Queen's Economics Department Working Paper No. 1176

Resource Intensive Production and Aggregate Economic Performance

Ian Keay
Queen's University

Department of Economics
Queen's University
94 University Avenue
Kingston, Ontario, Canada
K7L 3N6

7-2008

Resource Intensive Production and Aggregate Economic Performance: Evidence from Canada's Energy, Fishing, Forestry, and Mining Industries, 1970-2005

Ian Keay*
ikeay@econ.queensu.ca
Queen's University
Department of Economics
Kingston, ON
K7L 3N6

Summer 2008

*I wish to thank André Bernier, Marvin McInnis, Cherie Metcalf, and Henry Thille for their comments on earlier drafts. Herb Emery provided invaluable advice that helped to motivate and focus this work. Versions of this paper have been presented at the University of Calgary, the University of Alberta, Yale University, the University of California at Davis, the 2007 T.A.R.G.E.T. workshop in Vancouver, and the 2008 C.E.A. annual meetings in Vancouver. I gratefully acknowledge financial assistance provided by T.A.R.G.E.T. (S.S.H.R.C. I.N.E. grant # 512-2002-1005) and the Corporate Policy and Portfolio Coordination Branch of Natural Resources Canada. All remaining errors and omissions are my responsibility.

Abstract

Resource Intensive Production and Aggregate Economic Performance: Evidence from Canada's Energy, Fishing, Forestry, and Mining Industries, 1970-2005

The main objective of this paper is to determine whether specialization in resource intensive production had a positive impact on the performance of the aggregate Canadian economy over the 1970-2005 period. Specialization is simply measured as the proportion of aggregate employment, the aggregate fixed capital stock, and G.N.P. that may be attributed to Canada's energy, fishing, forestry, and mining industries. Direct contributions to intensive, or per capita performance are measured in terms of the resource industries' profitability, productivity, and capital intensity. Indirect contributions to economic performance are measured in terms of spill overs, or linkages to other non-resource intensive industries through raw material price advantages and demand generation. The possibility that resource intensive production may have been crowding out other sectors in the economy through input price inflation or currency appreciation is also investigated. Based on the evidence, I argue that Canada's resource industries were making a substantial positive impact on aggregate economic performance after 1970, but this conclusion depends on the inclusion of the energy industries in resource sector.

Keywords: Resource dependence, spill overs, crowding out, economic growth and development.

1 Introduction

The main policy question motivating the empirical investigation described in this paper concerns the desirability of promoting specialization in resource intensive production in Canada. Uncertainty regarding the extent to which it would be advantageous for the Canadian economy, in aggregate at least, to become increasingly specialized in resource extraction and processing activities is apparent in recent policy discussions and media coverage related to a wide range of government activity, including monetary policy and currency valuation, environmental regulation, taxation, inter-provincial migration, and industrial policy.[1] This uncertainty stems from not only the inherent problems associated with the estimation of future rates of resource discovery and depletion, but also from regional economic and policy diversity, and from conflicting theoretical predictions and empirical evidence.

To most Canadians who reside outside of southern Ontario, south-western Quebec, and possibly the lower mainland in British Columbia, it must seem quite unnecessary to seriously question the extent to which resource extraction and processing activities positively affect aggregate economic performance. Certainly, with respect to our understanding of Canadian performance in the long run, there has been a particularly rich and persistent vein of research that has emphasized the fundamental importance of resource exploitation for both intensive and extensive growth.[2] However, in a contemporary context it may not be totally self-evident that encouraging greater resource dependence is necessarily in the best interests of the aggregate economy, or the majority of Canadians. To those who reside within Canada's densely populated urban and industrial regions, questions about the desirability of continued and/or increased resource dependence may also seem unnecessary, but the assumed answer to these questions would likely be quite different from that proposed throughout the rest of the country. In addition, there are at least three strands of literature - the Dutch disease/resource curse literature, the new economy literature, and literature on twentieth century Canadian industrial development - that either implicitly or, in many cases, explicitly suggests that resource exploitation in Canada has not had a substantive positive impact on economic performance since the early 1900s.[3]

[1] To illustrate some of the many, many examples available from media coverage of federal and provincial policy issues that may be affected by our understanding of the impact of resource dependence within the Canadian economy see *The Globe and Mail* (March 11, 2008) Pg. B14: "Trade Figures Influence Loonie's Fate", (March 11, 2008) Pg. B8: "Irving Wants Cheap Power Environmentalist Says", (March 8, 2008) Pg. A4: "P.M.'s Message for Ontario: Cut Corporate Taxes, Expect No Bailouts", or (March 11, 2008) Pg. B1: "Awash in Cash, Oil Patch Braces for Changes".

[2] For example, see Innis (1930) and (1940), Watkins (1963), or Keay (2007).

[3] For just one illustrative example from each strand of literature see Sachs and Warner (2001) Pg. 832, Nordhaus

It is not the objective of this paper to make predictions about the economic contributions that will be made by Canada's resource industries in the future. Instead the approach adopted here is to look to the past in an effort to understand the economic impact that specialization in resource intensive production has had on the aggregate Canadian economy since 1970. The hope is that an understanding of the past will help to establish reasonable bounds for the formation of expectations about the economic impact we might expect to result from future specialization.

As a first step in the establishment of these reasonable bounds, we must assess the extent to which the aggregate Canadian economy was dependent on resource extraction and processing activities during the post-1970 period. More specifically, we must consider the resource industries' contributions to the size of the domestic economy. Based on a simple growth accounting exercise, we can think of resource specialization in terms of inputs employed and output produced. I have calculated the share of total employment, the aggregate fixed capital stock, and aggregate income (G.N.P.) originating in Canada's energy, fishing, forestry, and mining industries for each year between 1970-2005. The contrast between the resource intensive industries' shares and more human capital and technology intensive "new economy" industries' shares may be used as a useful benchmark in the assessment of the extent of resource specialization after 1970.

Determining exactly how much the resource industries have contributed to the size of the Canadian economy cannot tell us much about the impact this specialization has had on performance. To investigate the impact that resource dependency has had on the aggregate economy it is revealing to consider the resource industries' direct contributions to intensive, or per capita performance. Based on standard macroeconomic growth models we might reasonably expect indicators such as profitability, productivity, and capital intensity to be quite closely associated with average per capita income levels. To assess profitability I measure aggregate resource rents, or more specifically, value added generated in excess of the opportunity cost of the labour and capital employed by Canada's resource producers, as a proportion of G.N.P.. I measure productivity using indicators of relative total factor productivity (T.F.P.) and relative labour productivity. Capital intensity is measured as the real value of gross fixed capital per worker.

Resource based development theories, such as the "staples thesis", tell us that resource extraction and processing activities may have an impact on aggregate economic performance that extends beyond their direct contributions to per capita growth. The concentration of labour and capital into resource intensive production may foster structural diversification within an economy through

(2002) Pg. 233, and Easterbrook (1959) Pg. 76, respectively.

the formation of forward, backward, and final demand linkages. The presence of these linkages, or spill overs, suggests particular chronological patterns among sectoral output levels and raw material prices. Reduced form vector auto-regressive (V.A.R.) systems can be used to identify these chronological patterns. To be more specific, Granger causality tests may be used to determine the extent to which Canada's resource industries still comprised a leading sector in the economy, and the extent to which forward, backward, and final demand linkages may still have been operable, even after 1970.

There are other development theories, described in the "Dutch disease" and "resource curse" literature, for example, that are much more pessimistic about the possibility that promoting resource specialization may be good for the aggregate economy. These theories suggest that the pursuit of resource rents can draw labour and capital away from more "growth enhancing" activities by driving up labour and capital costs for the non-resource intensive sectors in the economy. It is also possible, according to these theories, that foreign demand for resource intensive exports can increase the demand for the domestic currency on international money markets, which in turn can increase the cost of imported inputs and reduce the demand for non-resource intensive domestic exports. Like the staples thesis' linkages, the damaging crowding out described by the Dutch disease and resource curse literature suggests particular chronological patterns among sectoral output levels, input prices, and foreign exchange rates. Again, reduced form vector auto-regressive systems can be used to identify these chronological patterns.

Based on the evidence described in this paper I suggest that, despite a precipitous decline in the extent of resource dependency in the aggregate Canadian economy after 1970, characterized by decreases in employment, capital, and income shares, resource extraction and processing industries were still making important contributions to aggregate economic performance. Indicators such as profitability, productivity, and capital intensity remained strong over the 1970-2005 period; resource producers' continued to comprise a leading sector in the economy; chronological patterns consistent with the operation of forward, backward, and final demand linkages may be identified; and; there is no evidence that resource intensive production was associated with adverse input market conditions or currency appreciation. There is, however, an important caveat to keep in mind - many of these conclusions depend critically on the inclusion of the energy extraction industries in the resource sector. If we consider energy extraction separately from the rest of the resource intensive producers, then the fishing, forestry, and mining industries no longer comprise a leading sector in the economy after 1970, their input and income contributions fall even more dramatically, and their contributions

to aggregate performance through their profitability, productivity, and capital intensity are more stable, but in some cases substantially lower.

In general, therefore, the evidence suggests that since 1970 there have been significant positive economic effects associated with resource specialization in Canada. The persistence of these effects into the future depends, at least in part, on continued "economic discovery" of resource endowments that may be profitably exploited, the retention of resource rents within the domestic economy, and the promotion of linkages from resource extraction and processing activities to other non-resource intensive industries.

