs of granite, and crushed and broken granite, including related rocks.

212315 Limestone Mining and Quarrying [CAN]

This Canadian industry comprises establishments primarily engaged in mining or quarrying dimension limestone, rough blocks or slabs of limestone, and crushed and broken limestone, including related rocks. Establishments engaged in the grinding or pulverizing of limestone are also included.

Exclusion(s): Establishments primarily engaged in producing lime (327410, Lime Manufacturing)

212316 Marble Mining and Quarrying [CAN]

This Canadian industry comprises establishments primarily engaged in mining or quarrying dimension marble, rough blocks or slabs of marble, and crushed and broken marble. Establishments engaged in mining or quarrying slate are also included.

212317 Sandstone Mining and Quarrying [CAN]

This Canadian industry comprises establishments primarily engaged in mining or quarrying dimension sandstone, rough blocks or slabs of sandstone, and crushed and broken sandstone.

21232 Sand, Gravel, Clay, and Ceramic and Refractory Minerals Mining and Quarrying

This industry comprises establishments primarily engaged in operating sand and gravel pits, including dredging for sand and gravel; mining or quarrying shale; and mining, beneficiating or otherwise preparing kaolin or ball clay, including china clay, paper and slip clays, and other clays and refractory minerals.

212323 Sand and Gravel Mining and Quarrying [CAN]

This Canadian industry comprises establishments primarily engaged in operating sand and gravel pits, including dredging for sand and gravel, and washing, screening or otherwise preparing sand and gravel.

212326 Shale, Clay and Refractory Mineral Mining and Quarrying [CAN]

This Canadian industry comprises establishments primarily engaged in mining or quarrying shale and mining, beneficiating or otherwise preparing kaolin or ball

clay and other clays and refractory minerals. Mines operated in conjunction with plants that manufacture cement, brick or other structural clay products, or pottery and related products, are included in this Canadian industry when separate reports are not available.
Exclusion(s): Establishments primarily engaged in:

- grinding, pulverizing or otherwise treating ceramic minerals, not in conjunction with mining or quarrying operations (327110, Pottery, Ceramics and Plumbing Fixture Manufacturing)
- grinding, pulverizing or otherwise treating clay and refractory minerals, not in conjunction with mining or quarrying operations (327120, Clay Building Material and Refractory Manufacturing)

21239 Other Non-Metallic Mineral Mining and Quarrying

This industry comprises establishments, not classified to any other industry, primarily engaged in mining, beneficiating or otherwise preparing non-metallic minerals, such as asbestos, gypsum and potash, and extracting peat.

Exclusion(s): Establishments primarily engaged in:

- mining or quarrying dimension stone (21231, Stone Mining and Quarrying)
- mining or quarrying shale and mining, beneficiating, or otherwise preparing clays and refractory minerals (21232, Sand, Gravel, Clay, and Ceramic and Refractory Minerals Mining and Quarrying)
- operating sand and gravel pits and dredging for sand and gravel (21232, Sand, Gravel, Clay, and Ceramic and Refractory Minerals Mining and Quarrying)
- the production of phosphoric acid, superphosphates or other manufactured phosphate compounds or chemicals (32531, Fertilizer Manufacturing)

212392 Diamond Mining CAN

This Canadian industry comprises establishments primarily engaged in mining diamonds of industrial or gem quality.

212393 Salt Mining CAN

This Canadian industry comprises establishments primarily engaged in mining rock salt or in the recovery of salt from brine wells.

212394 Asbestos Mining CAN

This Canadian industry comprises establishments primarily engaged in mining, beneficiating or otherwise preparing asbestos.

212395 Gypsum Mining CAN

This Canadian industry comprises establishments primarily engaged in mining, beneficiating or otherwise preparing gypsum.

212396 Potash Mining [CAN]

This Canadian industry comprises establishments primarily engaged in mining, beneficiating or otherwise preparing potash.

