Size, Productivity and Profitability: Canada's Natural Resource Industries in the Twentieth Century

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Abstract

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At the end of the twentieth century Canada's natural resource industries continued to play a substantial role in the growth and development of the domestic economy. Relative to the aggregate economy (and the manufacturing sector), the resource industries were large and growing, they were more capital intensive, and they enjoyed more rapid total factor productivity growth. Despite the strength of these "economic fundamentals" it is not clear that we should adopt an unambiguously optimistic perspective when we assess the long run economic performance of Canada's resource intensive industries. Among participants on Canada's equity markets, for example, pessimism may not have been uniform across time periods or sectors, but investors were clearly not bullish about the long run performance of domestic energy, forestry and mining producers. In this paper I investigate the relationship between the size of Canada's twentieth century resource industries - as measured by output, value added and employment - the productivity of these industries - as measured by labour and total factor productivity - and the profitability of these industries - as measured by the generation of resource rents and common stock prices. I present evidence that is generally supportive of the theoretical predictions made by natural resource and finance theory with respect to the relationship among performance indicators. In particular, T.F.P., output, capital intensity and relative prices were all significant determinants of resource rents, and in turn, resource rents were a significant determinant of stock market performance. The empirical support for these theoretical predictions suggests that we should look beyond productivity and size when assessing economic performance.

1 Introduction

In 1999 Canada's energy, forestry and mining industries generated 11.8% of domestic gross national product (G.N.P.), they employed 5.3% of the total workforce, and they housed 14.2% of the total fixed capital in the economy. These indicators of the size of the resource sector put it roughly on par with the domestic manufacturing sector, which generated 16.8% of Canadian G.N.P., employed 12.8% of the total workforce, and housed 12.2% of the total fixed capital in the economy in 1999. In addition, there is strong statistical evidence indicating that even at the very end of the twentieth century resource industries still comprised a leading sector in the Canadian economy, with increases in resource output associated with subsequent increases in non-resource intensive manufacturing output, increases in service sector output and falling resource intensive intermediate input prices.[1] The resource industries' longer run contributions to economic growth were equally substantive, with labour productivity among the energy, forestry and mining industries rising at an average annual rate of 2.51% per year (0.93% per year faster than the aggregate economy) between 1900-1999. These producers' total factor productivity (T.F.P.) rose at an average annual rate of 0.90% per year (0.25% per year faster than the aggregate economy) over the twentieth century, while their capital to labour ratios increased by more than 6.33% per year (0.73% per year faster than the aggregate economy), and their real output increased by an average of 3.88% per year (0.10% per year faster than the aggregate economy).

If we were to confine our assessment of twentieth century performance to the "economic fundamentals" captured by these size and productivity indicators, then we could comfortably maintain an optimistic view of the domestic resource industries' role in the aggregate economy. However, even this first pass at performance assessment indicates that we may want to pause in our rush to identify the resource industries as a strong and vibrant sector. If we consider the labour productivity figures and the real output figures, for example, it is clear that these industries were shedding workers. Indeed, between 1900-1999 Canada's energy, forestry and mining industries increased employment by just 1.37% per year on average (0.83% per year less than the aggregate economy). Although real output among the resource industries rose relative to the aggregate economy between 1900-1999, their share of G.N.P. actually fell, by an average of 0.51% per year, which indicates a substantial decline in the resource industries' terms of trade. The resource industries' output prices declined relative to the G.N.P. deflator by 0.24% per year on average between 1900-1999. It is apparent that the resource industries' twentieth century economic fundamentals were not uniformly robust.

The pursuit of economic profit by participants on Canada's equity markets leads them to collect

[1] See Keay (2006), Section 3 and 4.

information about potential investments, assess this information to the best of their abilities, then decide to buy or sell a particular stock at a particular price given the outcome of their assessment. If a stock, or a group of stocks, persistently under-performs the market average, then either investors have not had access to all the relevant information about the "economic fundamentals" and/or they have not exploited this information, or they have had access to, and used, all the relevant information and they have consistently formed a pessimistic performance assessment. As a group, common stock prices for Canada's energy, forestry and mining producers under-performed the Toronto Stock Exchange composite index by an average of 0.97% per year between 1900-1999. To illustrate the pessimism inherent in the resource producers' equity prices, consider the contrast between the resource industries' stock index and the industrial stock index, which grew 1.06% faster than the market average over the twentieth century on average.

In this paper I investigate the relationship between three very broadly defined indicators of long run economic performance for Canada's resource industries between 1900-1999: size (measured by real output, value added and employment), productivity (measured by labour and total factor productivity) and profitability (measured by resource rents and common stock prices).

Finance theory suggests that the risks and returns associated with equity prices should reflect the expected present value of the stream of future economic profits that an investment opportunity can generate. For resource intensive producers these profits should be dominated by resource rents, or more specifically, by the share of resource rents captured by capital owners. Resource theory, in turn, tells us that resource rents for both renewable and non-renewable resource intensive industries should be dependent on the costs of extraction and on the output prices producers receive for their products. Given that Canadian resource industries export a substantial proportion of their output, the Canada-U.S. exchange rate and the intensity of foreign competition should be important determinants of the output prices received by these producers.[2] Production and resource theory both indicate that the second principle determinant of resource rents, extraction costs, should be a function of productivity and stock depletion. From a basic growth accounting perspective we know that total factor productivity, and hence extraction costs and resource rents, should rely not only on technology, but also on capital intensity (capital to labour ratios) and the scale of production (real output).

This discussion suggests that we could, therefore, conceive of a multi-dimensional structural model that describes the connections between real output and capital intensity, productivity, output prices, resource rents, and equity prices. Others, Slade and Thille (1997) for example, have

[2]Norrie and Owram (1996), Pg. 321-26 and Table 17.1, discuss the resource intensity and destination of twentieth century Canadian exports.

undertaken part of this job. Unfortunately, the data required to estimate any model one might construct, including Slade and Thille's, is simply unavailable for the industries and time period considered in this paper. As a result of the data availability issues a more modest reduced form approach is adopted for this paper. More specifically, I assume that equity prices are endogenous, and I then estimate statistical relationships between energy, forestry and mining stock price indexes, and resource rents, total factor productivity, real output, capital intensity, output prices, and Canada-U.S. exchange rates, while controlling for market risk. My methodological approach is an adaptation of Sadorsky's (2001) multi-factor capital asset pricing model (C.A.P.M.). I find that over the twentieth century Canadian resource rents were a positive and significant determinant of the resource industries' common stock prices. I also show that productivity, output, capital intensity, and output prices (but not exchange rates) were positive and significant determinants of both resource rents and the resource industries' common stock prices. This evidence is consistent with the theoretical models that predict that resource rents operate as the conduit through which the economic fundamentals affect resource industries' equity prices. Based on the results presented in this paper I draw two conclusions - one is related to performance assessment, while the other is more specifically about our understanding of twentieth century Canadian development. First, it seems clear that one should exercise caution when using size and productivity as the sole indicators of long run economic performance, since changes in prices and profitability may not necessarily be congruent. Second, it is also apparent that among Canada's resource industries rapid capital accumulation and productivity growth were unable to offset falling output prices and resource rents during the twentieth century.

In Section 2 the relevant finance, resource and production theory literature is briefly reviewed. Section 3 includes a description of the data that is available for use in this study, and summary statistics are provided. The fourth section provides a more detailed discussion of the methodological approach that has been adopted, and the fifth section reports the empirical results from the application of the methodological approach. The sixth and final section summarizes the conclusions that may be drawn from the evidence.