2 Specializing in Resource Extraction and Processing: Input Employment and Income Generation

Before embarking on any investigation of the contributions Canada's resource intensive producers have made to late twentieth and early twenty-first century aggregate economic performance, we must first identify exactly which producers we wish to include in the resource sector. This task is more challenging if we wish to identify particular sub-groups within the sector, such as the energy extraction industries. We are, of course, presented with yet another set of challenges if we also wish to identify a non-resource intensive performance benchmark, such as the human capital and technology intensive new economy industries.

Natural resource industries should include those producers that are involved in the extraction and processing of a nation's physical resource endowments. We might initially expect that an obvious contrast to these industries would be new economy industries, which should include those producers whose main production inputs are human capital and technology. The challenges stem from the fact that any contrast of this sort is largely theoretical, because virtually all late twentieth century Canadian producers were involved, in some way, in the transformation, preparation, and processing of natural resource inputs, and virtually all used considerable quantities of both human capital and technology. This blurring of the line between new economy and resource industries is even more acute if we allow human capital to be defined as something more than simply years of formal education, and technology to be defined as something more than information transmission and processing equipment. Where I use the terms "new economy industries" and "resource industries" throughout this paper they should be understood to comprise *relatively* human capital (formal education) and technology (information transmission and processing) intensive producers, and *relatively* resource intensive producers, respectively.

To identify resource industries I have relied on a recent categorization of extraction, primary processing, and secondary processing industries involved in energy, fishing, forestry, and mining provided by *Natural Resources Canada* and the *Department of Fisheries and Oceans*.[4] To identify human capital and technology intensive industries I have relied on the classification provided by Robert Gordon (2000) and William Nordhaus (2002 and 2005), who have written a series of papers which describe the impact that increasing human capital and technology intensity has had on the aggregate U.S. economy over the past quarter century.[5] In these papers a set of broadly defined U.S. industries have been identified as "new economy" producers.[6] I have tried to match comparable Canadian industries to those specified by Gordon and Nordhaus.[7] Fortunately, the qualitative conclusions I report in the remainder of this paper are fairly insensitive to most reasonable reorganizations of the industry groups identified in Figure 1.

Insert Figure 1

For each industry group specified in Figure 1 and for the aggregate Canadian economy I have compiled annual figures covering the years 1970-2005 on: employment, real gross fixed capital, and value added; sector specific output price indexes, capital cost indexes, raw material price indexes, and wage indexes; and; the proportion of value added paid to labour (as wages and salaries) and to capital (calculated as a residual). For each of the four natural resource industries - energy, fishing, forestry, and mining - at each of three stages of production - extraction, primary processing, and secondary processing - my data series span 106 years from 1900-2005, although I only use information from 1947-2005 in this study.[8]

To assess the extent to which the Canadian economy was specialized in resource extraction and processing activities after 1970, I simply wish to identify the resource industries' contributions to the size of the aggregate economy. Given the rhetoric that has been disseminated about the expansion of the new economy, human capital and technology intensive industries seem to be a natural benchmark for the assessment of both the level of resource dependence in the Canadian

[4]These industries were identified on the N.R.Can. and D.F.O. web sites (accessed in April, 2004) at either the three or four digit N.A.I.C.S. level of aggregation.

[5]In addition to the U.S.-centric Gordon and Nordhaus papers, Gera and Mang (1998), and Beckstead et al. (2004) offer a Canadian perspective on the post-1970 ascension of human capital and technology intensive service industries.

[6]For example, Nordhaus (2005, Tables 6-8) provides a list of new economy industries, and Gordon (2000, Pg. 50) seems to use computer intensity as an identifying criteria for new economy industries.

[7]Because the education, health, and social service industries in Canada are part of the public sector, but they are clearly human capital and technology intensive, I have derived all of my new economy benchmarks with and without these industries.

[8]A complete Data Appendix with source citations and detailed compilation, construction, and aggregation techniques is available from the author.

Table 1: Labour, Capital, and Income Shares

	Labour Share			
	1970-74	2001-05	%Δ	ρ
All NR	0.100	0.057	-1.960^{***}	0.209
NR without Energy	0.097	0.055	-1.999^{***}	0.215
All NE	0.180	0.215	0.588^{***}	0.066
Private NE	0.122	0.138	0.340^{***}	0.053
	Capital Share			
	1970-74	2001-05	%Δ	ρ
All NR	0.196	0.157	-1.150^{***}	0.194
NR without Energy	0.153	0.105	-1.182^{***}	0.191
All NE	0.325	0.494	1.426^{***}	0.154
Private NE	0.243	0.417	1.825^{***}	0.190
	Income Share			
	1970-74	2001-05	%Δ	ρ
All NR	0.158	0.111	-1.393^{***}	0.180
NR without Energy	0.135	0.083	-1.577^{***}	0.190
All NE	0.274	0.349	0.886^{***}	0.104
Private NE	0.173	0.255	1.344^{***}	0.143

Note: *All NR* includes all the natural resource industries identified in Figure 1, *NR without Energy* includes all the natural resource industries except energy extraction, *All NE* includes all the new economy industries identified in Figure 1, *Private NE* includes all the new economy industries except education, health, and social services.

Note: $***/**/*$ indicates that the average annual %Δ is statistically significantly different from zero with at least 99% confidence, 95% confidence, 90% confidence, respectively. ρ = coefficient of variation ($= \sigma/\mu$).

economy, and changes in this dependence after 1970. I have, therefore, calculated the proportion of the aggregate Canadian workforce, fixed capital stock, and gross national product that originated in each of four industry groups - all natural resource industries, natural resource industries excluding energy extraction, all new economy industries, and private new economy industries (excluding the public sector industries - education, health, and social services) - for each year between 1970-2005. In Table 1 I report the mean level of the labour, capital, and income shares for the resource and new economy industry groups averaged over the years 1970-1974 and 2001-2005, the average annual percentage change in these shares over the 36 years following 1970, and the post-1970 coefficients of variation for each series.

From Table 1 we can see that the natural resource industries' contributions to aggregate size of the Canadian economy fell very rapidly after 1970. Canada's energy, fishing, forestry, and mining producers were sheading workers particularly quickly, reducing their share of total employment from 10% of the aggregate workforce at the beginning of the period, to less than 6% by the end of the period - an average annual rate of decline of nearly 2% per year. In addition, their investment rates were lower than the aggregate economy, leading to a reduction in their share of aggregate fixed

capital by 1.15% per year between 1970-2005. Income shares also fell, at an average annual rate of 1.39%, resulting in a reduction in the proportion of G.N.P. originating in the resource industries from almost 16% immediately after 1970 to just over 11% by 2001-2005. If we remove energy extraction from the resource producers' input and income shares, the erosion in their post-1970 contributions is even more precipitous. The fishing, forestry, and mining industries' employment shares dropped by 2% per year, capital shares by 1.18% per year, and income shares by 1.58% per year.

The contrast between the contributions made by the resource intensive producers, particularly the fishing, forestry, and mining industries, and the human capital and technology intensive producers is striking. We can see that in 1970-1974 the new economy industries were not even twice the size of the resource industries in terms of employment, capital, or income. If we consider only the private sector new economy industries, the initial differences in input and income contributions were very small indeed - less than 10% for all three indicators. By 2001-2005 the new economy industries employed nearly four times as many workers, they housed more than three times as much capital, and they generated more than three times as much income. These level differences at the end of the period are almost as large even if we do not include the public sector new economy industries. The differences in average annual growth rates reflect these changes in the groups' relative shares, with the new economy industries increasing their contributions to employment by 0.59% per year, on average, capital stock by 1.43% per year, and G.N.P. by 0.89%. The private sector new economy industries increased their capital and income shares even faster than the human capital and technology intensive industries as a whole - by 1.83% and 1.34% per year, respectively.

Although we must keep in mind that even at the very end of the period considered in this paper the resource industries were still employing a fairly large proportion of the aggregate labour force and capital stock, and they were still generating more than one out of every 10 dollars earned in Canada, the divergent trends in the input and income contributions certainly paint a fairly grim picture of the resource industries' post-1970 role in the Canadian economy (even if we include energy extraction). One can easily see how, at least at first glance, the figures in Table 1 seem consistent with a dramatic shift in economic specialization away from activities that were dependent on Canada's resource endowments, towards those that were dependent on Canada's human capital and technology endowments. However, there are a number of subtleties we may wish to consider with respect to this rather pessimistic (at least from the resource industries' perspective) conclusion. In particular, the post-1970 summary statistics reported in Table 1 may be only part of the story.

A more complete picture of resource dependence in the Canadian economy may emerge from the adoption of a longer run perspective and an investigation of other economic contributions.

2.1 A Longer Run Perspective

In February 1947 Imperial Oil's Number 1 well in Leduc, Alberta struck oil. The discovery of substantial reserves of petroleum that could be profitably exploited marked an economic, technological, and public policy transition in the Canadian economy, away from a dependence on traditional fish, timber, and mineral resources, towards energy. The early 1970s are, of course, also typically viewed as a period of transition in the resource dependence of the Canadian economy. To place this more recent transition into its appropriate context it seems reasonable to devote some attention to the resource industries' input and income contributions that preceded 1970, and to extend our focus beyond linear trends and average annual rates of change.

