Queen's Economics Department Working Paper No. 1143

Resource Rents and their Impact on Institutional and Economic Development

Ian Keay
Queen's University, Department of Economics

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

8-2007

Resource Rents and their Impact on Institutional and Economic Development:
Long Run Evidence from Canada's Natural Resource Industries

Ian Keay[1]
ikeay@econ.queensu.ca
Queen's University
Department of Economics and School of Environmental Studies
Kingston, ON
K7L 3N6

August 2007

[1]I would like to thank André Bernier, Patrick Coe, Herb Emery, James Fenske, Marvin McInnis, and Henry Thille for their comments on earlier versions of this paper. Much of the work on this paper was completed while visiting the Department of Economics at Yale. I would like to thank my colleagues there, particularly Tim Guinnane. I would also like to thank seminar participants at Yale, the University of Calgary, the University of Alberta, and the 2006 C.E.A. Annual Meetings. 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 is gratefully acknowledged. All remaining errors and omissions remain the responsibility of the author.

Abstract

Resource Rents and their Impact on Institutional and Economic Development: Long Run Evidence from Canada's Natural Resource Industries

Over the twentieth century Canada's energy, forestry, and mining industries played a substantial and increasing role in the growth and development of the aggregate economy. Despite the improving fundamentals that were underlying their increased contributions to the size, capital intensity, and productivity of the aggregate economy, the relative profitability and equity market performance of the resource industries deteriorated over the twentieth century. Without having to invoke entrepreneurial failure among the resource industries or equity market inefficiency, I am able to illustrate that falling relative output prices played the key role in a reconciliation of what, at first glace, appears to be a surprising relationship between the resource industries' fundamentals, resource rents, and equity market performance.

J.E.L. Classification: N22, N52, Q20, Q32.

1 Introduction

Economic growth based on the extraction and processing of natural resource endowments has been, and continues to be, one of the most common development paths pursued by nations seeking to achieve rapid and sustained increases in average income levels. What makes resource based growth so attractive is the potential generation of economic profit in the form of aggregate resource rents. As the return to a fixed factor, resource rents may contribute directly to per capita income growth. The possibility that inputs may receive payments in excess of their opportunity costs in resource extraction and processing industries draws labor and capital to these activities, contributing to extensive growth, while simultaneously generating demand spill-overs in non-resource intensive manufacturing and service sector production, including financial intermediation services. One of the problems with the pursuit of resource rents during the development process is the potential for market distortions introduced by these efforts. Among these distortions include the diversion of labor and capital away from higher productivity employment in more sustainable industries that are not dependent on a depleting natural resource endowment, the weakening of competitive pressures within input markets, including equity markets, and sub-optimal extraction, processing and technological decisions within the resource industries themselves.[1]

Canada provides us with an example of a resource intensive economy that has successfully developed into a wealthy, diversified, urbanized, and industrialized nation over the twentieth century. During the first quarter of the twentieth century, industries engaged in the extraction and processing of Canada's energy, forest, and mineral endowments employed 15.6% of the fixed capital in the economy and 14.1% of the labor, they produced 18.5% of the physical output, and they enjoyed labor productivity that was 32.9% higher and total factor productivity (T.F.P.) that was 24.9% higher than the national average. By the last quarter of the twentieth century these producers were employing 20.0% of the fixed capital in the Canadian economy and 7.1% of the labor, they were responsible for 19.4% of the physical output, and their labor productivity had risen to be more than 2.7 times the national average, while their T.F.P. was 53.1% higher than that enjoyed by the aggregate economy. If we confine our attention to the economic fundamentals that describe the inputs employed, the output produced, and the efficiency of their economic activities, then Canada's resource industries appear to have been both large and successful participants in the domestic growth process between 1900-1999.

Given their capital intensity, it is not surprising to find that the energy, forestry, and mining industries have played a substantial role in the establishment and growth of the largest formal equity market in Canada - the Toronto Stock Exchange (T.S.E.). Although it is not possible to provide exact annual figures, on average between 1900-1924 energy, forestry, and mining firms comprised approximately 45% of the total capitalized value of all the firms listed on the T.S.E.. Between 1975-1999 these firms' share of the composite index had fallen to just 27.3%. Because this decline in their share of the aggregate value of the firms listed on the T.S.E. may reflect nothing more than the increasing wealth, diversification, and industrialization one might hope to find in the wake of successful resource based growth, it is perhaps more surprising to note that on average over the twentieth century the prices for the resource industries' common shares fell by nearly 1% per year relative to the composite market. If we remove the energy, forestry, and mining companies from the T.S.E. composite index, then the contrast is even more dramatic - common share prices for non-resource intensive producers included in the T.S.E. composite increased at an average annual rate of 4.8% between 1900-1999, while the resource intensive producers' common share prices increased at an average annual rate of just 2.9% per year over this same period.

Because we can identify such substantial and persistent increases in their scale of production, their capital intensity and their productivity, at first glance it is surprising to find that Canada's resource industries' twentieth century equity market performance was deteriorating relative to non-resource intensive producers. Equity market inefficiencies and/or poor decision making among the resource industries' entrepreneurs could account for this apparent discrepancy among performance indicators. Some commentators have long argued that the small, insular nature of the Canadian equity market fostered information asymmetries and effectively muted competitive pressures, leading to price distortions and forcing many domestic firms to seek foreign, or less formal sources for their capital.[2] Others have suggested that Canada's resource intensive producers have been particularly prone to ineffective entrepreneurial decision making with respect to extraction and processing patterns, and their technological choices.[3]

In this paper I describe the results from an empirical investigation that has been based on the predictions proposed by theories of optimal resource extraction and efficient financial market operations. The results suggest that the apparently contradictory long run performance indicators for Canadian energy, forestry, and mining industries are actually consistent with optimal resource extraction patterns and the operation of an efficient and competitive domestic equity market. The pursuit of resource rents does not appear to have distorted or retarded the development of the Canadian economy or the domestic equity market. The key to reconciling the resource industries' improving fundamentals and deteriorating equity market performance, without having to invoke market inefficiencies or entrepreneurial failure, lies in a consideration of the relationship between resource prices, the economic fundamentals, and resource rents, on one hand, and resource rents and equity market performance, on the other. The identification of output prices as the key variable is not only consistent with the predictions made by resource and finance theories, but also with results reported in other empirical work on the determinants of Canadian resource industries' equity market returns.[4]

The empirical investigation proceeds in three stages, all of which use the aggregate Canadian economy as a benchmark to judge industry performance. In the first stage I employ a series of industry and sector specific reduced form estimating equations to quantify the strength of the connections linking Canadian resource rents to the variables that resource theory suggests should be important determinants of these rents, if extraction and processing decisions are being made optimally. In the second stage I estimate a series of industry and sector specific multi-factor capital asset pricing models (C.A.P.M.) to identify connections linking the equity market performance of Canadian resource industries to unanticipated changes in resource rents. In the third and final stage of the empirical exercise I again estimate a series of equations based on industry and sector specific multi-factor C.A.P.M. models. However, in this stage I am interested in the connection between equity market performance and the determinants of resource rents, as identified in the first stage of my investigation, rather than the rents themselves - I include unanticipated changes in productivity, capital intensity, scale, and output prices directly in the multi-factor C.A.P.M. equations.

The empirical exercise and resultant conclusions described in this paper are not purely a matter of historical interest, nor are they necessarily regionally specific. The results illustrate the nature of the relationships that one might expect to find among equity market development, resource rents, and economic fundamentals over a long time period in an economy that is successfully pursuing a resource based development path. While drawing some general conclusions about the pursuit of resource rents and the potential for effective decision making on equity markets and among the resource industries, we may simultaneously expose some of the predictions of natural resource and finance theories to high quality, long run empirical evidence. This exposure allows us to investigate the relevance of these predictions in a resource based economy over much of its development trajectory.

2 Data

It would be possible to conduct an empirical investigation employing theoretical models describing connections between equity market performance, profits, and economic fundamentals using any number of industries, geographic regions and time periods. I confine my investigation to producers engaged in the extraction and processing of resource endowments because they have traditionally been very active participants on equity markets, their output products are sold on competitive international markets, and resource rents provide a feasible, quantitative measure of their profitability.