2 Literature Review

The basic capital asset pricing model (Tobin, 1958) simply states that the expected rate of return on a portfolio (R_i) will be dependent on the risk free rate of return (R_f) and the market average rate of return (R_m), such that:

$$(R_i - R_f) = \beta_i(R_m - R_f) \quad (1)$$

Where, given certain assumptions, β_i should be equal to the covariance of the portfolio and market returns, divided by the variance of the market return: $\beta_i = \sigma_{im}/\sigma_m^2$. This basic model has survived exhaustive empirical testing, despite the fact that it is inherently static in structure and it requires "two-fund separation" to hold, which in turn requires either quadratic preferences or normally distributed returns for all risky assets traded on the market.[3]

To allow for the evolution of asset prices over time and to generalize the basic C.A.P.M. model, Ross (1976) proposed the arbitrage pricing theory (A.P.T.), in which the C.A.P.M. structure is preserved, but other factors are introduced to allow investors to hedge against future changes in the investment opportunity set.[4] Models that adopt this approach are often called K-factor, or multi-factor C.A.P.M. models because they allow multiple variables to explain the evolution of both the risk and returns associated with a portfolio.

Sadorsky (2001) and Sadorsky and Henriques (2001) have used multi-factor C.A.P.M. models to explain changes in late twentieth century Canadian energy and forestry equity prices, respectively.[5] They find that resource industries' equity price premia have been significantly related to not only the market risk premium, but changes in output prices and changes in the value of the Canadian dollar. Sadorsky's estimating equation takes the form:

$$(R_{it} - R_{ft}) = \alpha0_i + \alpha1_i(R_{mt} - R_{ft}) + \alpha2_i\Delta P_{it} + \alpha3_i\Delta CUX_t + \alpha4_i(R_{bt} - R_{ft}) + \epsilon_{it} \quad (2)$$

Where: i = Canadian energy or forestry industries, t = 1973:1 - 1999:1 (quarterly), R_i = rate of return on common stock prices for resource industry $i = (stkp_{i2} + div_i - stkp_{i1})/stkp_{i2}$, R_f = rate of return on 90 day treasury bills, R_m = rate of return on the Toronto Stock Exchange 300 composite index, ΔP_i = % change in commodity price index for resource industry i, ΔCUX = % change in foreign currency exchange rate relative to Canada's 10 largest trading partners, R_b = 10 year Government of Canada bond yield, $\epsilon_i = iid, N(0, \sigma)$.

Although Sadorsky provides little justification for his choice of independent variables in the estimating equation (2), in light of the theoretical literature on optimal renewable and non-renewable

[3]For detailed discussions of the empirical evidence related to the application of C.A.P.M. see Cragg and Malkiel (1982), or Black, Jensen and Scholes (1972).

[4]Slade and Thille (1997), Pg. 690-91, provide an excellent overview of the asset pricing models presented in this section in the context of resource industry equity prices.

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

resource extraction and optimal equity pricing, it does not seem unreasonable to include output prices, exchange rates and alternate investment premia as proxies for profitability and determinants of stock market performance. To be slightly more specific, dynamic models of optimal resource extraction suggest that changes in resource rents generated by energy, forestry or mining industries should depend on changes in output prices and extraction costs.[6] In addition, the standard approach to investment valuation suggests that the optimal price of any investment opportunity should depend on the expected present value of the stream of net returns (or resource rents) earned from the project.[7] These theoretical models, therefore, imply that by linking prices, exchange rates and capital costs to resource industries' equity prices, Sadorsky was simply skipping over any investigation of the conduit through which these links operated, namely - resource rents.

Slade and Thille (1997) have developed a structural model that formalizes the connections that are implicit in Sadorsky's's multi-factor C.A.P.M. approach. Their model explicitly links a multi-factor C.A.P.M. to the Hotelling Rule's (1931) predictions regarding the evolution of resource rents in response to the optimal extraction of non-renewable resources. The empirical application of Slade and Thille's model requires estimates of both an annual depletion effect for each resource industry and annual changes in *marginal* resource rents. Their estimating equation takes the form:

$$LDOT_{jt} = \omega 0 + \omega 1 CRL_{jt} + \omega 2 R_{ft} + \omega 3 R_{jt} + \omega 4 R_{bt} + \omega 5 GDFT_t + \omega 6 CDFT_t + \omega 7 EDFT_t + \epsilon_t \quad (3)$$

Where: j = Canadian copper mining firms, t = 1956 - 1982 (annual), $LDOT_j$ = growth rate of marginal resource rents for firm j, CRL_j = change in total cost in response to a small change in stock depletion for firm j, $GDFT$ = deviation from trend growth rate in Canadian G.D.P., $CDFT$ = deviation from trend growth rate in Canadian C.P.I., $EDFT$ = deviation from trend growth rate in the Canada-U.S. exchange rate. All other variables have been defined previously.

For the empirical exercise presented in this paper Slade and Thille's model is inappropriate because I do not have access to estimates of depletion effects or marginal resource rents for the industries or time period of interest. In addition to the data availability issues it is not intuitively appealing to assume that resource rents, rather than equity prices, are the appropriate endogenous variable. As a result of these concerns I rely more heavily on Sadorsky's multi-factor C.A.P.M. approach, although I am much more explicit about the proposed connection between equity prices and resource rents - on one hand - and resource rents, output prices and extraction costs - on the other.

[6] For standard textbook examples see Neher (1990) or Hartwick and Olewiler (1998).

[7] For a standard illustration in a natural resource context see Perman et al. (2003), Pg. 366-67.

There is one additional issue of concern related to the connection between the theoretical modeling described above and the empirical application described below. Not only do I not have access to information on depletion effects or marginal resource rents, in the absence of some heroic assumptions regarding input and output market structure, I do not have any estimates of extraction costs. Based on the theoretical definition of a well defined cost function we should expect resource industries' extraction costs to be dependent on stock depletion - which we do not know - and productivity, output levels and capital intensity - which we do know.[8] From a theoretical perspective, therefore, it is reasonable to propose a connection between twentieth century Canadian resource industries' common stock prices, risk free rates of return and market average rates of return (the basic C.A.P.M. theory), and, through their impact on resource rents (optimal resource extraction theory), output prices, foreign exchange rates, productivity performance, output levels and capital intensity (production and resource theory).

3 Data

To investigate the relationship between size, productivity and profitability for twentieth century Canadian resource industries I have collected information on bond yields, common stock price indexes, and quantities, values and prices of inputs used and outputs produced by energy, forestry, mining and manufacturing industries, as well as the aggregate economy, spanning the years 1900-1999. The data series include:

- Value Added
- G.N.P.
- Real Output: measured as value added deflated by an industry specific output price index.
- Capital to Labour Ratios: measured as the real value of gross fixed capital divided by total employment.[9]
- Output Price Indexes
- G.N.P. Deflator
- Labour Productivity: measured as real output divided by total employment.
- Total Factor Productivity: measured as a Tornqvist weighted average of partial factor productivities, with value added used as an output measure and average input income shares used as weights.

[8]For a text book definition of a well defined resource industry cost function see Neher (1990).

[9]All of the results reported in this paper have also been derived using an alternative capital stock measure: value added less wages and salaries, deflated by a capital cost index. The qualitative conclusions are independent of the capital stock measurement technique.