In Figures 2-4 the share of total employment, aggregate fixed capital, and G.N.P. for all energy, fishing, forestry, and mining industries are depicted for the years 1947-2005. These figures also illustrate the resource industries' input and income shares with the energy extraction industries removed. To emphasize the longer run cyclical movements in these shares each series has been decomposed into its stationary and non-stationary components using a Hoddrick-Prescott filter. The non-stationary, or smoothed components are included in the figures.

Insert Figures 2-4

Although one could tell very detailed region and industry specific stories about the chronological patterns that can be observed in Figures 2-4, I wish to focus on just three main points related to the extent of resource dependency in the aggregate Canadian economy. First, the post-1970 contractions in the resource industries' input and income contributions do not appear to have been chronologically coincident with any post-1970 structural changes in the economy. The resource industries' employment and G.N.P. shares, for example, were falling throughout the 1947-2005 period, and the erosion of these shares seems to have actually slowed over the last 10-15 years of the sample. The resource industries' contributions to the aggregate stock of fixed capital were in decline from at least the mid-1950s. These longer run patterns suggest that the contractions in domestic resource specialization that may be identified from the summary statistics reported in Table 1 were not triggered by the recent rise of the human capital and technology intensive new economy industries.

A second point that becomes even more striking after considering the series illustrated in Figures 2-4 is the increasing importance of energy extraction activities starting in the late 1960s. Although this increasing importance is not obvious in the resource producers' employment shares (which is interesting in its own right), if we consider the capital shares and income shares, the gap between the resource industries with and without energy extraction widens substantially over the last half of the 1947-2005 period.

The third point I wish to emphasize is again associated with the role played by energy extraction industries. If we consider the filtered series depicted in Figures 3 and 4 (leaving aside the employment shares which are remarkably similar with or without energy) it becomes clear that energy extraction adds a considerable amount of cyclical volatility to the resource industries' capital and income contributions. This additional volatility is not apparent from the post-1970 the coefficients of variation reported in Table 1, but over the longer run the energy booms beginning in the early 1970s and early 1990s, and the energy bust beginning the early 1980s can be clearly identified in these figures.

Based on the longer run chronological patterns we can observe in these figures it appears, therefore, that changes in the resource dependence of the aggregate economy were not coincident with any structural changes driven by an increasingly intensive use of human capital and technology. The longer run perspective also highlights the unique contributions made by energy extraction industries, particularly since the late 1960s. The substantial increases in both the size of the energy producers' contributions to extensive performance and the volatility in these contributions, appears much more obvious when one considers the full 1947-2005 period. Although the Canadian economy may not have been becoming increasingly resource dependent after 1970, it was clearly becoming increasingly energy dependent.

3 Contributions to Intensive Performance: Profitability, Productivity, and Capital Intensity

Even though the proportion of aggregate employment, the fixed capital stock, and G.N.P. originating in Canada's fishing, forestry, and mining industries was falling after 1970, and the energy industries input and income shares, while increasing rapidly on average, were highly volatile, the absolute size of these industries should lead us to safely accept their continued importance in the aggregate economy. Of course, just because Canada's resource industries remain a large part of the

domestic economy, this does not necessarily mean that resource specialization has been advantageous. If we are interested in standards of living and economic development, rather than simply the absolute size of an economy, then it seems reasonable to turn our attention to the resource industries' contributions to per capita or intensive economic performance.

Even the most basic macroeconomic growth models emphasize the positive relationship between income per capita, on one hand, and returns to labour and capital in excess of their opportunity costs, technological change, efficiency gains, and capital accumulation, on the other.[9] Therefore, if we accept the guidance provided by these models, then we may assess the contributions made by Canada's resource industries to intensive economic performance by considering their profitability, productivity, and capital intensity. For each year between 1970-2005 I have calculated the resource industries' (with and without energy extraction) aggregate resource rents (or economic profits) relative to G.N.P., and their total factor productivity, labour productivity, and capital-labour ratios relative to the aggregate economy.

Total resource rents have been measured as the value added generated by the energy, fishing, forestry, and mining industries in excess of the opportunity cost of their labour and capital, plus all resource royalties, licences, and fees paid to government:

$$R_t = (VA_t + T_t) - (WL_t^* \times L_t) - (WK_t^* \times K_t) \tag{1}$$

Where: the opportunity cost of the resource industries' labour (WL^*) is assumed to be the average return to labour in non-resource intensive manufacturing[10], and the opportunity cost of their capital (WK^*) is assumed to be the average return on Moody's AAA industrial bonds. The resource industries' T.F.P. performance has been assessed relative to the aggregate Canadian economy using a Tornqvist geometric weighted average of relative labour and capital productivity, with value added used as the measure of output:[11]

$$\frac{A_{it}}{A_{jt}} = \left(\frac{(VA/L)_{it}}{(VA/L)_{jt}}\right)^{0.5(sL_{it}+sL_{jt})} \left(\frac{(VA/K)_{it}}{(VA/K)_{jt}}\right)^{0.5(sK_{it}+sK_{jt})} \tag{2}$$

Where: the resource industries are indexed by i and the aggregate Canadian economy is indexed by j, and the elasticity of labour and capital with respect to output (SL and SK) are assumed to

[9] For a text book illustration of the theoretical connections among these variables see Barro and Sala-i-Martin (2004) Pg. 28-33 and 66-68.

[10] Non-resource intensive manufacturing is total manufacturing less the primary and secondary resource processing industries that may be categorized as "manufacturing".

[11] For a more detailed discussion of the Tornqvist index number approach to T.F.P. measurement see Allen and Diewert (1981).

Table 2: Profitability, Productivity, and Capital Intensity

	Rent Share			
	1970-74	2001-05	%Δ	ρ
All NR	0.089	0.113	0.233	0.227
NR without Energy	0.068	0.082	0.633	0.342
	TFP Ratio			
	1970-74	2001-05	%Δ	ρ
All NR	1.567	1.457	-0.297^{**}	0.088
NR without Energy	1.354	1.316	-0.247	0.108
	Q/L Ratio			
	1970-74	2001-05	%Δ	ρ
All NR	2.155	2.555	0.220	0.087
NR without Energy	1.700	1.891	0.233^{*}	0.086
	K/L Ratio			
	1970-74	2001-05	%Δ	ρ
All NR	1.970	2.767	0.605^{**}	0.158
NR without Energy	1.578	1.914	0.691^{***}	0.149

Note: *All NR* includes all the natural resource industries identified in Figure 1, *NR without Energy* includes all the natural resource industries except energy extraction.

Note: $***/**/*$ indicates that the average annual %Δ is statistically significantly different from zero with at least 99% confidence, 95% confidence, 90% confidence, respectively. ρ = coefficient of variation ($= \sigma/\mu$).

be cost shares that sum to one. The labour productivity performance of the resource industries has been assessed relative to the aggregate Canadian economy using value added, deflated by a sector specific output price index, divided by total employment. The capital intensity of the resource industries has been assessed relative to the aggregate Canadian economy using the ratio of real gross fixed capital divided by total employment.

In Table 2 I report the mean rent shares, T.F.P. ratios, labour productivity ratios, and capital-labour ratios for all natural resource industries, and for the natural resources industries excluding energy extraction, averaged over the years 1970-1974 and 2001-2005, the average annual percentage change in these shares and ratios over the 36 years following 1970, and the post-1970 coefficients of variation for each of these series. What is immediately striking in the summary statistics included in Table 2 is the apparent contrast between the resource industries' contributions to intensive performance, and their contributions to extensive performance (included in Table 1).

Among all the resource industries, total payments to labour and capital in excess of their opportunity costs rose from 9% of G.N.P. between 1970-1974 to over 11% of G.N.P. between 2001-2005. This not only indicates growth in the profitability of the resource industries over and above the average growth rate of the aggregate economy, but the total value of these rents was clearly substantial and persistent throughout the post-1970 period. It is also interesting to note that,

although the difference was not statistically significant, the resource industries without energy extraction actually increased their rent shares slightly faster than the sector as a whole (with energy extraction included): 0.63% per year relative to 0.23% per year, respectively.

For the total factor productivity, labour productivity, and capital-labour ratios the most dramatic illustration of the resource industries' impact on per capita economic performance after 1970 is the presence of very high levels among all three ratios relative to the aggregate economy. Between 1970-1974 the resource industries enjoyed T.F.P. that was almost 57% higher than the aggregate Canadian economy, and although this ratio fell slightly over the period, by 2001-2005 they were still almost 46% more productive. The relative ratios for labour productivity and capital intensity were even higher, with the resource industries generating over two and a half times more output per worker than the aggregate economy between 2001-2005, and employing more than two and a half times as much capital per worker. The resource industries' labour productivity and capital-labour ratios both increased faster than the aggregate economy after 1970, and like the rent shares, their average annual rates of change were virtually identical with and without energy extraction.

If we use these profitability, productivity, and capital intensity measures to assess the impact of resource specialization on post-1970 intensive economic performance, it would be difficult to support any suggestion that resource specialization was impeding performance by drawing inputs away from more growth enhancing sectors. Even the fishing, forestry, and mining industries were persistently profitable and productive, with very high capital-labour ratios, and these indicators of intensive performance were not falling sharply after 1970. In an effort to place the summary statistics reported in Table 2 into their appropriate chronological context, we may again adopt a longer run perspective and consider these indicators over the 1947-2005 period.