Canadian resource industries are a particularly valuable case study not only because data of sufficient quality and quantity exists for a detailed and long run empirical investigation, but also because the continued resource intensity of the Canadian economy, coupled with its rapid and persistent growth implies that much may be learned about performance in a nation successfully pursuing resource based growth and development. Focusing on the entire twentieth century facilitates a long run perspective that spans multiple business cycles, thereby avoiding conclusions that may be dependent on short and medium run resource booms and busts.

To undertake this investigation of the relationships linking Canadian resource industries' long run equity market performance to their resource rents and their fundamentals, I began by compiling annual information covering the years 1900-1999 on a very wide range of variables, including bond yields, common stock price indexes, the quantities, values and prices of inputs used and outputs produced by Canadian energy, forestry, and mining industries, and similar quantity and price information for the aggregate economy.[5] To be considerably more specific, the data series employed in my investigation include information on:

- Canadian G.N.P..
- Industry specific real output: measured as value added deflated by an industry specific output price index.
- Real industry specific gross fixed capital: measured as the reported value of fixed capital.[6]
- Industry specific labor: measured as total employment.
- Industry specific output price indexes.
- G.N.P. deflator.
- Industry specific total factor productivity: measured as a Tornqvist weighted average of partial factor productivities, with value added used as the output measure and average income shares used as weights.

- Industry specific aggregate resource rents: measured as value added less the opportunity cost of labor and the opportunity cost of capital. I assume that the opportunity cost of labor is total employment multiplied by the average annual labor income earned in non-resource intensive manufacturing. I assume that the opportunity cost of capital is the nominal value of net fixed capital times Moody's AAA industrial bond yields.[7]

- Composite market common stock price index: measured as the T.S.E. 300 composite index from 1956-1999, the T.S.E. composite market index from 1935-1956, the composite market index adjusted to account for changes in the mining index from 1914-1935, and Giddeon Rosenbluth's (2005) reconstructed composite index, adjusted to account for changes in the mining index from 1900-1914.

- Energy common stock price index: measured as the T.S.E. energy products index from 1956-1999, the "Oil and Gas" index from 1926-1956, and the weighted average of annual high-low quotations in the *T.S.E. Annual Review* for coal mines and petroleum firms from 1900-1926, using capitalized values calculated in 1900, 1910, 1920 and 1926 as firm weights.

- Forestry common stock price index: measured as the T.S.E. forestry and paper products index from 1914-1999, and the weighted average of annual high-low quotations in the *T.S.E. Annual Review* for forestry and paper firms from 1900-1914, using capitalized values calculated in 1900 and 1910 as firm weights.

- Mining common stock price index: measured as the T.S.E. mines and minerals index from 1935-1999, and the weighted average of annual high-low quotations in the *T.S.E. Annual Review* for all mining firms from 1900-1935, using capitalized values calculated in 1900, 1910, 1920 and 1926 as firm weights.[8]

- Government of Canada long term bond yields.[9]

- Moody's AAA industrial bond yields.

- Canada-U.S. foreign currency exchange rate: measured as the average of the monthly average rates.

My identification of energy, forestry, and mining industries follows the N.A.I.C.S. definitions used by Natural Resources Canada in 2004.[10] The decision to use contemporary industrial categories necessitated the reconstruction of industries from more disaggregate data for much of the early part of the century. There were particularly dramatic reorganizations of industry categories by the Dominion Bureau of Statistics and Statistics Canada in 1926, 1948 and 1982. Prior to the existence of the Dominion Bureau of Statistics, which began operations in 1926, much of the quantity, value and price data used in this study was only available from decennial Canadian Census Reports and periodic publications by the Department of Forestry, the Bureau of Mines, the Government of Canada Sessional Papers, and Canadian Year Books. For the series which had no annual data published outside of the census years (1901, 1911, and 1921) interpolation was based on the methodological approach employed by Urquhart (1993) in his reconstruction of late nineteenth-early twentieth century Canadian G.N.P.. To reduce some of the cross-sectional volatility in the data series used in this study, and to facilitate a discussion of the experiences of the more broadly defined natural resource sector as a whole, I have aggregated the industry specific series up to the sectoral level using the proportion of total value added to weight each industry in the aggregation process.[11]

Insert Table 1

The means and standard deviations for the variables employed in the empirical investigation described in this paper are reported in Table 1. These summary statistics represent differences in growth rates, with negative values - for example, output prices, resource rents, and stock prices - indicating that the aggregate economy grew faster than the resource industries over the twentieth century, and positive values - for example, T.F.P., labor productivity, physical output, and capital intensity - indicating more rapid resource industry growth. To provide some structure and statistical rigor to the assessment of the connections linking the series described in Table 1, I now turn to the specification of an empirical approach comprised of reduced form equations based on some of the predictions made by optimal resource extraction and finance theory.

3 Some Predictions from Resource and Finance Theory

When investigating the relationship between a sector's equity market performance, their profitability, and their economic fundamentals, it seems natural to be concerned about the exogeneity and endogeneity of the variables of interest. Fortunately, theories of optimal resource extraction and equity price determination provide considerable guidance in this regard.

We may begin by considering resource extraction costs, which are typically modeled as functions of the standard cost determinants, taken from production theory, and the size of the resource stock *in situ*.[12] Depletion of the *in situ* stock is assumed to be positively related to extraction and processing costs. Unfortunately, the estimation of Canadian energy, forest, and mineral *in situ* stocks for each year between 1900-1999 is probably impossible and certainly beyond the scope of this study. I do, however, have information on the standard determinants of extraction costs proposed by production theory, including total factor productivity (T.F.P.), the scale of production, and capital intensity.[13] By including scale and capital intensity independently, T.F.P. may be interpreted narrowly as a proxy for technological change in the determination of extraction costs.

Resource extraction costs are relevant because of their role in the determination of resource industry profits. Virtually all theories of optimal renewable and nonrenewable resource extraction are based on an assumption that resource industries choose their extraction patterns to maximize the present value of the stream of potential resource rents. The optimal extraction patterns, and resultant rents, hinge on the trade-off between extraction costs and output prices.[14] Because such a large proportion of Canadian resource intensive production has traditionally been exported - primarily to the United States - one might reasonably expect Canadian resource industries to consider both domestic output prices and the Canada-U.S. exchange rate when assessing this tradeoff.[15] Resource and production theories, therefore, suggest that we should expect aggregate resource rents to be dependent on a set of economic fundamentals, including output prices, exchange rates, and extraction costs, which in turn should depend on technological change, the scale of production, and capital intensity.

To link equity market performance to these fundamentals I turn to the basic capital asset pricing model (C.A.P.M.), which is founded on the notion that the expected rate of return on an equity portfolio should be dependent on only the risk free rate of return and the market average rate of return.[16] In its basic form C.A.P.M. suffers from the fact that it is inherently static in structure, it requires "two-fund separation" to hold, which requires either quadratic preferences or normally distributed returns for all risky assets traded on the market, and it cannot embrace any additional determinants of equity market performance, which we may wish to include to reflect the possibility that investors hedge against future changes in their investment opportunities. In an effort to address these shortcomings in the basic model, Ross (1976) introduced the arbitrage pricing theory (A.P.T.), which generalizes the basic C.A.P.M. structure by admitting additional, or supplementary explanatory variables. Estimating equations based on Ross' theory are often called K-factor, or multi-factor C.A.P.M. models.

In an effort to identify the relevant explanatory variables that we may wish to include in a multi-factor C.A.P.M. estimating equation for Canadian resource industries we can turn to another branch of finance theory - investment valuation techniques. To determine if firms are over or under-valued on equity markets it is typical to compare capitalized values to the present value of the stream of profits expected in the indefinite future.[17] This approach implies that we should expect resource industries' equity market performance, which contributes directly to the capitalized value of the industry, to be dependent on their ability to generate economic profits, or resource rents. In a multi-factor C.A.P.M., therefore, we should expect industry or sector specific equity market returns to be a function of not only the risk free rate of return and the composite market rate of return, but profitability and/or the determinants of profitability, as well. Of course, in an efficient, competitive equity market, anticipated changes in profitability should already be fully reflected in equity prices. This implies that we are more specifically interested in the relationship between equity market performance and deviations from expected profitability and/or its determinants.