- Total Resource Rents: measured as value added less the opportunity cost of labour and the opportunity cost of capital.[10]
- Resource Rents Paid to Capital Owners: measured as value added less wages and salaries, government revenues from indirect resource taxation and the opportunity cost of capital.
- Common Stock Price Indexes
- Government of Canada Long Term Bond Yields
- Moody's AAA Industrial Bond Yields

Much of the input, output and price information for the resource industries has been collected separately for the extraction, primary processing and secondary processing stages of production. My identification of industry groups and stages of production follows the current definitions used by Natural Resources Canada.[11] This identification procedure has necessitated the reconstruction of industry groups from more disaggregate data for the earlier time periods. There were particularly dramatic reorganizations of Dominion Bureau of Statistics and Statistics Canada industry groupings in 1926, 1948 and 1982.

Prior to the introduction of the Dominion Bureau of Statistics in 1926 much of the quantity, value and price data used in this study was only available from Canadian Census Reports, Department of Forestry and Bureau of Mines Annual Reports, Government of Canada Sessional Papers, and Canadian Year Books. Where no annual data existed, information for inter-census years was interpolated using the methodological approach employed by Urquhart (1993) in his 1870-1926 reconstruction of Canadian G.N.P..[12]

The construction of common stock price indexes for the resource industries, manufacturing sector and the aggregate market was quite labour intensive, particularly for the earliest years of the century. For the years 1956-1999 the Toronto Stock Exchange Annual Review reported common stock price indexes for the energy, forestry, mining and industrial firms listed on the exchange, as well as a T.S.E. 300 composite index.[13] Weights for the individual firms in these indexes were derived from total capitalized values. Between 1935-1956 a composite index reported by the Annual Review included all listed firms. Because the Annual Review's composite index did not include mining stocks for the years earlier than 1935, it has been adjusted to account for changes in the mining index over the 1900-1935 period. Between 1900-1914 the T.S.E. does not report any stock

[10] I assume that the opportunity cost of labour for the resource industries is total employment multiplied by the average annual income earned in non-resource intensive manufacturing. I assume that the opportunity cost of capital for the resource industries is the nominal value of net fixed capital times Moody's AAA bond yields.

[11] For a much more detailed discussion of the composition of industry groups used in this study see Keay (2006), Section 3.

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

[13] The industrial index includes forestry firms, but no energy or mining firms.

indexes. For this earliest period Rosenbluth's reconstructed industrial and composite indexes have been used rather than the similarly named indexes provided in the Coates (1915) *Board of Inquiry* data.[14] The energy index has been constructed from the average of annual high-low quotations in the T.S.E. Annual Review for coal mines and petroleum firms for the 1900-1926 period.[15] Between 1926-1956 the energy index used in this study was titled "Oil and Gas" in the T.S.E. Annual Review. For forestry firms an index is reported in the Annual Review after 1914 and by Coates for the years between 1900-1914. Unfortunately the Coates index includes only a single firm: Laurentide Paper. As a result, similar to the energy index, I have constructed a forestry index for the 1900-1914 period from the average of annual high-low quotations in the T.S.E. Annual Review for forestry and paper firms. A separate mining index is reported in the Annual Review starting in 1935. There are periodic reports of a mining index in Dominion Bureau of Statistics publications and in the Coates data for the earlier years, but because no information about construction or composition is provided I have again constructed an index for mining firms spanning the years 1900-1935 using the average of annual high-low quotations in the T.S.E. Annual Review.

Because 90 day treasury bill rates are unavailable for the early part of the twentieth century, I have used both McInnis' long term Government of Canada bond yields and Moody's AAA industrial bond yields to measure the Canadian risk free rate of return.[16]

In level terms each of the series used in this paper would be without any comparative context that could give them meaning as a performance indicator. In an effort to provide this context Table 1 reports the average annual percentage change (and standard deviation) in value added, real output, employment, capital intensity, output prices, labour productivity and total factor productivity, relative to the aggregate economy for all resource industries, the energy, forestry and mining industries separately, and all manufacturing industries (which include some of the primary and secondary processing resource industries). In addition, Table 1 also includes two profitability indicators: the average annual percentage change in resource rents (and resource rents captured by capital owners) relative to G.N.P., and the average annual percentage change in the industry specific equity price indexes relative to the composite index. The final series summarized in Table 1 is the average annual difference between the rate of change in the industry specific equity price indexes and long term Government of Canada bond yields.

Much of the discussion in the introductory section of this paper is based on the figures provided in Table 1. We can see that on average the resource industries' real output, capital intensity, labour

[14] Rosenbluth, G., *Stock Market Price Indices Database*, accessed on April 20, 2005: www.arts.ubc.ca/econsochist/.

[15] All of the constructed stock price indexes use capitalized values calculated in 1900, 1910, 1920 and 1926 as firm weights.

[16] McInnis, M., *Canadian Macroeconomic Data Set*, accessed on May 19, 2006: library.queensu.ca / webdoc / ssdc / cdbksnew / HistoricalMacroEconomicData /.

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

	N.R. Industries	Energy	Forestry	Mining	Manufacturing
VA/GNP	-0.51 (0.071)	0.67 (0.116)	-0.87 (0.110)	-0.64 (0.96)	-0.28 (0.54)
Q/AggQ	0.10 (0.057)	1.49 (0.097)	-1.26 (0.096)	0.34 (0.086)	-0.28 (0.054)
L/AggL	-0.83 (0.099)	-1.09 (0.112)	-1.09 (0.109)	-0.40 (0.122)	-0.70 (0.086)
KL/AggKL	1.36 (0.109)	1.62 (0.125)	0.97 (0.118)	1.35 (0.130)	0.16 (0.121)
P/AggP	-0.24 (0.061)	-0.84 (0.071)	0.40 (0.065)	-0.99 (0.089)	-0.08 (0.048)
QL/AggQL	0.93 (0.103)	2.58 (0.127)	-0.17 (0.116)	0.75 (0.120)	0.43 (0.080)
TFP/AggTFP	0.25 (0.082)	0.66 (0.083)	-0.54 (0.086)	0.69 (0.102)	0.29 (0.080)
Rent/GNP	-0.65 (0.129)	0.88 (0.135)	-0.98 (0.226)	-0.21 (0.183)	N.A.
Krent/GNP	-0.73 (0.255)	1.36 (0.171)	-2.81 (0.477)	-4.42 (0.479)	N.A.
Stkp/Composite	-0.97 (0.092)	-0.75 (0.140)	0.21 (0.225)	-1.93 (0.231)	1.06 (0.135)
$R_i - R_f$	-2.53 (0.196)	-2.31 (0.224)	-1.35 (0.285)	-3.49 (0.291)	-0.51 (0.185)

Note: Standard deviations are provided in (parentheses).

productivity and T.F.P. all grew faster over the twentieth century than the aggregate economy, with the energy industry consistently leading the way. In contrast, the resource industries' value added, employment and output prices all shrunk relative to the aggregate economy, with the forestry industry suffering the worst declines. Despite the improving productivity and capital intensity measures, resource rents as a proportion of G.N.P. (and capital owners share of those rents) fell for all resource industries, forestry and mining, although not for energy.[17] The stock indexes tell a slightly different story, with energy, mining and all resource industries' equity prices falling relative to the market average. What is surprising is that the forestry industry's equity prices actually increased in value relative to the market average, although even forestry's stock prices fell relative to the industrial average. The equity price returns were all lower than the risk free rate of return, despite the presence of risk premia in the stock returns. This unusual result stems from the fact that I do not have any information on dividend payments for any of the industries in my study. The lack of dividend information implies that my measure of the returns on stock market investments must be a substantial underestimate of the total returns that would have been earned. Slade and Thille (1997, Table 2) report that the dividend returns on Canadian copper mines between 1956-1982 averaged 5.1% per year - exactly one half of the total return earned by stock market investors on copper mine stocks.