3.1 A Longer Run Perspective

In Figures 5-8 the resource rent shares, relative T.F.P. ratios, labour productivity ratios, and capital-labour ratios for all energy, fishing, forestry, and mining industries are depicted for the years 1947-2005. These figures also illustrate the resource producers' shares and relative ratios with the energy extraction industries removed. Again, each series has been decomposed into its stationary and non-stationary components using a Hoddrick-Prescott filter, and the longer run cyclical movements are illustrated using the non-stationary, or smoothed components.

Insert Figures 5-8

In general the conclusions we can draw from a consideration of the longer run patterns in the resource industries' rent shares, productivity ratios, and capital-labour ratios reinforce the three points of interest that were discussed with respect to Figures 2-4. Specifically: there does not appear to have been any substantive or detrimental change in the chronological evolution of these series coincident with the post-1970 expansion of the human capital and technology intensive new economy industries in Canada; the energy extraction industries experienced a fairly dramatic increase in their contributions starting in the late 1960s; and; energy extraction was clearly more volatile than fishing, forestry, and mining after 1970, particularly with respect to their resource rents and capital accumulation.

With the exception of a short lived increase in the energy extraction industries' rent shares during the very early 1970s, the slow decline in these shares appears to have begun during the immediate aftermath of World War 2 and continued unabated until the late 1980s. The resource industries' relative T.F.P. performance has been remarkably stable since the late 1950s, and their relative labour productivity and capital-labour ratios appear to have been rising slowly, but persistently throughout the entire 1947-2005 period. Again, the early 1970s boom in energy extraction, and subsequent bust during the early 1980s, is evident in the labour productivity ratios, capital-labour ratios, and most obviously in the rent shares. It is interesting to note that the inclusion of the energy extraction industries does appear to increase the level of the resource industries' T.F.P. performance, but energy's boom and bust cycles are not evident in Figure 6. In fact, over the 1947-2005 period the fishing, forestry, and mining industries actually have slightly more volatile T.F.P. performance than the energy extraction industries (measured by the coefficient of variation).

Based on the summary statistics presented in Table 2 and the longer run chronological patterns that may be identified in Figures 5-8, it appears that although the resource industries (particularly the fishing, forestry, and mining industries) may have been getting smaller relative to the aggregate economy after 1970, this does not necessarily imply that they were constraining aggregate per capita economic performance. All of the resource industries appear to have been profitable, productive, and capital intensive long before and long after 1970. Of course, if we broaden our view beyond macroeconomic growth theories, and consider resource based theories of economic development, then profitability, productivity, and capital intensity may not be the only channels through which resource exploitation can have an impact on economic performance.

4 Indirect Contributions to Economic Performance: Spilling Over and Crowding Out

The staples thesis is a descriptive development model based on the notion that the extraction, processing, and export of a nation's physical resource endowments can lead to diversification, industrialization, and urbanization if connections between resource industries and other sectors in the economy can be fostered.[12] For example, resource extraction and processing requires both manufactured goods and services as inputs. Thus, resource intensive production increases the demand for the products produced by these other industries, creating backward linkages. In addition, domestic resource production increases the supply of raw materials available to other sectors of the economy, as well as reducing transportation and transactions costs for these inputs. Domestic production of raw material inputs, therefore, may reduce costs, increase profits, and encourage growth through the creation of forward linkages. Final demand linkages, on the other hand, may be formed as a result of the consumption of goods and services, such as financial transactions, infrastructure, residential capital construction, or consumer goods, by the labour and capital employed by resource producers. The presence of these three types of linkages, therefore, implies that resource exploitation may do more than contribute directly to the intensive performance of an economy through the generation of profits, productivity, and capital accumulation. Resource industries may comprise a leading sector, from which performance spills over into other sectors in the economy, resulting in indirect and subsidiary intensive growth.

Of course, the staples thesis is not the only resource based model of economic growth and development. Other models, including those associated with the empirical identification of "Dutch disease" or a "resource curse", have adopted a much more sombre view of the role played by resource specialization in the promotion of long run performance.[13] These models suggest that the concentration of labour and capital in resource intensive (rent seeking) industries may drive up input costs and/or the value of the domestic currency. These price effects may, in turn, harm non-resource intensive producers by making their labour, capital, and imported intermediate inputs more expensive, and their export products less desirable on foreign markets. The presence of these crowding out effects, therefore, implies that any positive raw material price or demand spill

[12] For a recent review of the literature on the staples thesis and a concise theoretical exposition of its main features see Findlay and Lindahl (1994).

[13] For surveys of the theoretical and empirical Dutch disease and resource curse literature see Corden (1984) and Auty (2001), respectively.

overs associated with resource specialization may be at best muted and at worst swamped by the coincident imposition of counteracting costs on the other non-resource intensive sectors in the economy.

4.1 Leading and Lagging Sectors

We can begin our investigation of the extent to which the resource industries may have contributed indirectly to domestic performance, in either a positive or negative way, by first determining if these producers comprised a leading or lagging sector in the Canadian economy after 1970. If the resource industries were leaders, then we should expect to find that increases in period $t-i$ natural resource output (NRQ) were statistically significantly related to subsequent increases in period t new economy output (NEQ) and rest of the economy output ($ROEQ$).[14] This chronological pattern in sectoral output growth can be identified using a reduced form vector autoregressive system and Granger causality tests. All of the V.A.R. systems and Granger causality tests described in this section have been run with and without energy extraction industries, and with and without the public sector new economy industries - education, health, and social services.

In general, Granger causality tests seek to establish the statistical strength of the relationship between a current (period t) dependent variable and past (period $t-i$) values of the independent variables, which include past values of the dependent variable itself. Because I am interested in the chronological relationship between changes in resource output, new economy output, and rest of the economy output, I have estimated the parameters from a three equation vector autoregressive system, described by Equations (3)-(5):

$$\Delta NRQ_t = \sum_{i=1}^{i=n} \alpha 1_i \Delta NRQ_{t-i} + \sum_{i=1}^{i=n} \alpha 2_i \Delta NEQ_{t-i} + \sum_{i=1}^{i=n} \alpha 3_i \Delta ROEQ_{t-i} + \epsilon 3_t \qquad (3)$$

$$\Delta NEQ_t = \sum_{i=1}^{i=n} \beta 1_i \Delta NRQ_{t-i} + \sum_{i=1}^{i=n} \beta 2_i \Delta NEQ_{t-i} + \sum_{i=1}^{i=n} \beta 3_i \Delta ROEQ_{t-i} + \epsilon 4_t \qquad (4)$$

$$\Delta ROEQ_t = \sum_{i=1}^{i=n} \gamma 1_i \Delta NRQ_{t-i} + \sum_{i=1}^{i=n} \gamma 2_i \Delta NEQ_{t-i} + \sum_{i=1}^{i=n} \gamma 3_i \Delta ROEQ_{t-i} + \epsilon 5_t \qquad (5)$$

Where: ΔNRQ = log difference in the value added generated by resource industries (with and without energy), deflated by industry specific price indexes; ΔNEQ = log difference in the value added generated by new economy industries (with and without the public sector), deflated by sector specific price indexes; $\Delta ROEQ$ = log difference in the value added generated by all industries not classified as resource or new economy industries, deflated by sector specific price indexes;

[14] As illustrated in Figure 1, R.O.E. is simply total economic activity less all of the natural resource and new economy industries.

α, β, γ = parameters to be estimated; and; ϵ = normally distributed i.i.d.$(0, \Omega)$ regression residuals. Optimal lag length (n) has been chosen using both the Schwartz and Akaike information criteria.[15] Stationarity in the log differences of all series has been established with at least 99% confidence using Phillips-Perron unit root tests.

If the parameter estimates associated with ΔNRQ_{t-i} ($\beta 1$ in Equation (4) and $\gamma 1$ in Equation (5)) are statistically significant and positive, then I can reject the hypothesis that past changes in resource intensive production were statistically *unrelated* to current changes in the output produced by new economy and rest of the economy industries, respectively. If I can reject these hypotheses, then I may conclude that changes in post-1970 Canadian resource output "Granger caused" changes in the output produced by the other two sectors. This conclusion does not necessarily imply any economic relationship among these variables, it merely implies that, with some statistical confidence, I can claim that increases in natural resource output chronologically preceded increases in new economy and rest of the economy output.

The parameter estimates reported in Panel A of Table 3 reveal that between 1970-2005 increases in energy, fishing, forestry, and mining production levels were associated with subsequent (statistically significant) increases in human capital and technology intensive production levels, and increases in the output produced by the rest of the economy group of industries. Increases in human capital and technology intensive production levels over this period were associated with subsequent (statistically significant) increases in the output produced by the rest of the economy group of industries, but not the output produced by the resource intensive industries. These estimates, therefore, are consistent with the view that Canada's natural resource producers played a leading role in the domestic economy after 1970, and the expansion of the new economy group of industries, although also playing a leading role with respect to the rest of the economy, was not associated with post-1970 contractions in the resource industries' output shares. Given the parameter estimates reported in Panels B-D of Table 3 one must be very cautious in the interpretation of this "leading sector" conclusion.

From Panel B we can see that if we remove energy extraction from the set of resource intensive producers, the significant correlation between period t new economy production and period $t-1$ resource production is lost, and the statistical connection between resource production and rest of the economy production becomes bi-directional. It is interesting to note that this single

[15] In Table 3 I report the estimation results using just one lag, which is the optimal lag length chosen by the Schwartz criteria in every case. The systems have been run with three lags with no change in the qualitative conclusions discussed below. A complete set of econometric results is available from the author.