Variants on the multi-factor C.A.P.M. approach, and its implicit distinction between the endogeneity of equity market returns and the exogeneity of the economic fundamentals and output prices, have been employed to study Canadian resource industries in a range of empirical settings. Sadorsky (2001), and Sadorsky and Henriques (2001) have used multi-factor C.A.P.M. models to explain the late twentieth century equity market performance of Canadian energy and forestry industries, respectively.[18] Slade and Thille (1997) have developed a structural model that formalizes the connections that are implicit in Sadorsky's multi-factor C.A.P.M. approach. Their model explicitly links the multi-factor C.A.P.M. structure to the Hotelling Rule's (1931) predictions regarding the determinants of resource rents in the presence of optimal resource extraction, and their empirical exercise tests their model using data from Canadian copper mines.

From a theoretical perspective it seems reasonable to propose a multi-factor C.A.P.M. approach in which changes in twentieth century Canadian resource industries' common stock prices may be considered endogenous, while risk free rates of return, market average rates of return, and, through their impact on resource rents, unanticipated movements in the economic fundamentals, including output prices, foreign exchange rates, productivity performance, output levels, and capital intensity, may be considered exogenous.

4 An Empirical Investigation in Three Stages

In an effort to understand the role played by Canadian resource prices in the reconciliation of the resource industries' seemingly contradictory twentieth century economic contributions - namely, improving productivity, increasing scale, and increasing capital intensity, coincident with deteriorating equity market performance - I employ an empirical approach that proceeds in three distinct stages. In the first stage I investigate the determinants of resource rents, as identified in theories of both renewable and non-renewable optimal resource extraction. In particular, I assume that between 1900-1999 changes in resource rents relative to G.N.P. for Canadian energy, forestry, and mining industries were dependent on changes in the determinants of extraction costs and output prices. The determinants of extraction costs that I consider include changes in relative T.F.P. (and its lags), capital intensity, and the scale of production. Lagged T.F.P. is included in the estimating equations to allow for a period of adaptation during which new technologies may be integrated into the resource industries' existing production processes. In addition to the determinants of extraction costs, I consider industry specific output prices relative to the G.N.P. deflator, and changes in the average Canada-U.S. exchange rate. The estimating equations in the first stage of my empirical investigation take the form:

$$\begin{aligned} \Delta Rentsh_{it} &= \beta 0_i + \beta 1_i \sum_{n=0}^{n=3} \Delta RelA_{i(t-n)} + \beta 2_i \Delta Qsh_{it} \\ &\quad + \beta 3_i \Delta KLsh_{it} + \beta 4_i \Delta RelP_{it} + \beta 5_i \Delta CUX_t + \epsilon 1_{it} \end{aligned} \tag{1}$$

Where: i = natural resource sector, energy, forestry, mining; t = 1900 - 1999 (annual); $\Delta Rentsh$ = % change in industry specific resource rents as a share of G.N.P.; $\Delta RelA$ = % change in industry specific T.F.P. relative to aggregate T.F.P.; ΔQsh = % change in industry specific real output as a share of aggregate real output; $\Delta KLsh$ = % change in industry specific capital/labor ratio as a share of aggregate capital/labor ratio; $\Delta RelP$ = % change in industry specific output price relative to G.N.P. deflator; ΔCUX = % change in Canada-U.S. average annual exchange rate; βX = parameters to be estimated; $\epsilon 1$ = regression residual. Given the predictions of resource theory and standard production theory, as well as the results reported by Slade and Thille (1997, Table 3), we should expect technological change, increases in the scale of production, increases in capital intensity, increases in relative prices, and currency appreciation to have had a positive and significant impact on resource rents.

In the second stage of my investigation I estimate a series of sector and industry specific multi-factor C.A.P.M. equations in an effort to identify a connection between resource rents and equity market performance. In these equations the prediction that unanticipated changes in resource industry profitability should be a significant determinant of equity prices, as proposed by basic finance theory, can be probed by introducing deviations from expected changes in resource rents relative to G.N.P. as a supplementary explanatory variable into the basic C.A.P.M. structure. Although there are an infinite number of ways to model expectations (or deviations from expectations), I use just three in this paper. First, I simply assume that investors on the T.S.E. expected resource rents as a proportion of G.N.P. to be constant across consecutive years. This implies that all of the annual change in resource rents as share of aggregate income may be considered unanticipated, and may therefore have had an impact on equity market performance. Second, I assume that investors on the T.S.E. used resource rents as a proportion of G.N.P. over the last three years to form their expectations about changes in current rents. This implies that unanticipated changes in resource rents may be measured by using the residuals from a preliminary estimation equation in which current rents as a proportion of G.N.P. are regressed against a constant, a linear time trend (to allow for changes in information gathering and processing technology over time) and past rents as a proportion of G.N.P.. For the third model of expectations formation I assume that investors on the T.S.E. used rents from the past 10 years to form their expectations, rather than using rent shares from just the past three years. My Stage 2 multi-factor C.A.P.M. estimating equations take the form:

$$(R_{it} - R_{ft}) = \kappa 0_i + \kappa 1_i (R_{mt} - R_{ft}) + \kappa 2_i RentDevX_{it} + \epsilon 2_{it} \tag{2}$$

Where: R_i = rate of return on industry i common stock prices = $ln(StkP_{i1}) - ln(StkP_{i0})$[19]; R_f = rate of return on long term Government of Canada bonds[20]; R_m = rate of return on the T.S.E. common stock price composite index; $RentDevX$ = unanticipated changes in resource rents as a proportion of G.N.P., where expectations are assumed to have been formed using information from the past X years ($X = 0, 3, 10$). All other variables have been previously defined. In Equation (2) we are primarily interested in the size and significance of $\kappa 2$. Given the predictions of basic finance theory, we should expect unanticipated increases in an industries' resource rents to be coincident with economically and statistically significant improvements in their equity market performance.

In the first stage of the empirical investigation I specified a reduced form aggregate resource rent equation. According to theories of optimal resource extraction, Equation (1) is not fully specified due to the absence of any explanatory variable capturing the impact of stock depletion on rent generation. It is possible, therefore, that the relationship between aggregate rents and equity market performance captured by Equation (2) may be unrelated to the variables available to us here - namely the economic fundamentals and output prices. To investigate the relative importance of the unanticipated resource rent movements that may be attributed to the fundamentals and prices alone, I complete the second stage of my investigation with a minor adaption of Equation (2). For this adaptation I first decompose the observed changes in resource rents as a share of aggregate income into those changes that can be explained by movements in the economic fundamentals and resource prices - the predicted rent shares from Equation (1) - and those changes that are not associated with these determinants - the regression residuals from Equation (1). I then use the decomposed rents in Equation (2) in place of $RentDevX$. This approach allows me to identify the extent to which rent movements associated with the fundamentals and output prices were driving the relationship that may be identified between the resource industries' equity market performance and their profitability. The multi-factor C.A.P.M. equations with decomposed rents as supplementary explanatory variables take the form:

$$(R_{it} - R_{ft}) = \gamma 0_i + \gamma 1_i (R_{mt} - R_{ft}) + \gamma 2_i \Delta \widehat{Rentsh}_{it} + \gamma 3_i \widehat{\epsilon 1}_{it} + \epsilon 3_{it} \tag{3}$$

Where: $\Delta\widehat{Rentsh}$ = unanticipated changes in resource rent as a proportion of G.N.P. that may be explained by changes in fundamentals and resource prices; $\widehat{\epsilon 1}$ = unanticipated changes in resource rent as a proportion of G.N.P. that cannot be explained by changes in fundamentals and resource prices. All other variables have been previously defined. By using Equation (1) to decompose resource rents I am implicitly adopting my first model of expectations formation in this stage of the investigation. More specifically, I am assuming that investors on the T.S.E. expected resource rents as a proportion of G.N.P. to remain unchanged across consecutive years. This implies that the total change in resource rents as a proportion of G.N.P. (the dependent variable in Equation (1)) may be considered unanticipated.