Insert Figure 1 - 9

Of course the summary statistics provided in Table 1 tell us nothing about the performance indicators' chronological patterns or their size. Figures 1 - 9 illustrate value added, real output, employment, capital intensity, output price, labour productivity, T.F.P., rent and equity price ratios for all resource industries relative to the aggregate economy for the years 1900-1999. To highlight the cyclical nature of the resource industries' performance indicators a Hodrick-Prescott filter has been used to decompose each series into its stationary and non-stationary components. We can see that many of the series appear to have broadly similar patterns over the century, with a contractionary phase spanning the first quarter century, rapid expansion through the 1930s and 1940s, followed by contraction (or at least a slowing of growth) from roughly mid-century through to the early 1990s, interrupted only briefly by an expansionary period during the late 1960s and early 1970s.[18] Although I do not present comparable figures for the individual industry groups, mining and forestry industries' series follow very similar chronological patterns to those depicted

[17] Even if we truncate the rent/G.N.P. ratios for the energy industries in 1971, their profits still grew faster than the aggregate economy by an average of 0.83% per year.

[18] In Keay (2006) I argue that these cyclical patterns in the resource industries' performance indicators appear to coincide with domestic resource discovery and depletion, rather than any changes in the non-resource intensive sectors of the economy.

in Figures 1 - 9, while energy's series also follow a very similar pattern up to the mid-1960s, after which strong growth becomes the dominant characteristic of the energy series.

Summary statistics and visual inspection of the data series are helpful in the development of a qualitative assessment of performance. However, because there is no consistent interpretation across performance indicators, time or industries, it seems that a more statistically rigorous investigation of the connections amongst these series is called for.

4 Methodological Approach

Although I hope to make the implied connections a bit more explicit, the methodological approach adopted in this paper borrows heavily from Sadorsky's (2001) multi-factor C.A.P.M.. In particular, my study of the relationship between size, productivity and profitability for Canada's twentieth century resource industries proceeds in four phases - with two brief "asides" that are intended to provide a comparison between my results to those generated by Sadorsky (2001), Sadorsky and Henriques (2001), and Slade and Thille (1997).

In the first phase basic C.A.P.M. equations have been estimated for each resource industry and for all resource industries together.

$$(R_{it} - R_{ft}) = \gamma 0_i + \gamma 1_i (R_{mt} - R_{ft}) + \epsilon_{it} \tag{4}$$

Similar to the definitions provided in Section 2: i = all resource industries, energy, forestry or mining, t = 1900 - 1999 (annual), R_i = rate of return on industry i common stock prices = $ln(stkp_{i1}) - ln(stkp_{i0})$, R_f = rate of return on long term Government of Canada bonds, R_m = rate of return on the T.S.E. composite index, $\epsilon_i = iid, N(0, \sigma)$. C.A.P.M. suggests that in theory $\gamma 0$ should be statistically insignificant and $\gamma 1 = 1.00$. It is straight forward to test these predictions with Equation (4).

In the second phase of my methodological approach the notion that resource rents should be a significant determinant of equity prices, as proposed by basic finance theories, can be probed. To accomplish this an additional factor - the percentage change in industry specific resource rents relative to G.N.P. - has been added to the basic C.A.P.M. structure.

$$(R_{it} - R_{ft}) = \gamma 0_i + \gamma 1_i (R_{mt} - R_{ft}) + \gamma 2_i \Delta Rentsh_{it} + \epsilon_{it} \tag{5}$$

Where: $\Delta Rentsh_{it}$ = % change in industry i total resource rents relative to G.N.P.. All other variables have been defined previously. Here we are simply interested in the size and significance of $\gamma 2$, and possibly the changes in R^2 associated with the inclusion of $\Delta Rentsh$ in the estimating equation.

The third phase follows Slade and Thille by providing a more explicit statistical connection between resource rents and the proxies used by Sadorsky to explain equity prices. More specifically, I assume that the percentage change in resource rents relative to G.N.P. for each industry (and all resource industries) is dependent on the determinants of extraction costs (the percentage change in relative T.F.P., capital intensity and real output) and the percentage change in relative output prices. To capture the importance of export markets the percentage change in the Canada-U.S. foreign exchange rate has also been included as an independent variable.

$$\Delta Rentsh_{it} = \gamma 0_i + \gamma 1_i \Delta RelA_{it} + \gamma 2_i \Delta Qsh_{it} + \gamma 3_i \Delta KLsh_{it} + \gamma 4_i \Delta RelP_{it} + \gamma 5_i \Delta CUX_t + \epsilon_{it} \quad (6)$$

Where: $\Delta RelA$ = % change in industry i T.F.P. relative to aggregate T.F.P., ΔQsh = % change in industry i real output relative to aggregate real output, $\Delta KLsh$ = % change in industry i capital to labour ratio relative to aggregate capital to labour ratio, $\Delta RelP$ = % change in industry i output price relative to G.N.P. deflator, ΔCUX = % change in Canada-U.S. average annual exchange rate. All other variables have been previously defined. 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 productivity, output, capital intensity, prices and currency depreciation to have a positive and significant impact on resource rents. This third phase of my methodological approach also includes the first "aside", in which I use aggregate Canadian mining data from the entire twentieth century, with an adapted version of Slade and Thille's estimating equation, to provide some basis for comparing my results with those in the related literature.

In the fourth and final phase I am interested in the direct connection between the determinants of resource rents - as described in Equation (6) - and equity prices. The estimating equation used here is an augmented version of Sadorsky's multi-factor C.A.P.M..

$$(R_{it} - R_{ft}) = \gamma 0_i + \gamma 1_i (R_{mt} - R_{ft}) + \gamma 2_i \Delta RelA_{it} + \gamma 3_i \Delta Qsh_{it} + \gamma 4_i \Delta KLsh_{it} + \gamma 5_i \Delta RelP_{it} + \gamma 6_i \Delta CUX_t + \epsilon_{it} \quad (7)$$

Where all variables have been previously defined. Given the theoretical predictions and the results reported by Sadorsky (and others), we should again expect productivity, output, capital intensity, prices and currency depreciation to have a positive and significant impact on equity market performance. In this phase the second "aside" involves the use of my data for the aggregate Canadian energy and forestry industries over the entire twentieth century, with an adapted version of Sadorsky's estimating equations to again compare my results with those already available in the literature.

5 Results

Before estimating Equations (4) - (7) the time series properties of the data were explored using standard augmented Dickey-Fuller and Phillips-Perron unit root tests (with a linear trend).[19] In light of the chronological patterns apparent in Figures 1 - 9 it was not surprising to find that the size, productivity and profitability indicators of interest were often non-stationary in levels.[20] However, because I am interested in stock market premia and growth rate differentials between the resource industries and the aggregate economy, the stationarity of the log differences of the relative performance indicators is the more relevant consideration. Non-stationarity can be rejected with at least 99% confidence for all of the variables included in Equation (7) for all of the resource industries considered in this study.[21]

Standard diagnostic tests have been performed on the residuals and parameter estimates from Equations (4) - (7) for all four of the resource industry groups. These tests include Breusch-Godfrey's test for serial correlation (at one, two and three lags), Engle's Lagrange multiplier test for autoregressive conditional heteroskedasticity (at one, two and three lags), and Ramsey's regression specification error test. Parameter stability has been checked by running recursive regressions on 30 year sub-periods and visually inspecting the parameter estimates for discontinuities. Correlation matrices for the complete set of independent variables for each industry have been calculated to check for the possible presence of multicollinearity.

