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A TALE OF TWO CITIES: CYCLICAL MOVEMENTS IN PRICE AND PRODUCTIVITY IN MINING AND MANUFACTURING

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1. Introduction

Over the past several decades Curtis Eaton has been at the forefront of a revolution in microeconomic theory. This revolution has shifted the focus of analysis from general equilibrium of competitive economies to the dynamics of strategic interaction in partially localized markets. In the process imperfect competition has replaced perfect competition as the primary focus of research in microeconomics.

The argument developed below is that imperfectly competitive analysis of the type expounded in Curtis' research is particularly appropriate for analysing long-run equilibrium in manufacturing. In this equilibrium, firms operate with price greater than marginal cost, substantial fixed costs and unexploited economies of scale. However, it is also argued that this model is not appropriate for mining firms. A different pattern of competition in mining is attributed to the structural conditions of heterogeneous resource deposits that are used to produce standardized products, which are often sold in well organized global markets. At least some mining firms appear to operate as price takers, with price equal to marginal cost and no unexploited economies of scale.

The focus of the current study is on disequilibrium, in particular the adjustment to cyclical shocks for an economy in which there coexist markets of the two types described above. Associated with the dichotomy in long-run equilibrium between mining and manufacturing is a difference in the short-run responsiveness of supply, which in turn implies differences in the price and quantity impacts of supply and demand shocks. As a result, demand shocks are expected to lead to pro-cyclical movements in the price of mining products relative to the price of manufactures.

In addition to implying that demand shocks affect prices differently across the mining and manufacturing sectors, the analysis suggests that demand shocks have different impacts on productivity in the two sectors. Productivity in manufacturing is expected to be pro-cyclical. However, in mining the cyclical behaviour of productivity is more complicated. At the bottom of the business cycle productivity is expected to be pro-cyclical, but during booms, such as that experienced recently, productivity is expected to be counter-cyclical.

Markets for mine products tend to be global with many products actively traded on organized commodity exchanges, while manufacturing markets tend to be segmented by country due to product differentiation and trade barriers.[1] Nonetheless, both markets can be observed in countries with both a globally integrated mining sector and a substantial manufacturing sector. Australia and Canada both fit these requirements and have sectoral data for prices and multi-factor productivity that extend back into the 1960s. These data are used to examine whether the dichotomy in competition in mining and manufacturing explains the pattern of cyclical movements in prices and productivity in the two sectors.

The remainder of the paper is organized as follows. The next section discusses competitive conditions between mining and manufacturing, resulting in the dichotomy

[1] Slade (2004) treats markets for mine products as global in examining the impact of market concentration on profitability, while Bloch and Olive (2003) provide evidence of the national segmentation of markets for manufactures.

indicated above. This is followed in Section 3 by an analysis that examines cyclical movements in the prices of mining and manufacturing products in Australia and Canada. In Section 4 the focus is on productivity, again using data from mining and manufacturing in Australia and Canada to illustrate the working of adjustments to cyclical shocks. Section 5 concludes and provides some observations on implications of cyclical movements in the relative prices and productivity between miners and manufacturers for inflation and the distribution of income.

2. Competitive Conditions

2.1 Manufacturing

A key feature of Curtis' analysis of imperfect competition is the localization of competition, for example through spatial separation (as in Eaton, 1972, Eaton and Lipsey, 1975, and Eaton and Wooders, 1985) or through production differentiation (as in Eaton and Lipsey, 1989). The localization of competition means that the market facing individual firms is imperfect and the firms face downward sloping demand for their product, even when there are large numbers of producers in the industry. When combined with free entry of firms, as in Eaton (1976) or Eaton and Lipsey (1978), this leads towards equilibrium with unexploited economies of scale.

Another argument for the existence of unexploited economies of scale that is analysed in Curtis' work is the effort of incumbents to deter entry. Building on the seminal work of Spence (1977), Eaton and Lipsey (1979, 1980 and 1981) examine conditions under which firms make strategic investments in capacity as a means of influencing entry decisions. While the case for using excess capacity as a deterrent to entry in these papers is shown to be less strong than in naïve models of entry deterrence, the possibilities of unexploited economies and of economic profit in equilibrium remain.

Curtis' theoretical work on competition suggests an important distinction for empirical research, namely the distinction between the impact of imperfect competition on economic profits and the impact on the ratio of price to marginal cost. Many of the models presented in Curtis' work analyse forward-looking equilibrium with free entry. Under at least some conditions this equilibrium is often characterized by economic profits approaching zero for incumbent firms. Yet, the corresponding ratio of price to marginal cost almost always exceeds one. Thus, imperfect competition in the sense of price exceeding marginal cost need not imply economic profit.