In the third and final stage of my investigation I again employ multi-factor C.A.P.M. estimating equations. However, having established the relative importance of the resource rent movements that may be associated with the fundamentals and output prices, I now consider the direct connection between unanticipated changes in the Canadian resource industries' productivity, size, capital intensity, domestic prices and foreign exchange rates, and their equity market performance. I again employ three expectations formation models for the fundamentals, output prices, and the Canada-U.S. exchange rates: all changes are unanticipated; expected changes are based on the past three years, a linear time trend and a constant; or expected changes are based on the past 10 years, a linear time trend and a constant. Equation (4) is an augmented version of that employed by Sadorsky (2001) and Sadorsky and Henriques (2001):

$$\begin{aligned}(R_{it} - R_{ft}) &= \eta 0_i + \eta 1_i (R_{mt} - R_{ft}) + \eta 2_i ADevX_{it} + \eta 3_i QDevX_{it} \\ &+ \eta 4_i KLDevX_{it} + \eta 5_i PDevX_{it} + \eta 6_i CUXDevX_t + \epsilon 4_{it}\end{aligned} \tag{4}$$

Where: $ADevX$ = unanticipated changes in industry specific T.F.P. relative to aggregate T.F.P., where expectations are assumed to have been formed using information from the past X years; $QDevX$ = unanticipated changes in industry specific physical output relative to aggregate physical output; $KLDevX$ = unanticipated changes in industry specific capital/labor ratios relative to aggregate capital/labor ratios; $PDevX$ = unanticipated changes in industry specific output prices relative to G.N.P. deflator; $CUXDevX$ = unanticipated changes in average Canada-U.S. exchange rate. All other variables have been previously defined. Given the predictions implied by basic finance theory and optimal resource extraction theory, and in light of the results reported by Sadorsky (and his co-authors), we should expect the unanticipated changes in productivity, output, capital intensity, prices, and currency depreciation to have had a positive and significant impact on equity market performance. Of course, much of the theoretical work suggests that the relationship between these economic fundamentals and equity market performance should merely reflect the fact that the fundamentals are proxies for the explanatory variable that is really of interest to investors - resource rents.

5 Estimation Results

Before estimating Equations (1)-(4), the time series properties of the data were explored using standard augmented Dickey-Fuller (1979) and Phillips-Perron (1988) unit root tests (with a linear trend).[21] It was not surprising to find that the series were often non-stationary in levels.[22] However, because I am interested in stock market premia and relative rates of change over time, the stationarity of the log differences of the relative performance indicators is more relevant than the stationarity of each series in level terms. Non-stationarity can be rejected with at least 99% confidence for all of the series employed in Equations (1)-(4).[23]

Standard diagnostic tests have been performed on the residuals and the parameter estimates from Equations (1)-(4) for each industry and the aggregate resource sector. Where there was evidence of autocorrelation and/or heteroskedasticity among the residuals at the 90% level of confidence Newey-West (1987) robust standard errors have been used to calculate the reported p-values.[24] A Cook's (1977) distance test for statistical influence has been used to identify outliers in the resource rent series. The outliers that have been identified are coincident with years in which negative aggregate resource rents were earned, particularly within the mining industry. In an effort to ensure error normality these outliers have been dropped prior to the derivation of the reported results.[25] Durbin (1954) - Wu (1973) - Haussman (1973) tests confirm the exogeneity of capital intensity with respect to equity market performance, with at least 95% confidence for all three resource industries and for the aggregate resource sector.[26] Because of the close correlation between capital intensity, T.F.P., and physical output, Equation (1) and (4) have been estimated with and without capital/labor ratios as an explanatory variable. The exclusion of the capital/labor ratios tends to have very little impact on the paramter estimates associated with physical output, while fairly substantially increasing the size and significance of the parameter estimates associated with T.F.P.. This suggests that among Canada's resource industries, twentieth century technological changes were often embodied in physical capital accumulation.

There is an additional issue regarding industry aggregation that must be touched on before reporting the estimation results. I have not only estimated parameters at the sectoral level using value added weighted averages of the industry specific series, but I have also organized the industries into a panel, and then used generalized least squares with corrections for cross-panel heteroskedasticity and panel specific autocorrelation to derive estimates for the resource sector as a whole. The panel approach to sectoral aggregation allows me to determine how sensitive my results are to the use of a value added weighting scheme. The use of both weighted averages and panel regressions allow me to focus on the Canadian resource sector as a whole, rather than becoming diverted by the need to explain industry specific idiosyncracies that may appear in the results.

Insert Table 2

In Table 2 the parameter estimates (and their p-values) for each of the independent variables included in Equation (1) are provided by industry and for the two sectoral aggregation schemes, along with the Adjusted R^2 standard measure of statistical fit and the number of observations.[27] Table 2 also indicates where corrections have been made for heteroskedasticity and autocorrelation, and where outliers have been dropped prior to estimation.

We can see that although the point estimates are generally positive for T.F.P. and its lags in Equation (1), if we include capital intensity as an explanatory variable, thereby allowing us to interpret T.F.P. fairly narrowly as technological change alone, there appears to have been a statistically significant (and positive) relationship betwen resource rents and T.F.P. only when we aggregate the individual industries up to the sectoral level.[28] In terms of statistical power there is an even weaker connection linking the capital intensity of Canadian resource industries to their rents - all three industries and both aggregation schemes produce positive point estimates for capital intensity, but forestry is the only industry for which the estimates are significant. With respect to the Canada-U.S. exchange rate, only the energy industry seems to have experienced a significant relationship between currency depreciation and rising resource rents over the twentieth century, while the forestry and mining industries not only had no statistically significant connection between the value of the Canadian dollar and resource rents, their point estimates are negative. These mixed results for exchange rates may reflect the indeterminacy of foreign demand elasticity for Canadian resource products over the 1900-1999 period. It is interesting to note that for later decades in the twentieth century Slade and Thille (1997, Table 3) found a considerably more robust connection between foreign exchange rates and marginal scarcity rents for the Canadian copper mining industry.

In contrast to T.F.P., capital intensity, and exchange rates, a consideration of the parameters associated with physical output brings us to some of the strongest statistical and economic connections documented in Table 2. All three resource industries and the sector as a whole enjoyed statistically significant increases in rents in response to rising relative output levels. For the forestry and mining industries the rent response to increases in the scale of production was particularly noteworthy. Among the economic fundamentals that may be associated with extraction costs, scale had by far the most economically and statistically substantive connection to the profitability of Canada's resource industries during the twentieth century. However, even output levels do not appear to have been as important as domestic output prices.

For all three industries and both aggregating schemes, improvements in the resource industries' domestic terms of trade (rising relative output prices) were associated with rapid increases in resource rents in excess of aggregate economic growth. The parameter estimates on output prices indicate that over the twentieth century this relationship was not just positive and significant, but a 1% increase in output prices in excess of average economy-wide inflation was associated with an increase in resource rents in excess of G.N.P. growth of between 1.15% and 2.52%.

In general, these results are quite consistent with the predictions implied by renewable and non-renewable resource extraction theories. Specifically, declining extraction costs (or more accurately, rising T.F.P., output levels, and capital/labor ratios) and rising output prices were associated with rising resource rents among Canada's energy, forestry, and mining industries during the twentieth century - with the strongest connections in terms of their absolute size and their statistical power linking rent generation to domestic output prices and output levels. The consistency between the long run empirical evidence from Canadian resource industries and theories of optimal extraction suggests that Canadian resource producers have not been prone to particularly ineffective decision making over the 1900-1999 period.