Where there was evidence of autocorrelation and/or heteroskedasticity among the residuals at the 90% level of confidence at lags one, two or three, Newey-West robust standard errors have been used to calculate the p-values reported in the tables below.[22] As a check on the sensitivity of the results reported in the following tables for the equations for which there is evidence of auto-

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

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

[21] Despite that fact that they are 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.

[22] Newey-West robust standard errors have been used for energy and forestry's Equation (6), and all mining equations.

Table 2: Equation (4): Basic C.A.P.M.

	Dependent Variable: $(R_i - R_f)$			
Independent Variable	N.R. Industries	Energy	Forestry	Mining
$(R_m - R_f)$	**1.016**†	**1.022**†	**1.026**†	**1.044**†
	(0.000)	(0.000)	(0.000)	(0.000)
Constant	-0.009	-0.007	0.003	-0.019
	(0.311)	(0.620)	(0.909)	(0.288)
$AdjR^2$	0.777	0.604	0.371	0.367

Note: P-values provided in (parentheses). Parameter estimates in **bold** are statistically significant. † indicates that we cannot reject the possibility that $\gamma 1 = 1.00$ with any standard level of significance.

correlation and/or heteroskedasticity among the residuals, I have estimated the relevant equations using a generalized autoregressive conditional heteroskedasticity (GARCH(1, 1)) model. There is no difference in sign or statistical significance among any of the parameters reported in this section when compared to the parameters estimated with the GARCH model.

Although there is evidence of misspecification among the forestry equations, the Ramsey test rejects misspecification for all equations and all industries when lagged T.F.P. or capital owners' rent shares are used as regressors.

Visual inspection indicates that the estimated parameters from Equation (7) for all four industries are fairly stable over all of the 1929-1999 sub-periods.

Not surprisingly, the correlation matrices for all industries indicate fairly strong relationships among some of the independent variables: T.F.P. and output prices, for example. Although this suggests the presence of multicollinearity, which may introduce some inefficiency into the estimates reported below, the parameter estimates will remain unbiased.

In Table 2 I report the parameter estimates (and their p-values) for each of the independent variables from the basic C.A.P.M. equation described by (4) for all resource industries, energy, forestry and mining. The adjusted R^2 for each industry are also included in Table 2. I also report the significance of the standard C.A.P.M. test: $\gamma 1 = 1.00$. The results in Table 2, therefore, reflect the first phase of my methodological approach. We can see that although $\gamma 1$ is slightly greater than one for all four industry groups, which indicates that resource stocks have been riskier than a fully diversified portfolio, we cannot statistically distinguish these estimated parameters from one. It is also apparent that the constant for all of the industries is statistically insignificant. These results not only reconfirm our confidence in the basic C.A.P.M., they are roughly consistent in size, sign and significance with those reported by Slade and Thille, Sadorsky, and Sadorsky and Henriques for late twentieth century Canadian mining, energy and forestry industries, respectively.

In Table 3 the results from the second phase of my methodological approach are reported. More specifically, the parameter estimates (and their p-values) for each of the independent variables from

Table 3: Equation (5): C.A.P.M. with Resource Rents

	Dependent Variable: $(R_i - R_f)$			
Independent Variable	N.R. Industries	Energy	Forestry	Mining
$(R_m - R_f)$	**0.968**	**1.035**	**0.928**	**1.043**
	(0.000)	(0.000)	(0.000)	(0.000)
$\Delta Rentsh_i$	**0.215**	**0.298**	**0.304**	0.001
	(0.004)	(0.004)	(0.003)	(0.907)
Constant	-0.009	-0.010	0.004	-0.019
	(0.332)	(0.488)	(0.856)	(0.294)
$AdjR^2$	0.794	0.633	0.420	0.360

Note: P-values provided in (parentheses). Parameter estimates in **bold** are statistically significant.

the C.A.P.M. equation (5) that has been augmented by the percentage change in resource rents relative to G.N.P. are provided in Table 3 for all resource industries, energy, forestry and mining. Again, the adjusted R^2 for each industry are also included. We can see that increases in the rate of growth of resource rents in excess of the aggregate G.N.P. growth rate were associated with increases in equity prices for all four industry groups. Only among the mining industries does there appear to have been little statistical connection between resource rents and equity market performance over the twentieth century. Comparing the results reported in Tables 2 and 3, we can see that statistical fit is improved by including resource rents as a regressor (for all industries other than mining), the constant remains insignificant, and the parameter estimates on the market premia remain strongly statistically significant and indistinguishable from one. These results suggest continued support for C.A.P.M., and they are consistent with finance theories that suggest that resource rents should be a substantive determinant of equity prices.[23]

Turning to the third phase of my methodological approach, in Table 4 the parameter estimates (and their p-values) for each of the independent variables from Equation (6) are provided. In this phase I am following Slade and Thille in trying to emphasize the role resource rents play as a conduit through which productivity, output, capital intensity, prices and exchange rates impact equity prices. We can see that (with the exception of mining) increases in relative T.F.P., output, capital intensity, prices, and exchange rate depreciation are all associated with increasing resource rents. The strongest statistical connections link output and prices to rents. It is interesting to note that if lagged T.F.P. is used in Equation (6) rather than current T.F.P., the relationship between productivity and rents becomes not only positive, but strongly statistically significant for all industries but mining.[24]

[23]If I use the share of resource rents captured by capital owners rather than total resource rents in Equations (5) and (6), the qualitative conclusions I draw continue to hold. In some cases statistical significance is substantially improved.

[24]I do not include lagged T.F.P. in Equation (6) because there is no theoretical reason for choosing any particular lag length. In addition, when I use a standard reduced form V.A.R. model to test for Granger causality among the

Table 4: Equation (6): Resource Rents and their Determinants

	Dependent Variable: $\Delta Rentsh_i$			
Independent Variable	N.R. Industries	Energy	Forestry	Mining
$RelA_i$	0.159	0.057	0.354	-5.757
	(0.454)	(0.383)	(0.350)	(0.113)
$RelQ_i$	**1.707**	**1.194**	**1.868**	**4.274**
	(0.000)	(0.000)	(0.000)	(0.016)
$RelKL_i$	0.105	**0.079**	0.133	2.822
	(0.264)	(0.051)	(0.333)	(0.108)
$RelP_i$	**1.831**	**1.152**	**2.471**	-0.848
	(0.000)	(0.000)	(0.000)	(0.654)
ΔCUX	0.139	0.081	-0.022	1.993
	(0.483)	(0.113)	(0.949)	(0.487)
Constant	0.0002	-0.001	0.005	-0.071
	(0.981)	(0.588)	(0.638)	(0.238)
$AdjR^2$	0.748	0.958	0.782	0.116

Note: P-values provided in (parentheses). Parameter estimates in **bold** are statistically significant.