Further support for the importance of the distinction between economic profit and the ratio of price to marginal cost as measures of the imperfection of competition is given by John Sutton's (1991 and 1998) application of game theory to the analysis of market structure. Sutton argues that firm expenditures on sunk cost items, such as advertising and R&D, affect the equilibrium outcome of the dynamic game. While Sutton's focus is on outcomes in terms of market structure, there are implications for outcomes in terms of economic profit and the ratio of price to marginal cost. In particular, the sunk cost expenditures are covered by revenues in equilibrium that implies, with constant marginal production cost generally assumed, price exceeds marginal cost even when economic profit is zero.

Strong empirical support for a degree of imperfection of competition is found in studies that directly estimate the degree of market imperfection in manufacturing industries. Iwata (1974) and Applebaum (1982) each estimate a cost function and estimate the degree of imperfect competition in the context of simultaneous equations for an industry's cost function, input demand functions and profit-maximizing price. Iwata applies his method to estimating the degree of conjectural variation for Japanese glass manufacturers and finds a ratio of price to marginal cost in the range of 2.0 to 2.5. Applebaum finds a low ratio of price to marginal cost in the US rubber and textiles industry in the order of around 1.05, a moderate ratio of price to marginal cost of about 1.25 for the electrical machinery industry and a high ratio of about 3 in the tobacco industry.[2]

Hall (1988) provides a method of estimating the imperfection of competition in terms of the ratio of price to marginal cost, which is of particular relevance to the focus in the current paper on productivity analysis. Hall infers the value of the ratio of price to marginal cost from observations on the Solow residual, measured by the difference between the real value of output growth and the weighted average growth in input usage. Using this method, Hall estimates that ratio of price to marginal cost in US manufacturing is somewhat greater than 2 for durable goods and somewhat greater than 3 for non-durable goods, with a greater range of values for more disaggregated industries.

Hall (1990) notes that his procedure for inferring estimates of the ratio of price to marginal cost depends on the identifying restrictions imposed in estimation. One such restriction is constant returns to scale. He examines the validity of this restriction by inferring estimates of the elasticity of scale from the measure of the Solow residual based on cost and input price data rather than output and input data. He finds evidence of substantial economies of scale in most manufacturing industries and suggests that this is consistent with a type of monopolistic competition equilibrium with price equal to average cost but greater than marginal.

A substantial literature has followed Hall's basic approach. The results have generally supported the conclusion that there is imperfect competition in terms of price exceeding marginal cost in US manufacturing, but the estimates of the margin are substantially lower when output is measured in gross terms rather than value added (see, for example, Domowitz et al, 1988). Particularly convincing is the work of Roeger (1995), who relies on the difference between primal and dual productivity measures and finds estimates of the ratio of price to marginal cost across US manufacturing industries of between 1.15 and 2.75.

The general representation of competition in manufacturing that emerges from both the theoretical and empirical literature is one of imperfect competition with price exceeding marginal cost to varying degrees across individual industries. There is no consensus on whether firms are able to earn economic profit in long-run equilibrium,

[2] Iwata and Applebaum both assume constant returns to scale technology and an absence of fixed inputs, implying constant marginal cost for production. These assumptions are problematic in terms of examining cyclical productivity movements, as they imposed average cost equal marginal cost and, hence, an insensitivity of productivity to demand shocks. However, the assumptions are relaxed in a study by Morrison (1992) of Canadian, Japanese and US manufacturing, which still reports evidence of price exceeding marginal cost in each of the countries.

in part due to the prevalence of sunk costs reflecting the efforts of incumbent firms to deter entry and protect their market positions.[3] To the extent that average cost is thereby elevated above marginal cost, profit is reduced while imperfect competition is sustained. Importantly for the analysis given later of cyclical movements in productivity, this implies that incumbent firms will generally be operating with unexploited economies of scale on the downward sloping portion of their average cost curves.

2.2 Mining

Modern economic theory of production and firm behaviour is meant to be universal and does not distinguish between manufacturing, mining or any other economic activity. This universality applies to Curtis' analysis of imperfect competition and the other theoretical developments discussed above. However, particular assumptions in these analyses are problematic when applied to mining.

Perhaps most problematic of the standard assumptions in the analyses of imperfect competition is the assumption that all producers have identical cost functions, at least in the long run. This assumption is generally justified by producers having equal access to best-practice production methods and being able to acquire the inputs to production of equivalent quality at equal prices. There is no clear basis for expecting mining and manufacturing firms to have different access to technology, but not all mining firms are able to acquire the identical inputs due to the heterogeneity of the non-renewable resource inputs that are essential to mining activity.[4]

The heterogeneity of non-renewable resource inputs suggests a constraint on the ability of firms to reproduce indefinitely, negating the assumption of free entry that is common in models of endogenous market structure, such as in Eaton and Ware (1987) or Sutton (1991). In addition to the heterogeneity of natural resource inputs there is fixity in their location. This interferes with the endogenous location mechanism that is central to Curtis' analysis of spatial competition. Thus, modern developments in the theory of imperfect competition are not directly applicable to the mining sector.