Insert Table 3

In Table 3 the results from multi-factor C.A.P.M. equations that comprise the first part of the second stage of my empirical investigation are reported. More specifically, the parameter estimates (and their p-values) for each of the independent variables from Equation (2) are provided for the resource sector as a whole, and for the energy, forestry, and mining industries. Equation (2) is the basic C.A.P.M. augmented to include unanticipated changes in resource rents relative to G.N.P. as a supplementary explanatory variable. Anticipated changes in resource rents have been derived under the assumption that investors on the T.S.E. used information from only the current year, the past three years, or the past 10 years in forming their expectations. We can see that unanticipated increases in resource rents in excess of G.N.P. growth were associated with fairly substantial improvements in equity market performance for both sectoral aggregations, and for the energy and forestry industries. Although resource rent growth was positively related to equity price increases for the mining industry, the absolute size of the parameter estimates on rent deviations for mining are very small compared to its resource industry counterparts, and under only the 10 year expectations model was the relationship significant. We can also see that the constants are very small and insignificant, and the parameter estimates on the composite market premia are strongly statistically significant and very close to one. These results suggest support for the basic C.A.P.M. formulation, and they are consistent with finance theories which suggest that in an efficient and competitive equity market, unanticipated changes in profitability should be a substantive determinant of equity market performance.[29]

Insert Table 4

In Table 4 I report the parameter estimates (and their p-values) for each of the independent variables from Equation (3) for the resource sector, energy, forestry and mining. Equation (3) uses the multi-factor C.A.P.M. structure to document the relationship between equity market performance and unanticipated changes in resource rents, where Equation (1) has been used to decompose rent changes into movements associated with the economic fundamentals and output prices ($\Delta\widehat{Rentsh}$), and movements that were unrelated to these determinants ($\widehat{\epsilon 1}$). We can see that the parameter estimates associated with the movements in resource rents that were independent of prices and the fundamentals ($\widehat{\epsilon 1}$) were small in size and statistically insignificant for all three industries and for the sector as a whole. In contrast, the parameter estimates associated with changes in rents that reflected the fundamentals and prices ($\Delta\widehat{Rentsh}$) were not just large and statistical significant, but with the exception of the mining industry, they were both larger and more statistically influential than the aggregate, observed changes in resource rents reported in Table 3. This suggests that unanticipated changes in productivity, output levels, capital intensity and resource prices not only had an impact on equity market performance, but perhaps because they were much more easily observable by stock market investors, they appear to have had more statistical influence than the aggregate resource rents themselves.

Insert Table 5

In Table 5 the parameter estimates (and their p-values) for each of the independent variables in Equation (4) are reported for the resource sector, energy, forestry, and mining. Equation (4) is a multi-factor C.A.P.M. equation with unanticipated changes in the determinants of extractions costs (T.F.P., physical output levels, and capital intensity) and output prices (including the Canada-U.S. average annual exchange rate) included as supplementary variables in an effort to explain movements in the Canadian resource industries' common stock prices over the 1900-1999 period. Anticipated changes in the resource rent determinants have, again, been derived under the assumption that investors used information from the current year, the past three years, or the past 10 years in the formation of their expectations. Unlike Equation (3), we are now focusing on the direct connection between the fundamentals, output prices, and equity market performance. The results reflect a pattern that is very reminiscent of the parameter estimates reported in Table 2.

From Table 5 we can see that the composite market premia continues to be a statistically important determinant of the resource industries' common stock price premia across all industries and all assumptions regarding the formation of investors' expectations. If we consider all industries and expectations formation models, in general the statistical strength of the relationship between T.F.P. and the equity price premia earned by Canada's resource industries appears to have been mixed, at best.[30] Unanticipated increases in capital intensity have the expected positive connection to equity market performance for the energy industry and the resource sector as a whole, but statistical power is weak, and the connection appears to have been negative for forestry and mining. An absence of explanatory power also characterizes the parameter estimates associated with the Canada-U.S. exchange rate. In addition, the point estimates on $CUXDevX$ vary quite widely in terms of their absolute size and their sign across industries and expectations formation models. Only for mining does there appear to have been a significant relationship between unanticipated changes in the value of the Canadian dollar and equity price premia, and even there the direction of this relationship is dependent on the model of expectations formation used.

Given our findings with respect to resource rents reported in Table 2 it is not surprising to find that from an economic and statistical perspective, unanticipated increases in the scale of production and improvements in the resource industries' relative output prices were consistently the most important determinants of their equity market performance. Unexpected increases in industry specific real output relative to aggregate real output were associated with substantial increases in equity prices in excess of the risk free rate of return for the resource sector as a whole, energy, and forestry. The link between the resource industries' output prices and their equity market performance appears to have been even stronger - the parameter estimates indicate that an unanticipated 1% increase in relative output prices was associated with an increase in equity prices in excess of the risk free rate of return of between 0.78% (energy) and 1.59% (mining). These results suggest, therefore, that the equity market performance of Canada's resource industries over the twentieth century was most closely connected to the two performance indicators that were not only the most easily observable to investors on the T.S.E., but also the most closely correlated to the resource industries' ability to generate rents. This conclusion is consistent with both effective decision making with respect to resource extraction patterns and the operation of an efficient and competitive domestic equity market.

6 Conclusions

Over the twentieth century Canadian natural resource industries' output prices and the determinants of their extraction costs appear to have been related to the generation of aggregate resource rents in a manner consistent with the predictions made by theories of optimal resource extraction. In particular, despite some variation in the degree of statistical power, productivity improvements, increases in the scale of production, increases in capital intensity, rising relative output prices, and the depreciation of the Canadian dollar relative to the U.S. dollar were all associated with rising resource rents between 1900-1999. The strongest connections in both economic and statistical terms linked the resource industries' output prices and their scale of production to their ability to generate profits.

With respect to the role played by Canada's energy, forestry, and mining industries in the domestic equity market between 1900-1999, just as finance theory suggests we should expect in the presence of an efficient domestic equity market, there was a statistically and economically robust connection linking improvements in equity prices to rising resource rents. It is also apparent that the economic fundamentals that were related to resource rent generation were related to equity market performance for the Canadian resource industries. To be more specific, although statistical power was not uniform, productivity improvements, increases in the scale of production, increases in capital intensity, rising relative output prices, and an appreciating Canadian dollar were associated with increases in industry specific equity price premia in excess of the risk free rate of return. The strongest economic and statistical connections linked the most easily observable and most important determinants of profitability - the resource industries' output prices and their scale of production - to their equity market performance.

These findings suggest that because movements in twentieth century Canadian resource rents were so closely and positively related to movements in resource prices, and the resource industries' equity market performance was so closely and positively related to their ability to generate rents, falling relative prices appear to have driven rents as a proportion of G.N.P., and in turn equity prices relative to the T.S.E. composite market, downwards over the century. This, in turn, implies that between 1900-1999, falling resource prices relative to the average domestic price level more than offset increases in Canadian resource industries' relative productivity levels, capital intensity, and scale of production in the determination of their profitability and equity market performance.

The results presented in this paper reveal that we need not invoke equity market inefficiency or entrepreneurial failure to reconcile the apparently contradictory changes we observe in the resource industries' contributions to the growth and development of the aggregate economy and domestic equity market over the twentieth century. The resource industries' relative output prices play the key role in this reconciliation. This conclusion not only sheds light on the Canadian experience, but more broadly, the evidence emphasizes importance of scale and output prices in the pursuit of resource based growth, and the relevance of the basic finance and resource extraction theories to developing economies in a long run context.

Tables

Table 1: Summary Statistics (Average Annual % Change, 1900-1999)

	N.R. Sector	Energy	Forestry	Mining
$\Delta A_i/AggA$	0.25	0.66	-0.54	0.69
	(0.082)	(0.083)	(0.086)	(0.102)
$\Delta(Q/L)_i/Agg(Q/L)$	0.67	2.60	-0.17	0.75
	(0.096)	(0.127)	(0.116)	(0.120)
$\Delta Q_i/AggQ$	0.10	1.49	-1.26	0.34
	(0.057)	(0.097)	(0.096)	(0.086)
$\Delta(K/L)_i/Agg(K/L)$	1.36	1.62	0.97	1.35
	(0.109)	(0.125)	(0.118)	(0.130)
$\Delta P_i/GNPDef$	-0.24	-0.84	0.40	-0.99
	(0.061)	(0.071)	(0.065)	(0.089)
$\Delta Rent_i/GNP$	-0.65	0.88	-0.98	-0.21
	(0.129)	(0.135)	(0.226)	(0.183)
$\Delta StkP_i/Composite$	-0.97	-0.75	0.21	-1.93
	(0.092)	(0.140)	(0.225)	(0.231)

Note: Standard deviations are provided in parentheses.

Note: A_i = T.F.P. for industry i; $(Q/L)_i$ = physical output per worker for industry i; Q_i = physical output for industry i; $(K/L)_i$ = real fixed capital per worker for industry i; P_i = output price index for industry i; $Rent_i$ = aggregate resource rent for industry i; $StkP_i$ = common stock price index for industry i; $GNPDef$ = G.N.P. deflator; $Composite$ = T.S.E. composite common stock price index.

Note: The average annual % change in the Canada-U.S. exchange rate between 1900-1999 was: $\Delta CUX = 0.40$ ($\sigma = 0.035$).