Unfortunately I cannot directly compare my results to those reported by Slade and Thille because I do not have access to marginal rents, depletion effects, or 90 day treasury bill rates. However, if I use average resource rents rather than marginal, if I assume no new resource discoveries, and if I assume that long term government bond yields are a good proxy for the 90 day treasury bill rate, then I can estimate an adapted version of Slade and Thille's nested C.A.P.M. - Hotelling Rule model. Although statistical significance in my adapted equation is poor, the signs on the parameter estimates are remarkably similar to those derived by Slade and Thille. I find that over the twentieth century among all Canadian mining industries depletion, equity prices, increases in output prices and exchange rate depreciation were all related to rising resource rents. However, I also find that the risk free rate of return, the average rate of return on Moody's AAA industrial bonds and G.D.P. growth were all associated with falling resource rents.

In the final phase of my methodological approach I investigate the relationship between the determinants of resource rents, as described in Equation (6), and equity prices. In Table 5 I report the parameter estimates (and their p-values) for each of the independent variables from Equation (7) for all resource industries, energy, forestry and mining. The adjusted R^2 for each industry are again included. We can see that, as C.A.P.M. predicts, the market risk premium continues to play an important role in explaining the resource industries' equity prices, and the constant remains small and insignificant. Aside from forestry, T.F.P. improvements (relative to the aggregate economy) have a positive influence on equity prices, as do increases in output, capital intensity, output prices and currency depreciation. From a statistical perspective, and in terms of the absolute

variables in Equation (6), I find only weak evidence of a connection between past changes in T.F.P. and current changes in resource rents after controlling for past changes in the rents themselves.

Table 5: Equation (7): C.A.P.M. with Determinants of Resource Rents

	Dependent Variable: $(R_i - R_f)$			
Independent Variable	N.R. Industries	Energy	Forestry	Mining
$(R_m - R_f)$	**0.989**	**1.053**	**0.826**	**1.062**
	(0.000)	(0.000)	(0.000)	(0.000)
$RelA_i$	**0.575**	0.348	-0.067	0.671
	(0.045)	(0.266)	(0.894)	(0.424)
$RelQ_i$	**0.499**	**0.292**	0.327	-0.142
	(0.004)	(0.056)	(0.178)	(0.762)
$RelKL_i$	0.063	0.042	-0.375	0.140
	(0.618)	(0.752)	(0.120)	(0.670)
$RelP_i$	**1.112**	**0.780**	**1.359**	0.668
	(0.001)	(0.024)	(0.022)	(0.371)
ΔCUX	-0.022	0.013	-0.147	-1.042
	(0.937)	(0.974)	(0.813)	(0.175)
Constant	-0.008	-0.007	0.002	-0.071
	(0.368)	(0.607)	(0.924)	(0.238)
$AdjR^2$	0.804	0.626	0.507	0.367

Note: P-values provided in (parentheses). Parameter estimates in **bold** are statistically significant.

size of the parameter estimates, output and output prices are consistently the most important determinants of equity market performance, with T.F.P. having a significant impact only when the resource industries are aggregated into a single group. Capital intensity has the expected sign for all industries aside from forestry, but statistical power is weak. Although Canada-U.S. exchange rates have the wrong sign for all industries but energy, indicating that domestic currency depreciation has been associated with falling equity prices, none of the parameters can be statistically distinguished from zero.

The results reported in Table 5 cannot be directly compared to those reported by Sadorsky or Sadorsky and Henriques because I do not have access to 90 treasure bill rates and I cannot replicate their "term premium" variable exactly. Despite these differences the results that can be compared are very similar. If I estimate an adapted version of Sadorsky's multi-factor C.A.P.M. for Canadian forestry and energy industries I find that output prices and market risk premia are the only two variables that are consistently both economically and statistically significant. The term premia and changes in the exchange rate have the expected sign, but they are not consistently significant across specifications.

6 Conclusions

It seems clear that among twentieth century Canadian resource industries there was a fairly strong connection between productivity performance, size and output prices - on one hand - and equity market performance - on the other. It also seems clear that resource rents acted as the conduit through which productivity, size and prices affected equity prices. This not only suggests that size and productivity alone cannot account for all aspects of economic performance, it also helps to explain the mixed signals the economic fundamentals were sending with respect to the assessment of long run performance among the resource industries. More specifically, improving T.F.P. and increasing capital intensity were unable to offset declining output prices and rising costs, such that both resource rents and equity prices were falling relative to the aggregate market. The parameter estimates reported in Table 5 help us to make this claim somewhat more concrete. If we leave all other performance indicators unchanged from their observed values, but we ask what T.F.P. growth would have had to have been for Canadian resource industries' common stock prices to have simply matched the rate of growth of the T.S.E. composite index, we find that productivity growth would have had to exceed the aggregate economy by an additional 1.69% per year, on average. This would imply that average T.F.P. growth among the resource industries would have had to more than double. Rapid T.F.P. growth and increases in capital:labour ratios do appear to have had a positive impact on both rents and stock market performance, but their influence was minor compared to the impact that output prices have had on profitability.

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Size, Productivity and Profitability:
Canada's Natural Resource Industries in the Twentieth Century