In the context of the old structure-conduct-performance (SCP) approach to analysing market power, the impediment to free entry would be associated with heterogeneity of natural resource inputs, which would be seen as contributing to the imperfection of competition. Likewise, the fixity of location of production activity would contribute to the imperfection of competition by limiting the degree to which producers can relocate production to provide competition. However, the application of game theory to other problems of market structure and competition has demonstrated that many inferences from the SCP approach need to be modified.[5]

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[3] Bhattacharya and Bloch (2000) provide evidence that advertising inhibits the lowering of industry concentration that would otherwise be associated with increasing market size.

[4] Heterogeneity occurs in other categories of input, but the usual reasoning is that supplies of any particular type of physical capital are indefinitely expandable and that the skill mix of the labour force is malleable in the long run. A more problematic category of input is organisational capability, but this category is generally ignored in the analysis of competitive conditions.

[5] An excellent example is given in Eaton and Lipsey (1980).

Extension of the game theoretic approach to competition in mining is complicated by the absence of an obvious closure condition that is equivalent to the zero profit restriction associated with free entry in manufacturing.[6] A further complication is that incumbent firms and new entrants would have different cost levels associated with the heterogeneous resource, which is likely to affect their strategic interaction. Until the analysis is undertaken, it is hazardous to speculate about the degree of competition that would prevail in equilibrium. Thus, theory does not yet provide a guide to specifying conditions of competition in the mining sector.[7]

The empirical literature on competition in mining is sparse. Ellis and Halvorsen (2002) point to the difficulties associated with the heterogeneous natural resource input as an impediment. Without a measure of the economic cost of the natural resource input used up during a production period, cost measures exclude the cost of this input. Ellis and Halvorsen argue that ignoring the cost of the natural resource input leads to misspecification in estimating market power in mining.

Ellis and Halvorsen overcome the absence of a measure of the user cost of natural resources by estimating a model that incorporates an implicit user cost for the natural resource input. They use an integrated system of cost function, input share equations and a pricing equation similar to that applied to manufacturing by Iwata (1974), Applebaum (1982) and Morrison (1992), aside from including terms for the amount of input mined and cumulative extraction. The model is applied to data for Inco, then the world's leading nickel producer. Their estimates imply substantial market power, with the average markup of price over marginal cost being of the order of 150%.

Slade (2004) finds evidence of market power for a broader sample of large firms in nonferrous mining and refining by examining the relationship among profits, risk, market share, cumulative exhaustion and a time trend for panel data covering a sample of large mining firms. No quantification of the impact of market power is provided due to the indirect method used to test for impact, but Slade notes that the level of market concentration ranges from fairly competitive to only moderately concentrated. This implies that the impact of concentration on firm behaviour is at most modest.

Morris Adelman's research on competition in the world petroleum industry provides evidence of a divergence in the exercise of market power across firms in the industry. The results of this research is summarised in the volume of collected papers, Adelman (1993), and reiterated in a recent article, Adelman and Watkins (2008). Essentially, the argument is that world supply of petroleum is dichotomous. OPEC producers act as a collusive cartel, restricting supply so that price substantially exceeds production cost, while non-OPEC producers expand capacity and production until expected price is equal to marginal cost.

[6] A zero profit condition for equilibrium can be applied to the marginal producer, but this leaves the number of producers and their relative size to be determined by the distribution of the natural resource in terms of cost of extraction for equivalent product.

[7] Sutton's (1991 and 1998) endogenous market structure approach is not directly applicable. Mining products are predominantly sold as intermediate products to well-informed buyers, so advertising, is unlikely to be effective as a sunk cost to deter entry. The use of technology to create niche markets is more promising, but examples of successful application in mining are limited.

Aside from petroleum, price-taking behaviour is explicitly or implicitly assumed in studies of the supply of mining production. For example, Ellerman, et al (2001) explain the time path of productivity in the US coal mining industry by linking investment and mine closure decisions to the time path for coal prices. A similar explanation for the time path of productivity in the US copper mining industry is given by Tilton and Landsberg (1999). Perfectly competitive behaviour is not tested explicitly, but the observed behaviour is consistent behaviour of at least marginal producers that disregard any impact of their decisions on market price.

The theoretical and empirical basis for characterizing competition in the mining sector is weak and certainly less compelling than in the case of manufacturing. Yet, the treatment of marginal supply as coming from price-taker firms is pervasive. Thus, the working hypothesis adopted for the analysis below is that the supply response of mining firms to demand shocks comes from price-taking firms. These firms might be perfectly competitive, part of a competitive fringe or even part of a Bertrand-type oligopoly.