212397 Peat Extraction [CAN]

This Canadian industry comprises establishments primarily engaged in extracting and processing peat.

212398 All Other Non-Metallic Mineral Mining and Quarrying [CAN]

This Canadian industry comprises establishments, not classified to any other Canadian industry, primarily engaged in mining, beneficiating or otherwise preparing non-metallic minerals.

Exclusion(s): Establishments primarily engaged in:

- mining or quarrying dimension stone (21231, Stone Mining and Quarrying)
- operating sand and gravel pits and dredging for sand and gravel (212323, Sand and Gravel Mining and Quarrying)
- mining or quarrying shale and mining, beneficiating or otherwise preparing clays and refractory minerals (212326, Shale, Clay and Refractory Mineral Mining and Quarrying)
- mining diamonds of industrial or gem quality (212392, Diamond Mining)
- mining salt or in the recovery of salt from brine wells (212393, Salt Mining)
- mining, beneficiating or otherwise preparing asbestos (212394, Asbestos Mining)
- mining, beneficiating or otherwise preparing gypsum (212395, Gypsum Mining)
- mining, beneficiating or otherwise preparing potash (212396, Potash Mining)
- extracting and processing peat (212397, Peat Extraction)

213 Support Activities for Mining and Oil and Gas Extraction

This subsector comprises establishments primarily engaged in providing support services, on a contract or fee basis, required for the mining and quarrying of minerals and for the extraction of oil and gas. Establishments engaged in the exploration for minerals, other than oil or gas, are included. Exploration includes traditional prospecting methods, such as taking ore samples and making geological observations at prospective sites.

2131 Support Activities for Mining and Oil and Gas Extraction

This industry group comprises establishments primarily engaged in providing support services, on a contract or fee basis, required for the mining and quarrying of minerals and for the extraction of oil and gas. Establishments engaged in the exploration for minerals, other than oil or gas, are included. Exploration includes traditional prospecting methods, such as taking ore samples and making geological observations at prospective sites.

21311 Support Activities for Mining and Oil and Gas Extraction

This industry comprises establishments primarily engaged in providing support services, on a contract or fee basis, required for the mining and quarrying of minerals and for the extraction of oil and gas. Establishments engaged in the exploration for minerals, other than oil or gas, are included. Exploration includes traditional prospecting methods, such as taking ore samples and making geological observations at prospective sites.

Exclusion(s): Establishments primarily engaged in:

- performing geophysical surveying services for minerals, on a contract or fee basis (54136, Geophysical Surveying and Mapping Services)

213117 Contract Drilling (except Oil and Gas) CAN

This Canadian industry comprises establishments primarily engaged in diamond, test, prospect and other types of drilling, for minerals, other than oil and gas.

Example activities include boring test holes for non-metallic minerals mining (except fuels), on contract basis; contract diamond drilling, metallic minerals; drilling services for non-metallic minerals mining (except fuels), on a contract basis; iron ore mine diamond drilling, contract services; metal mining, prospect drilling for, on a contract basis; prospect drilling for metal mining, on a contract basis; prospect drilling for non-metallic minerals (except fuels), on contract basis; test drilling for metal mining, on a contract basis; test drilling for non-metallic minerals mining (except fuels), on a contract basis.

213119 Other Support Activities for Mining CAN

This Canadian industry comprises establishments, not classified to any other Canadian industry, primarily engaged in performing mining services, for others, on a contract or fee basis. Establishments engaged in the exploration for minerals are included. Such exploration is often accomplished using purchased services of specialty businesses, such as contract drilling services to obtain core samples.

Exclusion(s): Establishments primarily engaged in:

- performing geophysical surveying services for oil and gas, on a contract or fee basis (541360, Geophysical Surveying and Mapping Services)

Example activities include draining or pumping of mines, on a contract basis; overburden removal, prior to working minerals, in quarries and open pit mines; stripping services, coal and lignite, on a contract basis; tunneling, coal and lignite mining, on a contract basis.