Figure 1: NR Industries VA / GNP

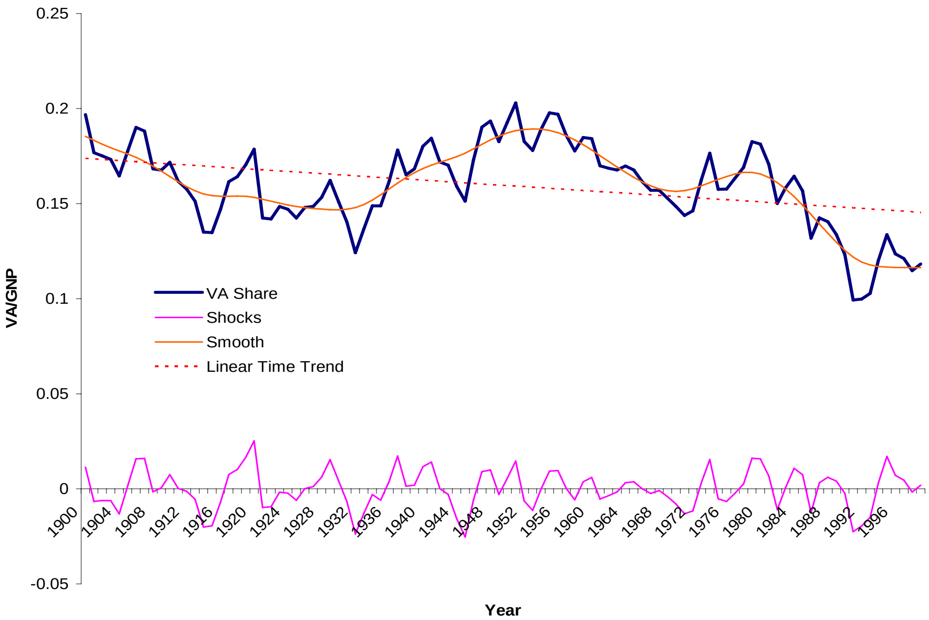

Figure 2: NR Industries Real Q / Aggregate Q

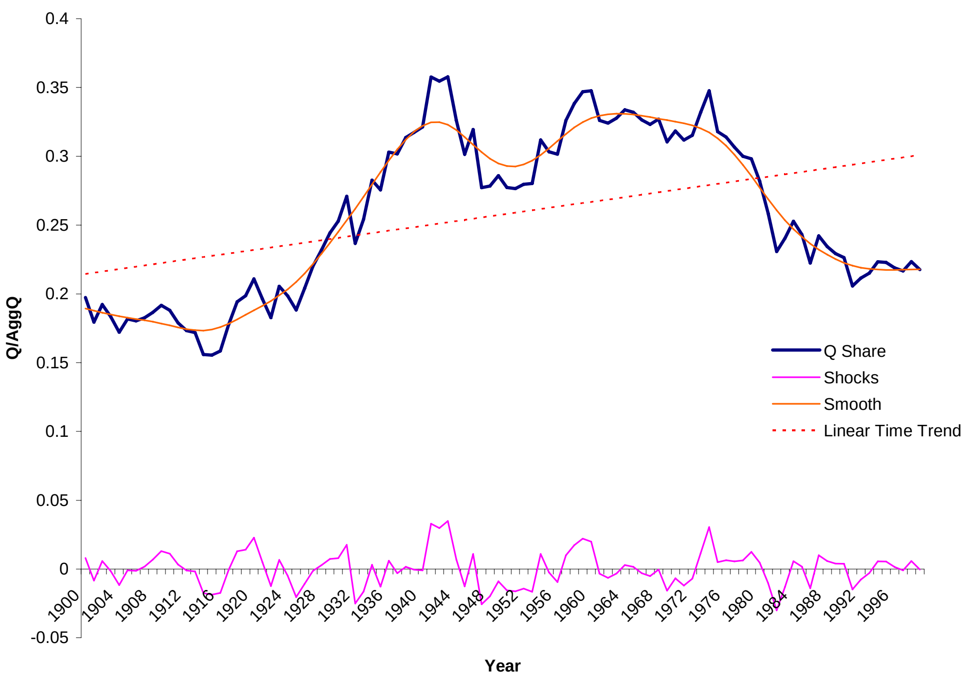

Figure 3: NR Industries Employment / Aggregate Employment

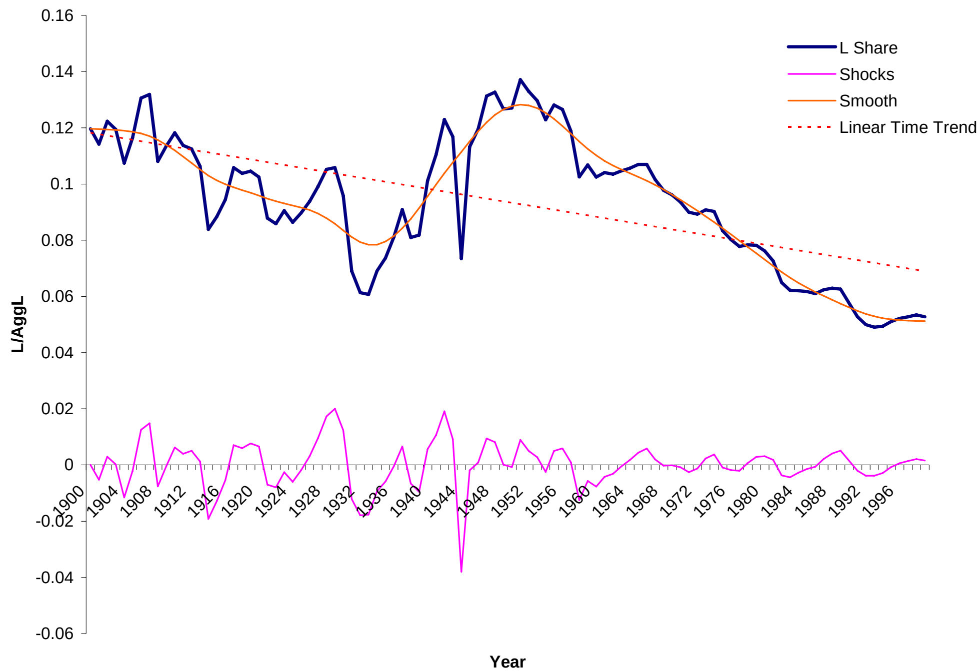

Figure 4: NR Industries K:L Ratio / Aggregate K:L Ratio

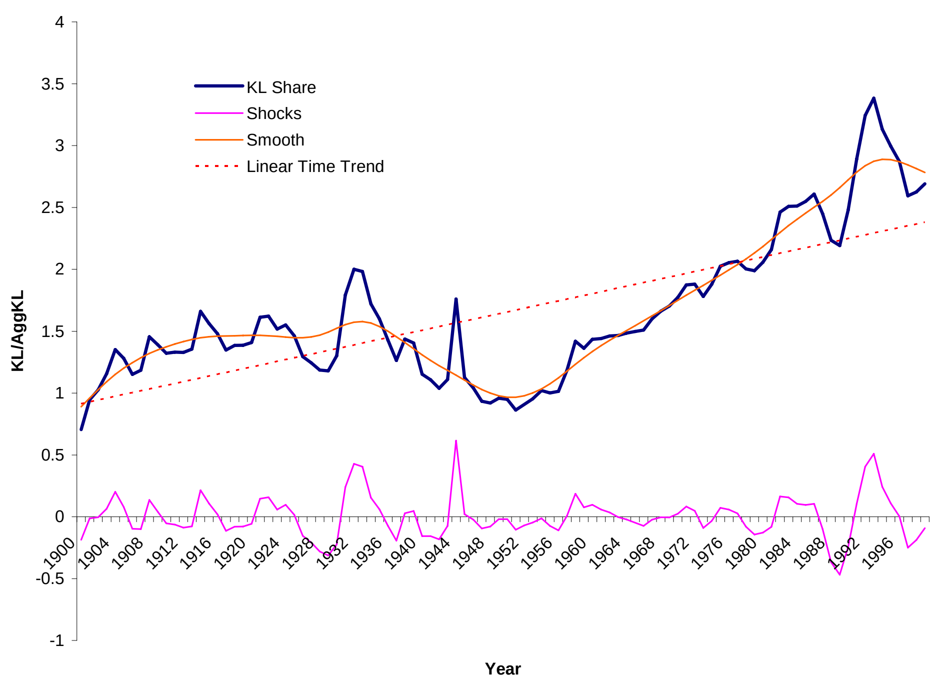

Figure 5: NR Industries Output P / GNP Deflator (1900=1.00)

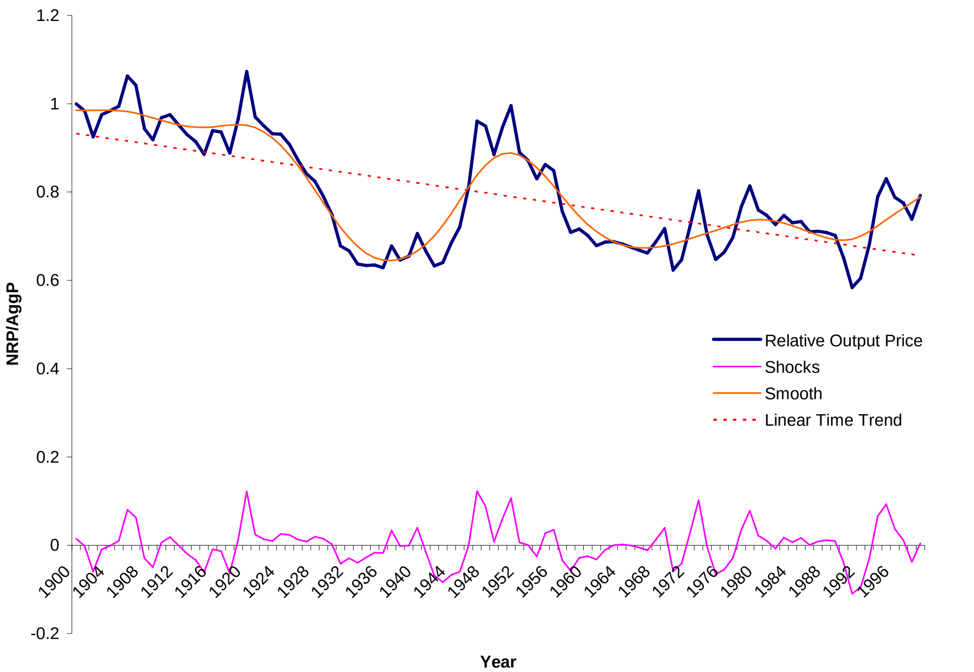

Figure 6: NR Industries L Productivity / Aggregate L Productivity (1900=1.00)