3. The Business Cycle and Prices in Mining and Manufacturing

Mining and manufacturing are linked together through the use of mine products as raw materials in manufacturing. This means that shocks to one sector impact on the demand or supply conditions of the other. In particular, demand or supply shocks in the manufacturing sector that lead to changes in output levels or input substitution are reflected in demand shocks to the mining sector. Further, demand or supply shocks to the mining sector that lead to changes in mine output are reflected in supply shocks to the manufacturing sector.

Importantly, the transmission of shocks between mining and manufacturing occurs at the global level. For example, the substantial expansion of industrial production in China over recent years transmits a positive demand shock to the markets for mine products across the world, not just in China. The resulting rise in global prices of mine products appears as a negative supply shock to manufacturers worldwide, even though the initiating demand shock may have affected only a few countries.

Given the characterization of competition in manufacturing developed in Section 2.1 above, demand shocks have an ambiguous impact on prices. With marginal cost held constant, price varies with the ratio of price to marginal cost. Neither theory nor empirical evidence provides a clear indication as to whether the price-cost margin responds positively or negatively to demand shocks.[8] Thus, it is reasonable to treat manufacturing price as generally insensitive to demand shocks.

[8] The theoretical arguments and evidence on cyclical movements in the price-cost margin are reviewed in Bloch and Olive (2001). The evidence presented there suggests that in US manufacturing the price-cost margin is insensitive to demand in low concentration industries and somewhat counter-cyclical in high concentration industries. However, Bloch and Olive (2003) find that across four major industrial economics, the US, UK, Japan and Germany, demand has a positive impact on the price-cost margin, especially in high concentration industries. Other evidence on cyclical variation in price-cost margins is similarly mixed.

With price in manufacturing insensitive to demand shocks, fluctuations in price reflect the impact of supply shocks. Indeed, if the price-cost margin is constant, the impact of a supply shock on price is equal to its impact on marginal cost. These impacts can be localized if the supply shocks are specific to a particular industry and/or country.[9] Alternatively, domestic prices may be affected by supply shocks that reflect changes in technology generally available to producers (for example, new capital goods) or worldwide changes in the prices of inputs, including mine products. Thus, domestic price movements for manufacturing products may reflect either domestic or global influences.

Supply shocks to individual mining operations will be reflected in changes in the quantity produced at given prices of mine products. This implies that an impact on world markets for mine products will depend on the mine operation being of substantial size or there being many operations affected by the same shock. The latter may occur where mine operations are heavily concentrated in a particular region and shocks involve factors that affect all firms, such as weather, labour strikes or political unrest. Also, shocks associated with technology or prices of purchased inputs, such as energy, might be expected to noticeably impact on world prices. However, many supply shocks will be idiosyncratic to isolated operations and would be expected to only minimally impact either domestic or global prices.

If, as suggested in Section 2.2 above, incremental supply of mine products comes from mining firms behaving as price-takers, demand shocks can significantly affect quantities produced only through their influence on world market prices. With the main use of mine products as raw materials for industry, fluctuations in world industrial production are an obvious source of demand shocks that would be of sufficient magnitude to have noticeable impact on mining prices. Further, to the extent that the fluctuations in industrial production are manifestations of the world business cycle, there will be corresponding demand shocks to mining that lead to pro-cyclical movements in prices of mine products. Thus, movements in both domestic and global prices of mine products are expected to reflect the impact of the world business cycle.

Figure 1 shows price indexes for mining and manufacturing in Australia for the period 1968-69 through 2006-7, along with the ratio of the two price indexes, also expressed as an index number. Corresponding indexes are shown in Figure 2 for Canada for the period from 1957 through 2007. The indexes are annual data for the available series with the broadest possible grouping of products in each sector. Details of the composition and sources for the data are provided in the Data Appendix.

Our analysis suggests that prices in mining rise and fall with the ups and downs of the world business cycle, while manufacturing prices are relatively insensitive to either domestic or world business cycle influences. The pattern for Australia as shown in Figure 1 is that manufacturing prices increase continually, albeit at a rate that varies somewhat over the years. In contrast, mining prices exhibit a high degree of volatility, particularly in recent years. The pattern of prices in Figure 2 for Canada exhibits similar characteristics.

[9] Bloch and Olive (2003) examine the determinants of manufacturing prices in 24 industries across the US, UK, Japan and Germany and find that there is a positive impact of direct variable costs on prices across all industries and all countries.