Table 3: Testing for Leading Sectors

PANEL A			
Dependent	Independent Variables		
Variables	ΔNRQ_{t-1}	ΔNEQ_{t-1}	$\Delta ROEQ_{t-1}$
ΔNRQ_t	-0.056	-0.182	0.802
	(0.736)	(0.718)	(0.148)
ΔNEQ_t	**0.087**	**0.753**	0.084
	(0.054)	(0.000)	(0.581)
$\Delta ROEQ_t$	**0.188**	**0.376**	**0.344**
	(0.002)	(0.039)	(0.085)
PANEL B			
Dependent	Independent Variables		
Variables	$\Delta NoEngyNRQ_{t-1}$	ΔNEQ_{t-1}	$\Delta ROEQ_{t-1}$
$\Delta NoEngyNRQ_t$	-0.111	-0.538	**1.255**
	(0.496)	(0.369)	(0.058)
ΔNEQ_t	0.014	**0.748**	0.105
	(0.723)	(0.000)	(0.515)
$\Delta ROEQ_t$	**0.099**	**0.389**	0.341
	(0.066)	(0.050)	(0.121)
PANEL C			
Dependent	Independent Variables		
Variables	ΔNRQ_{t-1}	$\Delta NoPubNEQ_{t-1}$	$\Delta ROEQ_{t-1}$
ΔNRQ_t	-0.052	-0.132	0.773
	(0.755)	(0.779)	(0.181)
$\Delta NoPubNEQ_t$	0.082	**0.645**	0.212
	(0.166)	(0.000)	(0.329)
$\Delta ROEQ_t$	**0.180**	**0.313**	**0.363**
	(0.003)	(0.068)	(0.086)
PANEL D			
Dependent	Independent Variables		
Variables	$\Delta NoEngyNRQ_{t-1}$	$\Delta NoPubNEQ_{t-1}$	$\Delta ROEQ_{t-1}$
$\Delta NoEngyNRQ_t$	-0.093	-0.324	1.096
	(0.569)	(0.563)	(0.111)
$\Delta NoPubNEQ_t$	-0.008	**0.653**	0.216
	(0.882)	(0.000)	(0.310)
$\Delta ROEQ_t$	0.086	**0.321**	0.366
	(0.115)	(0.085)	(0.111)

Note: $NoEngyNRQ$ = natural resource industries with energy extraction removed. $NoPubNEQ$ = new economy industries with education, health, and social services removed.

Note: $N = 34$ for all equations. "P-values" are provided in parentheses. Parameter estimates in **bold face** are statistically significant with at least 90% confidence.

example of bi-directionality represents the only evidence in Table 3 that the resource industries comprised a lagging sector in the Canadian economy after 1970. In Panel D we can see that if we remove both the energy extraction industries and the public sector new economy industries from the exercise, we can no longer identify any chronological connection between changes in resource intensive production and the output of any of the other sectors. In Panel C we can see that even if we do not exclude energy from the resource sector, but we do exclude the public sector human capital and technology intensive producers, the statistical connection linking resource production and new economy production is again lost. Clearly, the treatment of both energy extraction and public sector industries matters: if these industries are included, energy, fishing, forestry, and mining industries comprise a leading sector in the Canadian economy after 1970, but if these industries are excluded, the statistical evidence in support of this conclusion becomes tenuous (at best).

Although the energy industries' key role in the resource sector is again evident, we may tentatively view the results reported in Table 3 in a favourable light, from the resource industries' perspective. If, as a whole, the resource industries comprised a leading sector between 1970-2005, or at the very least they did not comprise a lagging sector, then it seems reasonable to attempt to further refine our understanding of the connections linking the resource intensive industries to the other sectors of the domestic economy. To be more specific, I now wish to ask: "If natural resource industries played a leading role in the Canadian economy after 1970, what were the channels through which they exerted influence on the other sectors of the economy?"

4.2 Forward, Backward, and Final Demand Linkages

In the absence of a formal structural model I cannot directly test for the presence of forward, backward, and final demand linkages in Canada after 1970. However, the estimation of reduced form V.A.R. systems allows me to identify chronological patterns that are at least *consistent* with the operation of these linkages. More specifically, if forward linkages were operable after 1970, then we would expect to find that increases in resource intensive output chronologically preceded reductions in real domestic raw material prices, and increases in non-resource intensive manufacturing output. If backward linkages were operable, then we would expect to find that increases in resource intensive output preceded increases in non-resource intensive manufacturing and service sector output. If final demand linkages were operable, then we would again expect to find that increases in resource intensive output preceded increases in non-resource intensive manufacturing and service sector output. I am, therefore, interested in the connections between period $t-i$ resource output (NRQ

- with and without energy extraction), and period t non-resource intensive manufacturing output ($ManuQ$), service sector output ($ServQ$), and real domestic raw material prices (WM). This implies the need to estimate the parameters from a four equation vector autoregressive system, described by Equations (6)-(9):

$$\Delta NRQ_t = \sum_{i=1}^{i=n} \kappa 1_i \Delta NRQ_{t-i} + \sum_{i=1}^{i=n} \kappa 2_i \Delta WM_{t-i} + \sum_{i=1}^{i=n} \kappa 3_i \Delta ManuQ_{t-i} + \sum_{i=1}^{i=n} \kappa 4_i \Delta ServQ_{t-i} + \epsilon 6_t \tag{6}$$

$$\Delta WM_t = \sum_{i=1}^{i=n} \delta 1_i \Delta NRQ_{t-i} + \sum_{i=1}^{i=n} \delta 2_i \Delta WM_{t-i} + \sum_{i=1}^{i=n} \delta 3_i \Delta ManuQ_{t-i} + \sum_{i=1}^{i=n} \delta 4_i \Delta ServQ_{t-i} + \epsilon 7_t \tag{7}$$

$$\Delta ManuQ_t = \sum_{i=1}^{i=n} \omega 1_i \Delta NRQ_{t-i} + \sum_{i=1}^{i=n} \omega 2_i \Delta WM_{t-i} + \sum_{i=1}^{i=n} \omega 3_i \Delta ManuQ_{t-i} + \sum_{i=1}^{i=n} \omega 4_i \Delta ServQ_{t-i} + \epsilon 8_t \tag{8}$$

$$\Delta ServQ_t = \sum_{i=1}^{i=n} \theta 1_i \Delta NRQ_{t-i} + \sum_{i=1}^{i=n} \theta 2_i \Delta WM_{t-i} + \sum_{i=1}^{i=n} \theta 3_i \Delta ManuQ_{t-i} + \sum_{i=1}^{i=n} \theta 4_i \Delta ServQ_{t-i} + \epsilon 9_t \tag{9}$$

Where: ΔWM = log difference in the domestic raw material price index relative to the G.N.P. deflator (1970=1.00); $\Delta ManuQ$ = log difference in the value added generated by all non-resource intensive manufacturing industries deflated by a sector specific price index; $\Delta ServQ$ = log difference in the value added generated by all service sector industries deflated by a sector specific price index; $\kappa, \delta, \omega, \theta$ = parameters to be estimated; and; ϵ = normally distributed i.i.d.$(0, \Omega)$ regression residuals. As with Equations (3)-(5), optimal lag length in Equations (6)-(9) has been chosen using both the Schwartz and Akaike information criteria, and the stationarity of the data series has been confirmed using Phillips-Perron unit root tests.[16]

The parameter estimates associated with ΔNRQ_{t-1} ($\delta 1$ in Equation (7), $\omega 1$ in Equation (8) and $\theta 1$ in Equation (9)) in Panel A of Table 4 indicate that after 1970 increases in Canadian energy, fishing, forestry, and mining output "Granger caused" subsequent reductions in real domestic raw material prices, and increases in non-resource intensive manufacturing and service sector output. The insignificance of the parameter estimates on $\Delta ManuQ_{t-1}$ and $\Delta ServQ_{t-1}$ ($\kappa 3$ and $\kappa 4$ in Equation (6)) indicates that among the three industry groups statistical causality was uni-directional. These parameter estimates, while not conclusive evidence of the presence of forward, backward, and final demand linkages, suggest that between 1970-2005 changes in resource output preceded changes in domestic raw material prices, non-resource intensive manufacturing output, and service sector output in a way that was consistent with the continued operation of these linkages. However,

[16] Both the Schwartz and Akaike information criteria identify $n = 1$ as the optimal lag length, and non-stationarity can be rejected for all four dependent variables with at least 99% confidence.

Table 4: Chronological Patterns Consistent with Forward, Backward, and Final Demand Linkages

PANEL A				
Dependent Variables	Independent Variables			
	ΔNRQ_{t-1}	ΔWM_{t-1}	$\Delta ManuQ_{t-1}$	$\Delta ServQ_{t-1}$
ΔNRQ_t	-0.173	0.205	0.054	0.519
	(0.373)	(0.313)	(0.822)	(0.138))
ΔWM_t	**-0.394**	0.239	-0.157	**0.676**
	(0.042)	(0.238)	(0.512)	(0.053)
$\Delta ManuQ_t$	**0.367**	-0.253	0.221	-0.106
	(0.014)	(0.107)	(0.235)	(0.695)
$\Delta ServQ_t$	**0.111**	**-0.112**	**0.117**	**0.752**
	(0.031)	(0.039)	(0.068)	(0.000)
PANEL B				
Dependent Variables	Independent Variables			
	$\Delta NoEngyNRQ_{t-1}$	ΔWM_{t-1}	$\Delta ManuQ_{t-1}$	$\Delta ServQ_{t-1}$
$\Delta NoEngyNRQ_t$	-0.113	0.108	0.135	0.530
	(0.546)	(0.642)	(0.653)	(0.225))
ΔWM_t	**-0.294**	0.150	-0.209	**0.736**
	(0.057)	(0.435)	(0.398)	(0.041)
$\Delta ManuQ_t$	0.183	-0.148	0.234	-0.099
	(0.143)	(0.341)	(0.242)	(0.734)
$\Delta ServQ_t$	-0.002	-0.066	0.099	**0.794**
	(0.959)	(0.224)	(0.157)	(0.000)

Note: $NoEngyNRQ$ = natural resource industries with energy extraction removed.