Table 2: Resource Rents and the Economic Fundamentals (Equation 1)

	Dependent Variable: $\Delta Rentsh_i$				
	N.R. Sector	Panel	Energy	Forestry	Mining
$\Delta RelA_{i(t)}$	0.164	-0.028	0.075	0.286	-0.785
	(0.473)	(0.860)	(0.395)	(0.438)	(0.250)
$\Delta RelA_{i(t-1)}$	**0.212**	0.053	-0.036	**0.305**	0.098
	(0.018)	(0.453)	(0.407)	(0.070)	(0.481)
$\Delta RelA_{i(t-2)}$	0.010	0.046	-0.053	-0.100	-0.013
	(0.904)	(0.388)	(0.141)	(0.443)	(0.900)
$\Delta RelA_{i(t-3)}$	0.123	**0.172**	0.086	0.337	0.101
	(0.145)	(0.078)	(0.130)	(0.168)	(0.518)
ΔQsh_i	**1.773**	**1.543**	**1.200**	**1.900**	**1.942**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$\Delta KLsh_i$	0.122	0.112	0.062	**0.252**	0.357
	(0.251)	(0.131)	(0.143)	(0.041)	(0.192)
$\Delta RelP_i$	**1.886**	**1.508**	**1.153**	**2.524**	**1.032**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.039)
ΔCUX	0.099	0.095	**0.101**	-0.168	0.0001
	(0.617)	(0.707)	(0.089)	(0.600)	(0.999)
$Constant$	-0.0002	-0.005	-0.001	0.008	-0.005
	(0.978)	(0.436)	(0.842)	(0.418)	(0.736)
N	96	281	96	96	89
$AdjR^2$	0.758	0.687	0.964	0.814	0.525
Outliers Dropped		√			√
Robust S.E.		√	√	√	√
AR Correction		√		√	

Note: P-values provided in parentheses. Parameter estimates in bold are statistically significant with at least 90% confidence.

Note: $RelA_i$ = T.F.P. for industry i relative to aggregate T.F.P.; Qsh_i = physical output for industry i as a share of aggregate physical output; $KLsh_i$ = capital/labor ratio for industry i as a share of aggregate capital/labor ratio; $RelP_i$ = output price for industry i relative to G.N.P. deflator; CUX = average annual Canada-U.S. exchange rate.

Note: Joint statistical significance (p value) of T.F.P. and its lags: **N.R. Sector = 0.062**; Panel = 0.309; Energy = 0.476; Forestry = 0.167; Mining = 0.356.

Table 3: C.A.P.M. with Resource Rents (Equation 2)

	Dependent Variable: $(R_i - R_f)$														
	N.R. Sector			Panel			Energy			Forestry			Mining		
	$X=0$	$X=3$	$X=10$	$X=0$	$X=3$	$X=10$	$X=0$	$X=3$	$X=10$	$X=0$	$X=3$	$X=10$	$X=0$	$X=3$	$X=10$
$(R_m - R_f)$	**0.968**	**0.961**	**0.947**	**0.928**	**0.929**	**0.941**	**1.035**	**1.039**	**1.064**	**0.752**	**0.766**	**0.805**	**0.917**	**0.908**	**0.870**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$RentDevX_i$	**0.215**	**0.248**	**0.257**	**0.033**	**0.035**	**0.045**	**0.298**	**0.299**	**0.301**	**0.328**	**0.331**	**0.364**	0.010	0.012	**0.022**
	(0.004)	(0.002)	(0.003)	(0.027)	(0.013)	(0.009)	(0.004)	(0.005)	(0.009)	(0.000)	(0.000)	(0.000)	(0.185)	(0.182)	(0.053)
$Constant$	-0.009	-0.011	-0.009	-0.009	-0.010	-0.011	-0.010	-0.008	-0.010	0.012	0.013	0.008	-0.003	-0.002	-0.002
	(0.332)	(0.258)	(0.373)	(0.532)	(0.493)	(0.455)	(0.488)	(0.563)	(0.508)	(0.559)	(0.508)	(0.702)	(0.879)	(0.888)	(0.912)
N	99	96	89	294	285	265	99	96	89	98	95	88	97	94	88
$AdjR^2$	0.794	0.796	0.785	0.448	0.444	0.451	0.633	0.639	0.650	0.407	0.413	0.430	0.362	0.360	0.209
Outliers Dropped				√	√	√				√	√	√	√	√	√
Robust S.E.				√	√	√							√	√	√
AR Correction															

Note: P-values provided in parentheses. Parameter estimates in bold are statistically significant with at least 90% confidence.

Note: $RentDevX$ = deviations from expected changes in resource rents as a proportion of G.N.P., where expectations are assumed to have been formed using information from the past X years.

Table 4: C.A.P.M. with Decomposed Resource Rents (Equation 3)

	Dependent Variable: $\Delta Rentsh_i$				
	N.R. Sector	Panel	Energy	Forestry	Mining
$(R_m - R_f)$	**0.968**	**0.905**	**1.041**	**0.779**	**0.891**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$\Delta \widehat{Rentsh}_i$	**0.275**	**0.295**	**0.313**	**0.419**	0.082
	(0.001)	(0.000)	(0.004)	(0.000)	(0.580)
$\widehat{\epsilon 1}_i$	0.017	0.003	0.204	-0.092	0.007
	(0.910)	(0.572)	(0.635)	(0.651)	(0.412)
$Constant$	-0.009	-0.014	-0.012	0.017	-0.001
	(0.326)	(0.334)	(0.337)	(0.400)	(0.945)
N	96	285	96	95	94
$Adj R^2$	0.796	0.469	0.638	0.429	0.388
Outliers Dropped		√		√	√
Robust S.E.		√			√
AR Correction					

Note: P-values provided in parentheses. Parameter estimates in bold are statistically significant with at least 90% confidence.

Note: $\Delta \widehat{Rentsh}$ = unanticipated changes in resource rents as a proportion of G.N.P. associated with economic fundamentals; $\widehat{\epsilon 1}$ = unanticipated changes in resource rents as a proportion of G.N.P. unrelated to economic fundamentals.

Table 5: C.A.P.M. with the Economic Fundamentals (Equation 4)

	Dependent Variable: $(R_i - R_f)$														
	N.R. Sector			Panel			Energy			Forestry			Mining		
	$X=0$	$X=3$	$X=10$	$X=0$	$X=3$	$X=10$	$X=0$	$X=3$	$X=10$	$X=0$	$X=3$	$X=10$	$X=0$	$X=3$	$X=10$
$(R_m - R_f)$	**0.989**	**0.976**	**0.941**	**0.889**	**0.883**	**0.900**	**1.053**	**1.050**	**1.094**	**0.722**	**0.733**	**0.752**	**0.855**	**0.806**	**0.813**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$ADevX_i$	**0.575**	**0.503**	0.466	0.134	0.219	0.081	0.348	**0.600**	**0.602**	-0.140	-0.126	-0.205	1.142	1.092	0.204
	(0.045)	(0.095)	(0.139)	(0.630)	(0.436)	(0.778)	(0.266)	(0.057)	(0.074)	(0.759)	(0.776)	(0.648)	(0.163)	(0.202)	(0.820)
$QDevX_i$	**0.499**	**0.459**	**0.499**	**0.346**	**0.261**	**0.269**	**0.292**	**0.284**	**0.326**	**0.411**	**0.409**	**0.470**	0.092	-0.119	-0.112
	(0.004)	(0.013)	(0.022)	(0.006)	(0.042)	(0.040)	(0.056)	(0.066)	(0.055)	(0.066)	(0.088)	(0.074)	(0.827)	(0.757)	(0.787)
$KLDevX_i$	0.063	0.012	0.031	0.079	0.042	0.095	0.042	-0.068	-0.067	-0.109	-0.072	-0.094	-0.010	-0.050	0.336
	(0.618)	(0.936)	(0.844)	(0.414)	(0.715)	(0.476)	(0.752)	(0.635)	(0.664)	(0.631)	(0.770)	(0.715)	(0.975)	(0.867)	(0.321)
$PDevX_i$	**1.112**	**0.977**	**1.041**	**0.842**	**0.984**	**0.829**	**0.780**	**0.977**	**0.972**	**1.324**	**1.522**	**1.515**	**1.508**	**1.586**	0.704
	(0.001)	(0.005)	(0.005)	(0.002)	(0.001)	(0.004)	(0.024)	(0.004)	(0.008)	(0.015)	(0.005)	(0.007)	(0.041)	(0.079)	(0.462)
$CUXDevX$	-0.022	-0.054	-0.129	-0.301	-0.434	-0.473	0.013	-0.117	0.044	-0.049	-0.017	-0.316	**-1.258**	**1.499**	**1.500**
	(0.937)	(0.858)	(0.708)	(0.391)	(0.229)	(0.255)	(0.974)	(0.790)	(0.931)	(0.931)	(0.549)	(0.647)	(0.078)	(0.025)	(0.034)
$Constant$	-0.008	-0.010	-0.009	-0.008	-0.011	-0.012	-0.007	-0.008	-0.009	0.007	0.011	0.006	0.009	-0.003	-0.003
	(0.368)	(0.273)	(0.370)	(0.577)	(0.454)	(0.451)	(0.607)	(0.570)	(0.527)	(0.713)	(0.549)	(0.750)	(0.621)	(0.886)	(0.894)
N	99	96	89	294	285	265	99	96	89	98	95	88	97	94	88
$AdjR^2$	0.804	0.794	0.784	0.474	0.483	0.481	0.626	0.642	0.649	0.461	0.463	0.485	0.442	0.463	0.453
Outliers Dropped				√	√	√				√	√	√	√	√	√
Robust S.E.				√	√	√							√	√	√
AR Correction				√	√	√							√		√