Figure 1 - Price Indexes for Mining and Manufacturing - Australia

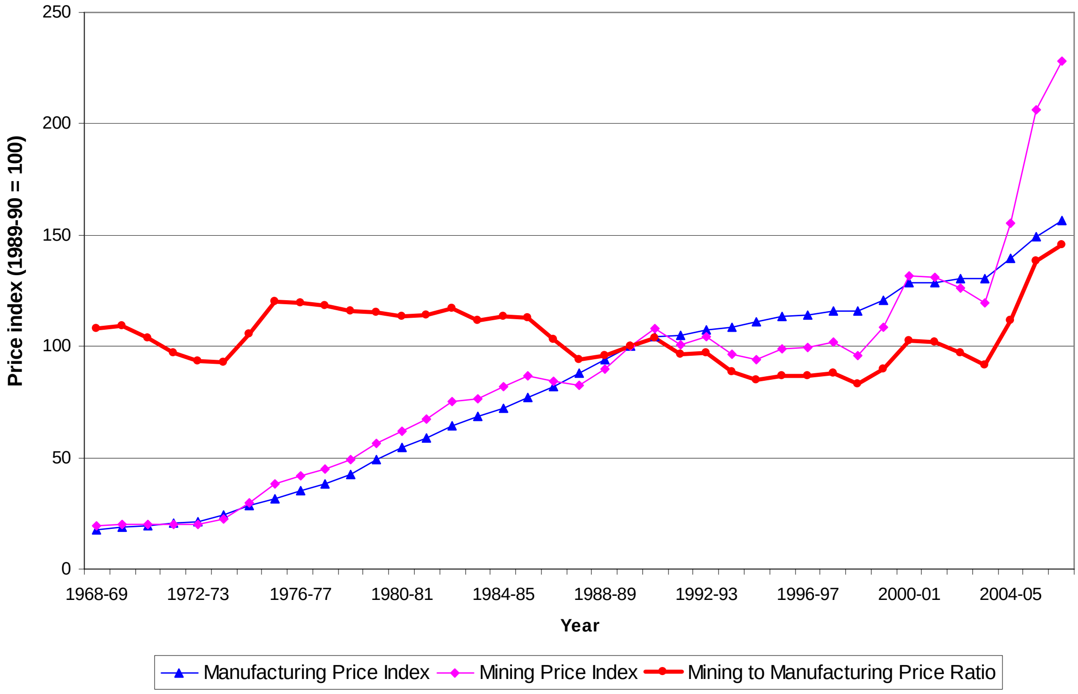
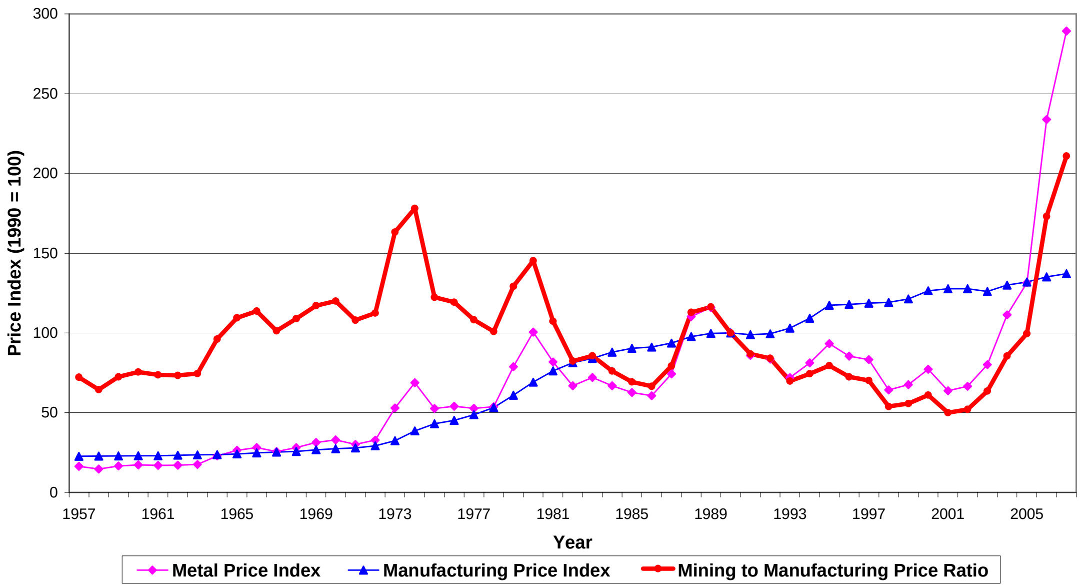