Note: $N = 34$ for all equations. "P-values" are provided in parentheses. Parameter estimates in **bold face** are statistically significant with at least 90% confidence.

consideration of Panel B in Table 4 should again encourage caution in the interpretation of these "linkage" conclusions.

From Panel B we can see that if we remove energy extraction, increases in resource intensive output still led reductions in domestic raw material prices, but the statistical significance of the connection between resource output and non-resource intensive manufacturing and service sector output is lost. Once again we find that energy extraction industries played a key role in fostering a strong statistical connection among the resource, manufacturing, and service sectors in the Canadian economy between 1970-2005.

The qualitative conclusions based on the parameter estimates reported in Table 4 are robust across a wide range of sensitivity tests. For example, if we re-estimate our four equation V.A.R. system using only human capital and technology intensive new economy manufacturing and service sector output, rather than all non-resource intensive manufacturing output ($ManuQ$) and all service sector output ($ServQ$), we still find that increases in resource output chronologically preceded reductions in real domestic raw material prices, and increases in new economy manufacturing and service sector output. Again, these chronological patterns cannot be identified with statistical confidence if we remove energy extraction, but they are still evident even if we consider only the private sector new economy service industries. The inclusion of constants into Equations (6)-(9) has no impact on our qualitative conclusions, nor does the use of a value added weighted average of only energy, fishing, forestry, and mining output price indexes, rather than an aggregate raw materials price index (WM). If we include only domestically unique changes in real raw material prices, thereby removing the effects of international price volatility, statistical confidence is weakened in some cases, but our main conclusions still hold.[17] Finally, if we include control variables in this V.A.R. system to account for the possibility that it was actually coincident U.S. demand (real G.D.P. per capita), or international resource price movements (U.S. energy, fishing, forestry, and mining output prices) that were driving the chronological patterns we identify, we still find that between 1970-2005 increases in resource output (including energy extraction) preceded increases in non-resource intensive manufacturing output, increases in service sector output, and reductions in real raw material prices.

Based on the parameter estimates reported in Tables 3 and 4 and the results from sensitivity testing, I suggest that the evidence, while still consistent with the operation of forward, backward,

[17] For a detailed discussion of the identification of idiosyncratic raw material price movements see Keay (2007) Pg. 21.

and final demand linkages connecting Canada's natural resource industries to other sectors in the economy (and to domestic raw material prices) during the post-1970 period, is not unambiguous. Of course, the ambiguity should not necessarily undermine our confidence that the resource industries *as a whole* maintained their position as a leading sector in the Canadian economy after 1970 by reducing domestic raw material prices and generating demand for the output produced by non-resource intensive manufacturing industries and service sector industries. The evidence merely suggests that the resource industries' indirect contributions to aggregate economic performance were critically dependent upon the inclusion of energy extraction industries in the resource sector. Without energy extraction there appears to be, at best, mixed statistical support for the view that the fishing, forestry, and mining industries comprised a leading sector on their own, or that forward, backward, or final demand linkages connected these producers to other manufacturing, service, or human capital and technology intensive sectors in the Canadian economy between 1970-2005.

4.3 Input Price Inflation and Currency Appreciation

So far we have only discussed the positive spill overs that may have connected Canadian resource intensive activities to the other non-resource intensive sectors in the economy. The Dutch disease and resource curse literature suggests that there may have been coincident and counteracting negative spill overs, or crowding out, that also connected resource producers to the other manufacturing and service industries in Canada after 1970. A formal structural model would be required to directly test for the presence of crowding out, but once more the estimation of reduced form V.A.R. systems facilitates the identification of chronological patterns that could be at least *consistent* with the presence of crowding out. More specifically, if there were negative spill overs imposing costs on the non-resource intensive sectors in the Canadian economy, then we might expect to find that after 1970 increases in domestic resource intensive production chronologically preceded increases in the prices paid for labour and capital by the non-resource intensive manufacturing and service industries, and increases in the value of the Canadian dollar relative to the U.S. dollar. The connections between period $t-i$ resource output (NRQ - with and without energy extraction), and period t non-resource intensive labour costs (WL), a user cost for capital (WK), and the average annual Canada-U.S. exchange rate (CUX) are the variables of interest. This implies the need to estimate the parameters from another four equation vector autoregressive system, described by Equations

(10)-(13):

$$\Delta NRQ_t = \sum_{i=1}^{i=n} \eta 1_i \Delta NRQ_{t-i} + \sum_{i=1}^{i=n} \eta 2_i \Delta WL_{t-i} + \sum_{i=1}^{i=n} \eta 3_i \Delta WK_{t-i} + \sum_{i=1}^{i=n} \eta 4_i \Delta CUX_{t-i} + \epsilon 10_t \quad (10)$$

$$\Delta WL_t = \sum_{i=1}^{i=n} \lambda 1_i \Delta NRQ_{t-i} + \sum_{i=1}^{i=n} \lambda 2_i \Delta WL_{t-i} + \sum_{i=1}^{i=n} \lambda 3_i \Delta WK_{t-i} + \sum_{i=1}^{i=n} \lambda 4_i \Delta CUX_{t-i} + \epsilon 11_t \quad (11)$$

$$\Delta WK_t = \sum_{i=1}^{i=n} \psi 1_i \Delta NRQ_{t-i} + \sum_{i=1}^{i=n} \psi 2_i \Delta WL_{t-i} + \sum_{i=1}^{i=n} \psi 3_i \Delta WK_{t-i} + \sum_{i=1}^{i=n} \psi 4_i \Delta CUX_{t-i} + \epsilon 12_t \quad (12)$$

$$\Delta CUX_t = \sum_{i=1}^{i=n} \nu 1_i \Delta NRQ_{t-i} + \sum_{i=1}^{i=n} \nu 2_i \Delta WL_{t-i} + \sum_{i=1}^{i=n} \nu 3_i \Delta WK_{t-i} + \sum_{i=1}^{i=n} \nu 4_i \Delta CUX_{t-i} + \epsilon 13_t \quad (13)$$

Where: ΔWL = log difference in the non-resource intensive manufacturing hourly wage index relative to the G.N.P. deflator (1970=1.00); ΔWK = log difference in a user cost for capital (comprised of Moody's AAA industrial bond yields, an assumed 10% depreciation rate, and a purchase price index for industrial machinery and equipment (1970=1.00)) relative to the G.N.P. deflator; ΔCUX = log difference in the average annual Canada-U.S. currency exchange rate reported by the Bank of Canada; η, λ, ψ, ν = parameters to be estimated; and; ϵ = normally distributed i.i.d.$(0, \Omega)$ regression residuals. Again, optimal lag length has been chosen using both the Schwartz and Akaike information criteria, and the stationarity of the data series has been confirmed using Phillips-Perron unit root tests.[18]

The interpretation of the parameter estimates reported in Table 5 is straight forward: there is no statistical evidence of Granger causality among any of the variables. More specifically, with statistical confidence we can reject the possibility that increases in resource intensive production in Canada after 1970 (with or without energy included in the resource sector) were correlated with subsequent increases in non-resource intensive labour costs, capital costs, or domestic currency values. From both Panel A and B we can see that the parameters associated with period $t-1$ resource output in the labour cost and exchange rate equations ($\lambda 1$ in Equation (11) and $\nu 1$ in Equation (13)) are not only insignificant, the point estimates are actually negative. This evidence is not consistent with the presence of negative spill overs or crowding out. This conclusion is again robust over a wide variety of sensitivity tests including: the use of labour costs for new economy manufacturing industries alone, rather than all non-resource intensive manufacturers; the use of average annual labour costs in non-resource intensive manufacturing, rather than hourly labour

[18] Both the Schwartz and Akaike information criteria identify $n = 1$ as the optimal lag length, and non-stationarity can be rejected for all four dependent variables with at least 99% confidence.

Table 5: Chronological Patterns Consistent with Input Price Inflation and Currency Appreciation

PANEL A				
Dependent Variables	Independent Variables			
	ΔNRQ_{t-1}	ΔWL_{t-1}	ΔWK_{t-1}	ΔCUX_{t-1}
ΔNRQ_t	0.003	0.192	-0.0001	-0.051
	(0.987)	(0.760)	(0.999)	(0.872))
ΔWL_t	-0.012	**0.487**	0.009	-0.021
	(0.798)	(0.002)	(0.741)	(0.791)
ΔWK_t	0.128	-0.132	0.095	-0.125
	(0.683)	(0.902)	(0.593)	(0.817)
ΔCUX_t	-0.062	-0.419	0.037	**0.448**
	(0.498)	(0.179)	(0.478)	(0.005)
PANEL B				
Dependent Variables	Independent Variables			
	$\Delta NoEngyNRQ_{t-1}$	ΔWL_{t-1}	ΔWK_{t-1}	ΔCUX_{t-1}
$\Delta NoEngyNRQ_t$	-0.022	0.401	0.055	-0.115
	(0.904)	(0.599)	(0.650)	(0.760))
ΔWL_t	-0.036	**0.455**	0.012	-0.016
	(0.338)	(0.004)	(0.644)	(0.832)
ΔWK_t	0.137	-0.030	0.098	-0.131
	(0.601)	(0.978)	(0.574)	(0.808)
ΔCUX_t	-0.016	-0.418	0.029	**0.442**
	(0.839)	(0.195)	(0.574)	(0.005)

Note: $NoEngyNRQ$ = natural resource industries with energy extraction removed.