Note: P-values provided in parentheses. Parameter estimates in bold are statistically significant with at least 90% confidence.

Note: $ADevX$ = deviations from expected changes in relative T.F.P., where expectations are assumed to have been formed using information from the past X years; $QDevX$ = deviations from expected changes in relative physical output; $KLDevX$ = deviations from expected changes in relative capital intensity; $PDevX$ = deviations from expected changes in relative output prices; $CUXDevX$ = deviations from expected changes in average annual Canada-U.S. exchange rate.

Notes

[1]There is a considerable body of literature on successful and unsuccessful resource based growth in a historical context, and a growing body of literature on the "curse" of natural resources for recently developing nations. For examples see Wright (1990), Keay (2007), Taylor (1998), and Sachs and Warner (2001).

[2]Claims of Canadian capital market inefficiency may be found in Naylor (1975), Rudin (1982), and Taylor and Baskerville (1994). Others, such as Bliss (1987) and Evans and Quigley (1990), have called some of these claims into question.

[3]Claims of entrepreneurial failure within the Canadian business elite may be found in Levitt (1970), Naylor (1975), and Williams (1994). Evidence of an effective entrepreneurial class in Canada has been presented in Keay (2000) and Wylie (1989).

[4]For example, see Slade and Thille's (1997) Table 3, estimates for Canadian copper mines, Sadorsky and Henriques' (2001) Table 5, estimates for the Canadian forestry industry, or Sadorsky's (2001) Table 4, estimates for the Canadian energy industry.

[5]A complete Data Appendix, with detailed descriptions of sources and construction techniques for all data used in this paper, is available from the author.

[6]As a sensitivity test, all results have been derived using value added less wages and salaries, deflated by a capital cost index, as an alternate capital measure. The qualitative conclusions are unaffected by the choice of capital measure.

[7]Total resource rents may be disaggregated into rents paid to government, labor, and capital owners. As a sensitivity test, all results have been derived using only rents paid to capital owners as an alternate rent measure. The qualitative conclusions are unaffected by the choice of rent measure. If I use this approach to aggregate rent measurement to calculate total economic profits earned by the Canadian manufacturing sector over the twentieth century (which includes some resource processing firms), I find that on average their profits were less than one third of those enjoyed by the resource intensive producers. Note that I have not calculated marginal scarcity rents (or shadow prices) for each resource industry. Scarcity rents have an impact on extraction

decisions, but they do not directly determine aggregate profitability. For a detailed discussion of the derivation of scarcity rents in a Canadian context see Ellis and Halvorsen (2002) or Livernois, Thille and Zhang (2006).

[8]There are periodic mining indexes reported in D.B.S. publications earlier than 1935 that have been used as a check on my constructed index. For example an example see Coates (1915).

[9]Information on Canadian government bond yields for the earliest part of the twentieth century is scarce. I have used the series compiled by Marvin McInnis (2006).

[10]For a much more detailed discussion of the composition of the industries used in this study see Keay (2007).

[11]Alternate weighting schemes that use real output, labor figures, or no weights whatsoever, generate only small changes in the quantitative results, and no changes in the qualitative conclusions. The aggregated common stock price index uses capitalized values, rather than value added, to weight the three industry specific indexes.

[12]For textbook depictions of these cost determinants see Varian (1992) Chapter 5, or Neher (1990) Chapter 6.

[13]Input prices are not included as extraction cost determinants because resource theories typically assume that firms' control variables are extraction patterns, rather than input quantities.

[14]For textbook depictions of some of these optimal extraction theories see Neher (1990) Chapters 2 and 17, or Hartwick and Olewiler (1998) Chapters 8 and 10.

[15]See Norrie and Owram (1996) Pg. 321-26 and Table 17.1, for information on the resource intensity and destination of twentieth century Canadian exports.

[16]The modeling of risk-return tradeoffs in equity markets may be traced to a series of papers by Tobin (1958), Sharpe (1964), Lintner (1965), and Mossin (1966). Slade and Thille (1997) Pg. 690-91, provide a concise summary of the development of the basic C.A.P.M. structure. See Cragg and Malkiel (1982), or Black, Jensen, and Scholes (1972), for an overview of the empirical performance of C.A.P.M..

[17]For a textbook depiction of "discounted cash flow" valuation techniques see Damodaran (2002) Chapter 2. For an example drawn from natural resource industries see Perman et al. (2003), Pg. 366-67.

[18]For similar U.S. and British examples see El-Sharif et al. (2005), Jones and Kaul (1996), or Washburn and Binkley (1993).

[19]It would be ideal if dividend returns could be incorporated into R_i and R_m, but this information is not available through much of the century. The absence of this information from both the composite market and the industry specific premia explain the relatively low rates of return that are observed. The average annual premium earned by the natural resource sector as a whole was -2.53% and the average annual composite market premium was -1.58%.

[20]As a sensitivity test all results have been derived using Moody's AAA industrial bond yields as an alternate measure of the risk free rate of return. The qualitative conclusions are unaffected by the choice of risk free rate.

[21]A complete set of econometric results is available from the author.

[22]Non-stationarity could not be rejected with 90% confidence or more for four of the seven natural resource sector's series when tested in levels, five of the seven energy industry's series, only one of the seven forestry industry's series, and five of the seven mining industry's series.

[23]Despite the fact that they are almost all I(1), I cannot find any statistically significant evidence of a long run, stable, cointegrating relationship among the equity price premia, relative resource rents, or relative T.F.P. series when measured in levels for any of the industries.

[24]The use of robust standard errors, corrections for autocorrelation, and the elimination of outliers are all noted by equation and industry in Tables 2-5.

[25]Although statistical significance is affected by the removal of the outliers, the relative size and the signs on the parameter estimates are not substantively altered if the outliers are left in the series, or if dummy variables are used to control for their presence.

[26]The endogeneity of capital intensity and equity prices has been singled out for further testing because there is theoretical work suggesting that the direction of causation should be reversed from

what has been assumed in this paper. Specifically, much of the research associated with the use of Tobin's (1969) Q-ratio implies that equity market performance may determine a firm's ability to invest, which in turn implies that capital intensity may be endogenous, while equity prices may be exogenous.

[27]Equation (1) is based on theories of resource rent maximization that assume firms control extraction patterns, rather than input quantities. If we wished to base this equation on a more standard characterization of a profit function, then we might be tempted to include industry specific real wages and real capital costs as explanatory variables. As a sensitivity test, Equation (1) has been estimated using real wages and real capital costs in place of capital intensity as right hand side variables. The qualitative conclusions are unaffected by the inclusion of the input prices, which tend to be statistically irrelevant. For example, in Equation (1) real wages and real capital costs have p-values of 0.992 and 0.767, respectively, for the resource sector as a whole.

[28]If capital intensity is dropped as an explanatory variable, the statistical influence of the more broadly defined T.F.P. measure improves, but still only forestry displays a significant relationship between productivity and resource rents among the individual industries.