Figure 2 - Price Indexes for Mining and Manufacturing - Canada



The ratio of mining prices to manufacturing prices within a country serves as a particular useful indicator of world business cycle impacts, as it minimizes the influence of country-specific influences that affect both manufacturing and mining prices, especially changes in foreign exchange rates. For both Australia and Canada there are two periods of high values for the price ratio as shown in Figures 1 and 2, respectively. The first is from the mid 1970s through the early 1980s (with a dip between 1975 and 1981 that is more pronounced in Canada than in Australia) and the second in the last few years, especially since 2003. These reflect the cumulative impact of periods of sustained above average growth in world industrial production leading up to the two major commodity price booms of the last half century.[10]

In between the two booms, the period from the early 1980s through early into the current century is one of depressed values of the price ratio in both countries, with a recovery in common in the late 1980s, for Canada alone at the end of the 1970s and for Australia, and to a slight extent Canada, at the end of the 1990s. The low values of the price ratio reflect relatively sluggish growth in the world economy with incipient booms punctuated by the stock market crash of 1987 and the combination of the Asian financial crisis of 1997 and the terrorist attacks on the US in 2001. The 1990s were particularly negative for the price ratio as world industrial growth was particularly sluggish prior to the China boom.

4. Cyclical Movements in Productivity

4.1 Costs and productivity

In this section the analysis of the impact of the business cycle is extended from prices to productivity, again building on the differences in competition identified in Section 2. Productivity measures reflect the amount of output produced relative to the input used in production. The simplest measure is the ratio of output to input when there is only a single input used in production of a single output or when a single output and input are isolated from other inputs and outputs in a partial productivity measure, such as in measures of labour productivity. Broader measures of productivity, such as in indexes of multi-factor productivity, measure the ratio of an index of multiple outputs to an index of multiple inputs utilized in production.

The analysis in Section 2 focuses on costs rather than directly on productivity. However, productivity is inversely related to cost per unit of output. If input prices are held constant, a productivity rise of say ten percent should be reflected in requiring ten percent less input per unit of output and the average cost associated with those inputs would fall by ten percent. The formal relationship is conveniently expressed as

$$MFP_t / MFP_0 = [AC_0 / w_0]/[AC_t / w_t] \qquad (1)$$

In (1) MFP is an index of multi-factor productivity. AC is a measure of the unit cost for inputs used in producing the outputs included in the MFP index and w is an appropriately weighted index of prices of the inputs.[11] Thus, multi-factor productivity is inversely related to the appropriately deflated average cost.

In the analysis of the conditions of competition in manufacturing (Section 2.1), theory and evidence suggest that manufacturing firms are generally operating with

[10] Bloch and Sapsford (2000) estimate that a World Bank index of non-fuel commodity prices rises by about one and a half percent for every one percent rise in the IMF index of world manufacturing production.
[11] If there is only a single input to production, the input price index is replaced by the price of the single input.

unexploited economies of scale on the downward sloping portion of their average cost curves. This means that demand shocks can be expected to lead to pro-cyclical movements in output and countercyclical movements in deflated average cost. From (1), demand shocks are then expected to lead to pro-cyclical movements in multi-factor productivity in manufacturing.[12]

In the analysis of the conditions of competition in mining (Section 2.2), marginal supply of mine products is taken to come from price-taker firms. Demand shocks then lead to pro-cyclical movements in output, price and marginal cost. The movement in average cost and productivity depends on the stage of the business cycle. At the bottom of the cycle, price and marginal cost will be below average cost and a rise in output will lead to falling average cost and rising productivity. At the top of the cycle, price will be above average cost and the reverse relationships occur. Thus, demand shocks have a non-linear relationship to productivity, with productivity moving in a pro-cyclical manner during the low part of the cycle and a counter-cyclical manner during the high part.[13]

4.2 Productivity movements in Australia and Canada

Figure 3 shows the path over time for multi-factor productivity (MFP) for both the manufacturing and mining sectors in Australia from 1968-69 to 2006-7 along with the ratio of prices in mining and manufacturing, while Figure 4 shows the corresponding data for Canada for the period 1961 through 2006. The MFP values are shown on an inverted right-hand scale to reflect the inverse relationship between productivity and average cost as indicated in (1). The length of the period in each country is dictated by the availability from government agencies of sectoral estimates of multi-factor productivity. Details of the data and sources are given in the Data Appendix.

Figure 3 shows that MFP in manufacturing in Australia generally increases over time (shown by a decrease over time in the inverted MFP measure). There is clearly trend growth in MFP over the almost four decades covered. However, there are notable exceptions to the trend, namely the decade from the early 1980s to the early 1990s, when MFP plateaus with a pronounced dip in 1988-89, and the period since 2003-4. The decade of the early 1980s to early 1990s was one of sluggish growth in manufacturing production, due to a relatively depressed domestic economy (negative monetary and fiscal policy shocks applied to bring down domestic inflation), especially following the stock market crash of late 1987 (negative financial market shock). The period since 2003-4 has been buoyant for the domestic economy generally. However, the manufacturing sector has been sluggish due to the positive shock to the terms of trade and corresponding appreciation of the Australian dollar, which is a negative shock for manufactured exports and for manufactured goods that compete with imports.