Note: $N = 34$ for all equations. "P-values" are provided in parentheses. Parameter estimates in **bold face** are statistically significant with at least 90% confidence.

costs; the use of interest rates alone, or purchase price indexes alone, rather than a user cost for capital; and; the inclusion of constants and control variables for U.S. demand and international resource prices.

In light of the considerable body of literature on Dutch disease and resource curse effects, and much of the recent policy discussion and regional discord involving issues linked to energy pricing and trade, the absence of any chronological patterns that are consistent with the presence of a connection between Canadian resource output and input price inflation or currency appreciation may seem surprising. Of course, we would only expect the labour and capital cost effects to be present if Canadian input markets were not well integrated across regions or with international markets. We should also expect the currency appreciation effects to be substantive only if the Canada-U.S. exchange rate was determined by forces originating in Canada's resource sector, rather than other Canadian export sectors (such as the auto sector), or the U.S. economy (due to expensive overseas military entanglements, for example).[19] This suggests that the results should perhaps not be quite so surprising, if we believe that Canadian input markets have been fairly well integrated over the 1970-2005 period, and the forces determining the value of the Canadian dollar relative to the U.S. dollar have not been persistently and substantially determined within the domestic resource sector alone.

5 Conclusions

Based on the evidence described in this paper, it appears that, although they may have been relatively large throughout the post-1970 period, Canada's resource industries' employment, investment, and income shares dropped quite precipitously between 1970-2005. The rapid erosion in the extent to which the aggregate economy specialized in resource extraction and processing activities coincided with a dramatic expansion in Canada's human capital and technology intensive industries. However, it also appears that the resource intensive producers' input and income shares had been gradually falling throughout much of the post-World War 2 era, and even with their flamboyant booms and busts, the energy extraction industries' contributions to the aggregate size of the Canadian economy increased substantially after 1970. When we look at the resource industries' profitability, productivity, and capital intensity, we find that throughout the post-1970

[19]The absence of a significant relationship between resource output and the exchange rate over the full 1970-2005 period is consistent with Issa, Lafrance and Murray's (2008) findings. They suggest that the relationship between Canadian energy prices and the exchange rate switched from positive to negative during the early 1990s due to changes in policy and trade patterns.

period, but (perhaps surprisingly) particularly among the fishing, forestry, and mining industries, their contributions to intensive economic performance were large, positive, and growing. Turning to the resource industries' indirect economic contributions, we find that between 1970-2005 increases in resource intensive production chronologically preceded increases in the output produced by new economy industries and other non-resource intensive industries. There is no evidence to suggest that this Granger causality was by-directional. If, as the chronological patterns among the sectors suggest, the resource industries maintained their role as a leading sector in the domestic economy after 1970, then the channels through which they exerted their influence may have been related to the operation of forward, backward, and final demand linkages. The estimation of reduced form V.A.R. systems indicates that increases in resource industry output preceded reductions in real domestic raw material prices, and increases in non-resource intensive manufacturing output and service sector output. While these results from the Granger causality tests are consistent with the continued operation of traditional staples thesis linkages, they are dependent on the inclusion of energy extraction industries among the set of resource intensive producers. Finally, I can find no evidence to suggest that there was relationship between increases in the output produced by Canada's energy, fishing, forestry, and mining industries and subsequent increases in non-resource intensive labour or capital costs, or the value of the Canadian dollar relative to the U.S. dollar.

What can we conclude from this evidence? Even at the beginning of the twenty-first century Canada's aggregate economy was still specialized to a considerable degree in resource production, particularly energy production. However, the resource sector as a whole, even without energy, does not appear to have been constraining per capita performance, and as long as we include energy, the natural resource industries still appear to have comprised a leading sector in the domestic economy, with positive spill overs driving down domestic raw material prices and generating demand for non-resource intensive production. In addition, we cannot find any evidence consistent with input price or currency crowding out. In total, therefore, the evidence seems to suggest that since 1970 resource specialization has been quite advantageous for the aggregate Canadian economy.

In light of this qualitative conclusion it is tempting to go one step further and argue that policies designed to promote resource specialization into the future will have few negative side effects and many positive side effects for the aggregate economy. If we wish to make this argument based on the evidence presented in this paper we must use considerable caution. The evidence described here is descriptive, not predictive. The success of resource specialization for Canada in the past has been conditional on our ability to generate a steady flow of resource rents, retain these

rents within Canada, and foster linkages between resource intensive production and domestic non-resource intensive production. In other words, the economic discovery of a series of new resource stocks that could be profitably exploited (Fort McMurray's oil sands, Voisey's Bay, Hibernia, for example) has been necessary for rent generation, increasing government resource rent taxation and encouraging domestic capital ownership has been necessary to keep rents within the country (government's share of total resource rents increased from 9% in 1970 to 23% in 1999[20]), and monetary, environmental and industrial development policies have been necessary to encourage diversification and the formation of linkages. If we are not able to maintain these "conditions", then there is no guarantee that continued resource specialization will lead to continued economic success.

[20]For a more detailed illustration of the distribution of resource rents in Canada see Keay (2007) Table 3.

References

[1] Allen, R. and E. Diewert, 1981, "Direct Versus Implicit Superlative Index Number Formulae", *Review of Economics and Statistics,* Vol. 63, Pg. 430-35.

[2] Auty, R.M., 2001, *Resource Abundance and Economic Development,* Oxford University Press, New York.

[3] Barro, R. and X. Sala-i-Martin, 2004, *Economic Growth, Second Edition*, M.I.T. Press, Cambridge, MA.

[4] Beckstead, D., M. Brown, G. Gellatly, and C. Seaborn, 2004, "Assessing the Growth of the New Economy across Canadian Cities and Regions: 1990-2000", *Journal of Regional Analysis and Policy,* Vol. 34, Pg. 21-45.

[5] Corden, W.M, 1984, "Booming Sector and Dutch Disease Economics: Survey and Consolidation", *Oxford Economic Papers,* Vol. 36, Pg. 359-380.

[6] Easterbrook, W., 1959, "Recent Contributions to Economic History: Canada", *Journal of Economic History,* Vol. 19, Pg. 76-102.

[7] Findlay, R. and M. Lundahl, 1994, "Natural Resources, Vent for Surplus, and the Staples Theory", in *From Classical Economics to Development Economics*, G. Meier (Ed.), Macmillan Press, Basingstoke, UK, Pg. 68-93.

[8] Gera, S. and K. Mang, 1998, "The Knowledge Based Economy: Shifts in Industrial Output", *Canadian Public Policy,* Vol. 24, Pg. 149-184.

[9] Gordon, R., 2000, "Does the New Economy Measure up to the Great Inventions of the Past?", *Journal of Economic Perspectives,* Vol. 14, Pg. 49-74.

[10] Innis, H., 1930, *The Fur Trade in Canada: An Introduction to Canadian Economic History,* University of Toronto Press, Toronto.

[11] Innis, H., 1940, *The Cod Fisheries: The History of an International Economy,* University of Toronto Press, Toronto.

[12] Issa, R., R. Lafrance and J. Murray, 2008, "The Turning Black Tide: Energy Prices and the Canadian Dollar", *Canadian Journal of Economics,* Vol. 41, Pg. 737-759.

[13] Keay, I., 2007, "The Engine or the Caboose? Resource Industries and Twentieth Century Canadian Economic Performance", *Journal of Economic History,* Vol. 67, Pg. 1-32.

[14] Nordhaus, W., 2002, "Productivity Growth and the New Economy", *Brookings Papers on Economic Activity,* Vol. 2, Pg. 211-265.

[15] Nordhaus, W., 2004, "Retrospective on the 1970s Productivity Slowdown", *N.B.E.R. Working Paper No. 10950.*

[16] Nordhaus, W., 2005, "The Sources of the Productivity Bebound and the Manufacturing Employment Puzzle", *N.B.E.R. Working Paper No. 11354.*

[17] Sachs, J., and A. Warner, 2001, "Natural Resources and Development: The Curse of Natural Resources", *European Economic Review,* Vol. 45, Pg. 827-838.

[18] Watkins, M., 1963, "A Staple Theory of Economic Growth", *Canadian Journal of Economics and Political Science,* Vol. 29, Pg. 141-158.