[29]If I consider only those resource rents captured by capital owners rather than total resource rents in Equation (2), the qualitative conclusions continue to hold.

[30]If capital intensity is dropped as an explanatory variable, then unanticipated productivity growth is a significant and positive determinant of equity market performance for the weighted average of all three industries, energy, and mining.

References

[1] Black, F., M. Jensen and M. Scholes (1972), "The Capital Asset Pricing Model: Some Empirical Tests", in *Studies in the Theory of Capital Markets*, M. Jensen (ed.), Praeger, New York.

[2] Bliss, M. (1987), *Northern Enterprise: Five Centuries of Canadian Business*, Toronto, McClelland and Stewart.

[3] Coates, E. (1915), *Report of the Board of Inquiry into the Cost of Living in Canada, Volume 2*, Government of Canada Supply and Services, Ottawa.

[4] Cook, R.D. (1977), "Detection of Influential Observations in Linear Regressions", *Technometrics*, Vol. 19, Pg. 15-18.

[5] Cragg, J. and B. Malkiel (1982), *Expectations and the Structure of Share Prices*, University of Chicago Press, Chicago.

[6] Damodaran, A. (2002), *Investment Valuation: Tools and Techniques for Determining Value*, Wiley, New York.

[7] Dickey, D.A. and W.A. Fuller (1981), "Liklihood Ratio Statistics for Autoregressive Time Series with a Unit Root", *Econometrica*, Vol. 49, Pg. 1057-72.

[8] Durbin, J. (1954), "Errors in Variables", *Review of the International Statistical Institute*, Vol. 22, Pg. 23-32.

[9] Ellis, G.M. and R. Halvorsen (2002), "Estimation of Market Power in a Non-Renewable Resource Industry", *Journal of Political Economy*, Vol. 110, Pg. 833-99.

[10] El-Sharif, I., D. Brown, B. Burton, B. Nixon and A. Russell (2005), "Evidence on the Nature and Extent of the Relationship between Oil Prices and Equity Values in the U.K.", *Energy Economics*, Vol. 27, Pg. 819-30.

[11] Evans, L.T. and N.C. Quigley (1990), "Discrimination in Bank Lending Policies: A Test Using Data From the Bank of Nova Scotia, 1900-1937", *Canadian Journal of Economics*, Vol. 23, Pg. 210-25.

[12] Hartwick, J. and N. Olewiler (1998), *The Economics of Natural Resource Use, Second Edition*, Addison-Wesley, Toronto.

[13] Haussman, J.A. (1978), "Specification Tests in Econometrics", *Econometrica*, Vol. 46, Pg. 1251-72.

[14] Hotelling, H. (1931), "The Economics of Exhaustible Resources", *Journal of Political Economy*, Vol. 30, Pg. 137-75.

[15] Jones C. and G. Kaul (1996), "Oil and the Stock Markets", *Journal of Finance*, Vol. 51, Pg. 463-91.

[16] Keay, I. (2000), "Scapegoats or Responsive Entrepreneurs: Canadian Manufacturers, 1907-1990", *Explorations in Economic History*, Vol. 37, Pg. 217-40.

[17] 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.

[18] Levitt, K. (1970), *Silent Surrender: The Multinational Corporation in Canada*, Toronto, Macmillan.

[19] Lintner, J. (1965), "The Valuation of Risky Assets and the Selection of Risky Investments in Stock Portfolios and Capital Budgets", *Review of Economic Studies*, Vol. 47, Pg. 13-37.

[20] Livernois, J., H. Thille and X. Zhang (2006), "A Test of the Hotelling Rule Using Old Growth Timber Data", *Canadian Journal of Economics*, Vol. 39, Pg. 163-86.

[21] McInnis, M. (2006), *Canadian Macroeconomic Data Set*, accessed May 19, 2006: http://library.queensu.ca/webdoc/ssdc/cbdksnew/HistoricalMacroEconomicData.

[22] Mossin, J. (1966), "Equilibrium in a Capital Asset Market", *Econometrica*, Vol. 34, Pg. 768-83.

[23] Naylor, R.T. (1975), *The History of Canadian Business, 1867-1914, Volume 1*, Toronto, James Lorimer.

[24] Neher, P. (1990), *Natural Resource Economics: Conservation and Exploitation*, Cambridge University Press, New York.

[25] Newey, W.K. and K.D. West (1987), "A Simple, Positive Semi-Definite Heterskedasticity and Autocorrelation Consistent Covariance Matrix", *Econometrica*, Vol. 55, Pg. 703-8.

[26] Norrie, K. and D. Owram (1996), *A History of the Canadian Economy, Second Edition*, Harcourt-Brace, Toronto.

[27] Perman R., Y. Ma, J. McGilvray and M. Common (2003), *Natural Resource and Environmental Economics, Third Edition*, Pearson Press, Toronto.

[28] Phillips, P. and P. Perron (1988), "Testing for a Unit Root in Time Series Regressions", *Biometrika*, Vol. 75, Pg. 335-46.

[29] Rosenbluth, G. (2005), *Stock Market Price Indexes Database*, accessed April 20, 2005: http://www.arts.ubc.ca/econsochist.

[30] Ross, S. (1976), "The Arbitrage Theory of Capital Asset Pricing", *Journal of Economic Theory*, Vol. 13, Pg. 341-60.

[31] Rudin, R. (1982), "Montreal Banks and Urban Development in Quebec, 1840-1914", in *Shaping the Urban Landscape: Aspects of the Canadian City*, G. Stelter, A. Artibise (eds.), Ottawa, Carleton University Press.

[32] Sachs, J. and A. Warner (2001), "Natural Resources and Development: The Curse of Natural Resources", *European Economic Review*, Vol. 45, Pg. 827-38.

[33] Sadorsky, P. (2001), "Risk Factors in Stock Returns of Canadian Oil and Gas Companies", *Energy Economics*, Vol. 23, Pg. 17-28.

[34] Sadorsky, P. and I. Henriques (2001), "Multifactor Risk and the Stock Returns of Canadian Paper and Forest Products Companies", *Forest Policy and Economics*, Vol. 3, Pg. 199-208.

[35] Sharpe, W. (1964), "Capital Asset Prices: A Theory of Market Equilibrium Under Conditions of Risk", *Journal of Finance*, Vol. 19, Pg. 425-42.

[36] Slade, M. and H. Thille (1997), "Hotelling Confronts C.A.P.M.: A Test of the Theory of Exhaustible Resources", *Canadian Journal of Economics*, Vol. 30, Pg. 685-708.

[37] Taylor, A. (1998), "On the Costs of Inward Looking Development: Price Distortions, Growth, and Divergence in Latin America", *Journal of Economic History*, Vol. 58, Pg. 1-28.

[38] Taylor, G.D., and P.A. Baskerville (1994), *A Concise History of Business in Canada*, Toronto, Oxford University Press.

[39] Tobin, J. (1958), "Liquidity Preference as Behaviour Towards Risk", *Review of Economic Studies*, Vol. 25, Pg. 65-86.

[40] Tobin, J. (1969), "A General Equilibrium Approach to Monetary Theory", *Journal of Money, Credit and Banking*, Vol. 1, Pg. 15-29.

[41] Toronto Stock Exchange (Various), *T.S.E. Annual Review*, Toronto, Toronto Stock Exchange.

[42] Urquhart, M. (1993), *Gross National Product of Canada, 1870-1926: The Derivation of the Estimates*, Queen's-McGill Press, Kingston.

[43] Varian, H. (1992), *Microeconomic Analysis, Second Edition*, Norton, New York.

[44] Washburn, C. and C. Binkley (1993), "Do Forest Assets Hedge Inflation?", *Land Economics*, Vol. 69, Pg. 215-24.

[45] Williams, G. (1994), *Not For Export*, Toronto, McClelland and Stewart.

[46] Wright, G. (1990), "The Origins of American Industrial Success", *American Economic Review*, Vol. 80, Pg. 651-68.

[47] Wylie, P. (1989), "Technological Adaptation in Canadian Manufacturing, 1900-29", *Journal of Economic History*, Vol. 49, Pg. 569-91.

[48] Wu, D.-M. (1973), "Alternative Tests of Independence between Stochastic Regressors", *Econometrica*, Vol. 41, Pg. 733-50.