[12] The pro-cyclical movement of aggregate productivity in industrialized countries is a stylized fact of macroeconomics according to Basu and Fernald (2001) and they point to expansion of durable goods manufacturing as particularly important in explaining this cyclicality.
[13] If mining firms earn zero economic profit on average, there should be equal periods of pro-cyclical and counter-cyclical relationships to demand shocks.

Figure 3 - Ratio of Price Indexes and MFP for Mining and Manufacturing - Australia

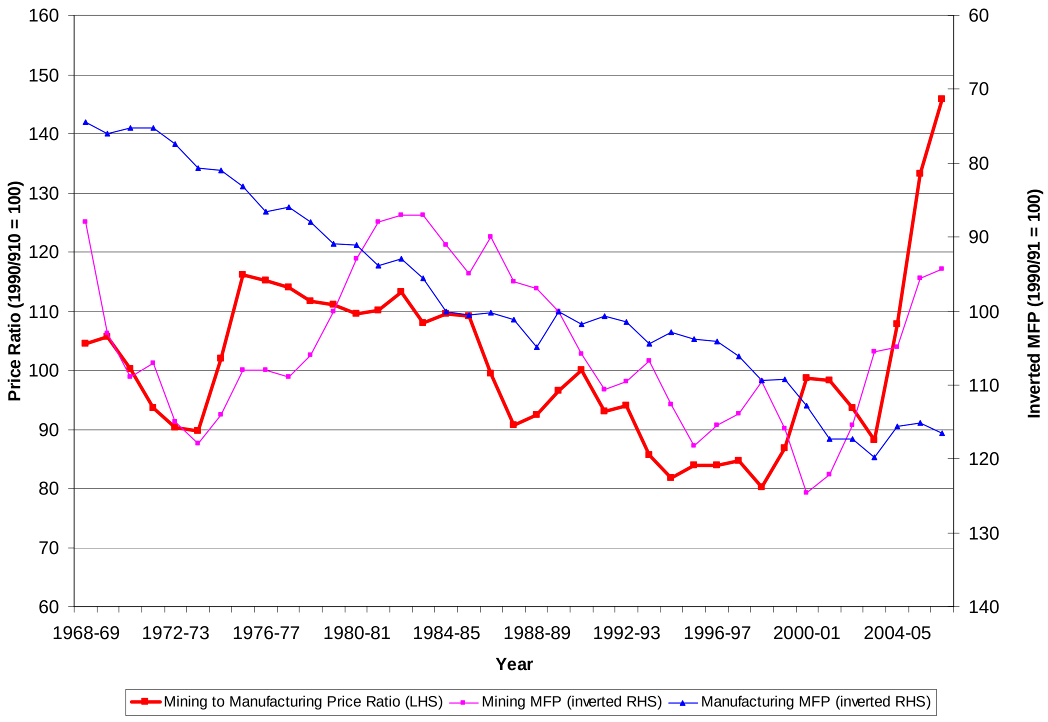
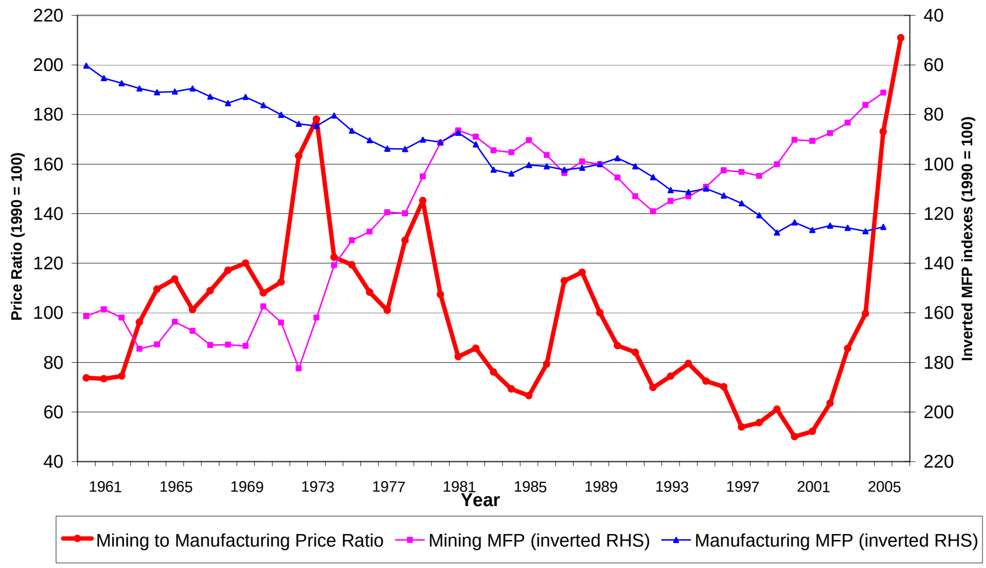