Figure 1: Industry Categorization

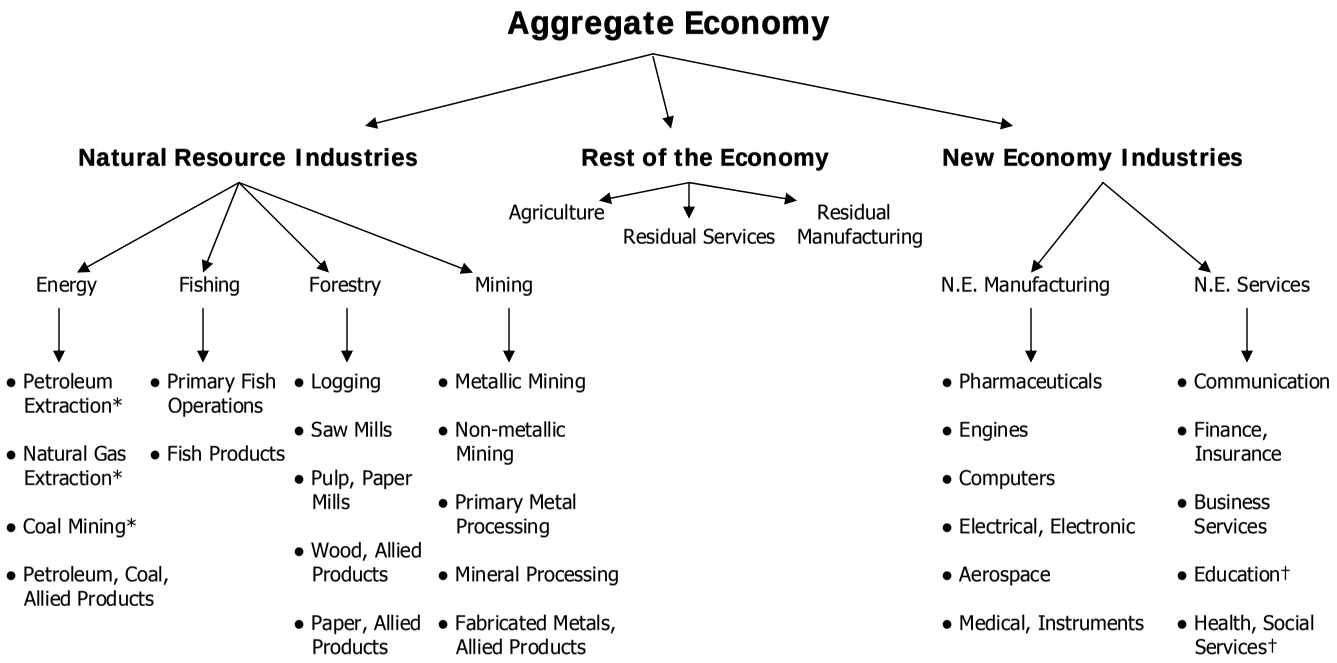

Figure 2: Long Run Employment Shares

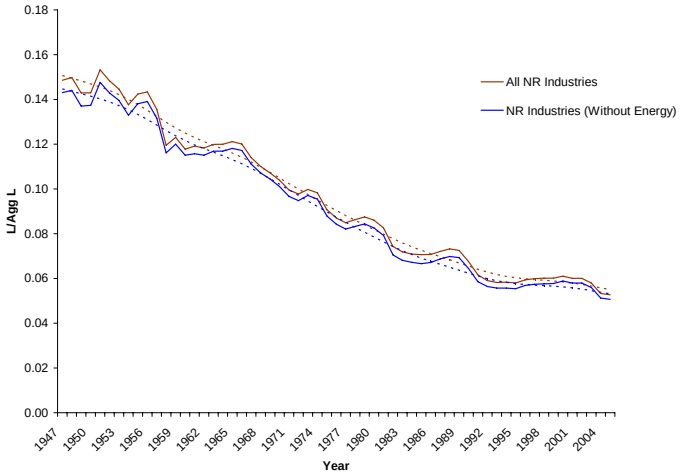

Figure 3: Long Run Capital Stock Shares

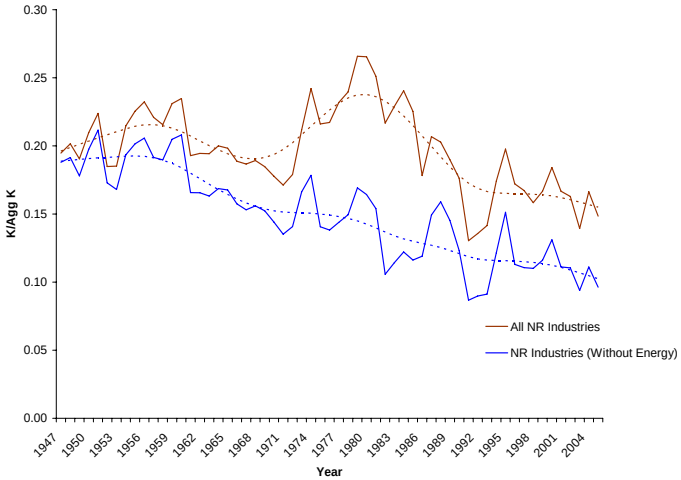

Figure 4: Long Run Value Added Shares

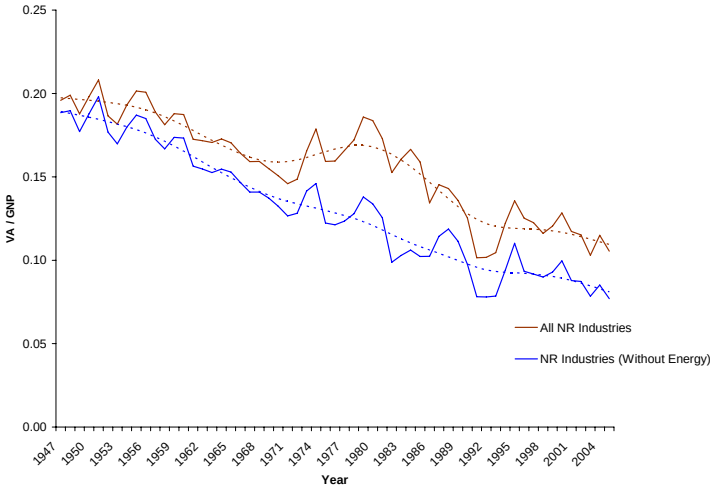

Figure 5: Long Run Resource Rent Shares

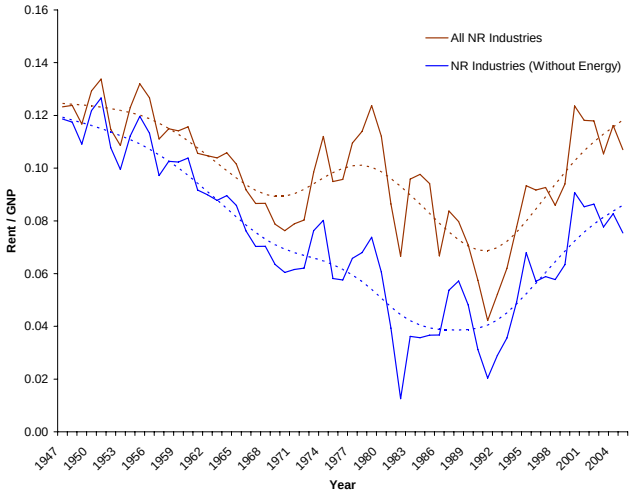

Figure 6: Long Run Relative Total Factor Productivity
(Aggregate Economy = 1.00)

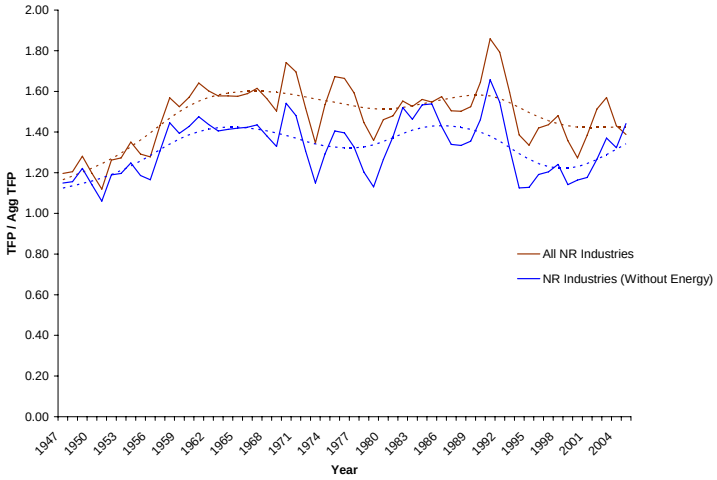

Figure 7: Long Run Relative Labour Productivity
(Aggregate Economy = 1.00)

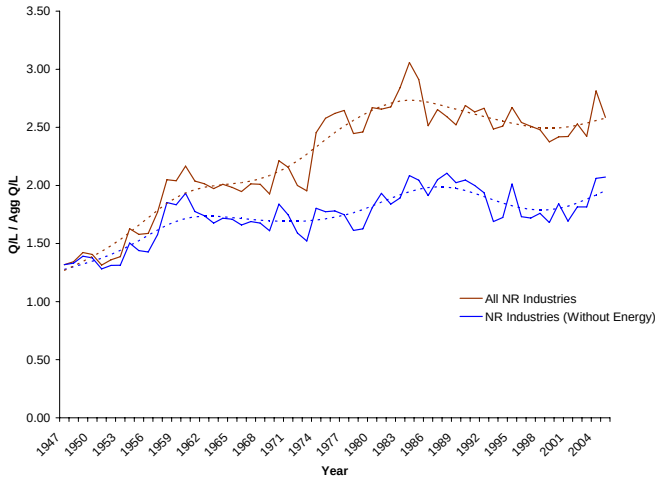

Figure 8: Long Run Relative Capital/Labour Ratios
(Aggregate Economy = 1.00)