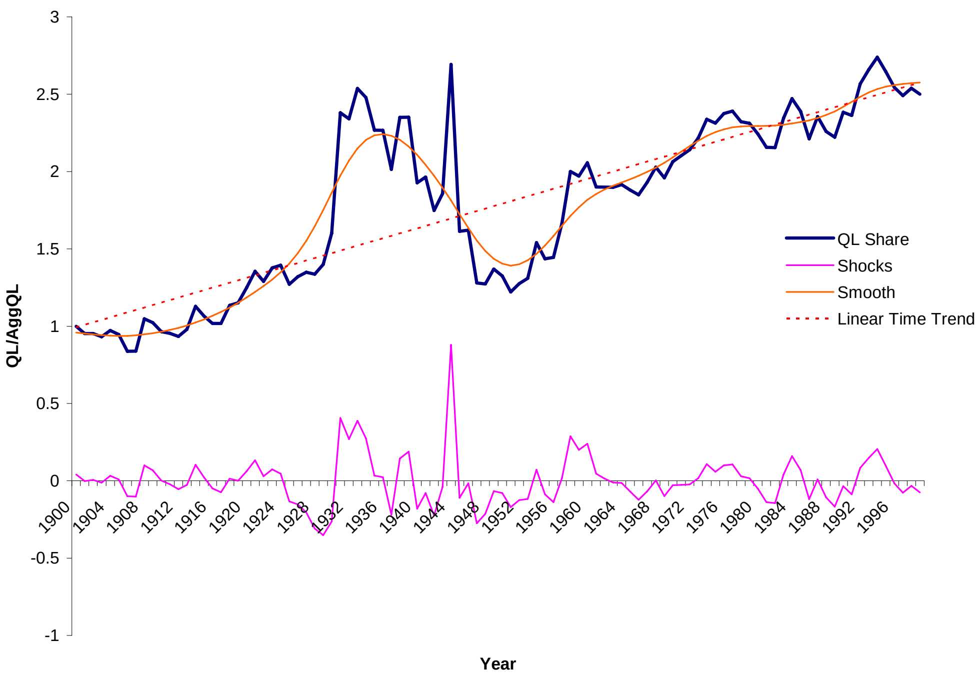

Figure 7: NR Industries TFP / Aggregate TFP (1900=1.00)

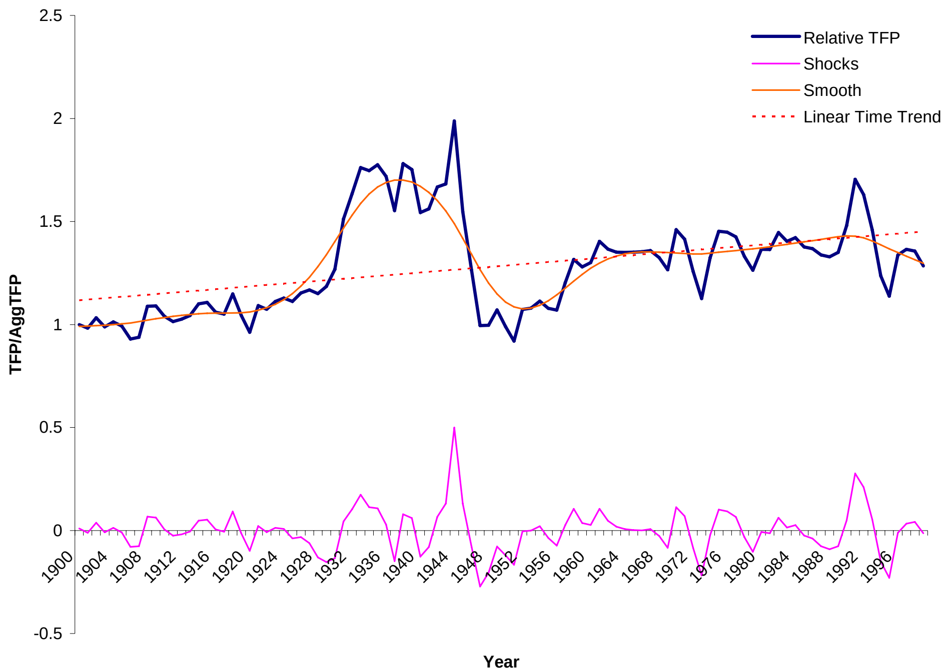

Figure 8: NR Industries Resource Rents / GNP

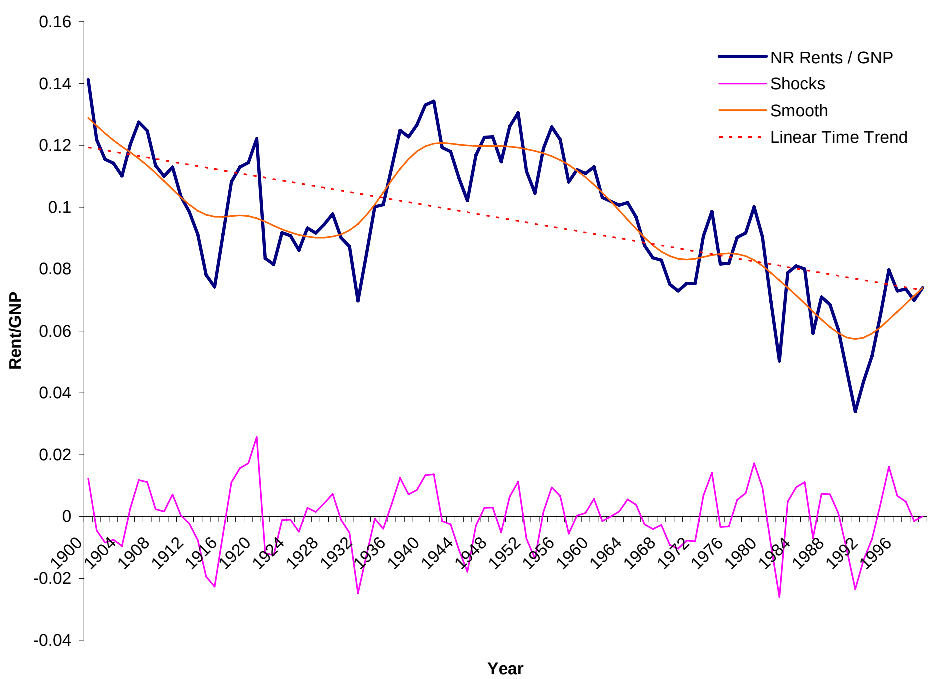

Figure 9: NR Industries Stock Price Index / Composite Index (1900=1.00)