Figure 4 - Ratio of Price Indexes and MFP for Mining and Manufacturing - Canada



The pattern of MFP movements for manufacturing in Canada is similar to that in Australia, except that the two episodes of negative or nil MFP growth both started earlier in Canada, 1979 for the first episode and 2001 for the second. Also, there was a sub-period of growth in MFP from 1982 to 1985 in the midst of the 1979 to 1991 run of negative or nil growth. The earlier start to the latest period of MFP stagnation can be tied to the negative shock of the 9/11/2001 terrorist attacks on the US, as the Canadian economy is so closely tied to the American economy. However, the overriding influence in Canada, as in Australia, is the impact of a positive shock in the terms of trade pushing up the local currency and negatively impacting on domestic manufacturers who export or compete with imports. The earlier start to the first episode may reflect a quicker use of monetary and fiscal policy to deal with rising inflation, with the interruption from 1982 to 1985 reflecting a softening in the policy regime.

The pattern of movements in manufacturing MFP in both Australia and Canada fit the hypothesis that domestic demand shocks lead to pro-cyclical MFP movements around a long-run trend of MFP growth.[14] At least negative deviations from trend MFP growth can be related to negative domestic demand shocks. Further, the somewhat different timing of the deviations between Australia and Canada corresponds with the special circumstances of each country, while the overall similarity in pattern reflects the common external influences on both economies, especially their common role as exporters of primary commodities.[15]

Figure 3 shows that productivity in mining is characterized by substantial volatility in Australia, while a similar picture is given for Canada in Figure 4. Further the patterns are similar, with productivity experiencing substantial declines from the mid 1970s through the early 1980s (shown by upward movement for the inverted productivity measure in the figures), followed by improvements from the early 1980s through the mid 1990s and then declining again from around 2000 onwards. The similarity in pattern suggests a common causal factor and one that has general impact across different sub-sectors of mining so that the similar pattern occurs in spite of the different mix of mining activity in the two countries.

The analysis in Section 3 identifies the world business cycle as the common causal factor behind movements in mining prices relative to manufacturing prices in both Australia and Canada. Further, in Section 4.1 above, it is noted that during booms, when mining prices are above average cost, productivity moves counter-cyclically with demand shocks, while during substantial slumps, when prices are below average cost, mining productivity moves pro-cyclically.

Based on the ratio of mining to manufacturing prices, there are two boom periods shown in Figures 3 and 4. They are the mid 1970s through the early 1980s and the last few years, especially since 2003-04. Mining productivity declined substantially in both Australia and Canada during both booms. Declining productivity fits with the expectation that positive demand shocks decrease productivity during booms. However, the positive demand shock in the first boom arguably had abated well before 1983, when the first signs of improvement in mining productivity occurred in

[14] Kaldor (1967) attributes a positive relationship between output growth and productivity growth in manufacturing to the existence of increasing returns to scale. This is broadly consistent with our interpretation. However, our analysis is based on long-run equilibrium with unexploited economies of scale existing for manufacturing firms with substantial fixed costs. Expansion of the market might result in an increased number of firms or increased expenditures on sunk costs to prevent entry. In such circumstances, the increase in productivity following a demand shock might only be temporary.

[15] See Bloch, et al (2006) for a comparative analysis of the impact of the world primary commodity price cycle on the exchange rate and inflation rate in Australia and Canada.

either country. One possible explanation is that productivity movements lag demand shocks due to the generally long gestation period for mining projects.[16]

The ratio of mining prices to manufacturing prices is clearly below average during the 1990s in both Australia and Canada, indicating sluggish world business conditions. During this decade, the price ratio and productivity generally move in opposite directions, perhaps more clearly in Figure 3 for Australia than in Figure 4 for Canada. As the productivity scale is inverted, this implies pro-cyclical movements in productivity when the depressed price ratio is taken as the indicator that price is below average cost in for mining firms. This pattern fits the expectation that mining productivity is pro-cyclical when business conditions are sluggish.

5. Conclusions and Implications

The analysis presented above indicates a dichotomy in the conditions of competition between mining and manufacturing. Long-run equilibrium in manufacturing occurs with firms having price greater than marginal cost and unexploited economies of scale. Further, competition is expected to be at least partially localized to the domestic economy. In mining, at least some firms operate as price-takers and supply output up to a point where marginal cost equals price in the long run and competition is global.

As a result of the dichotomy, prices in mining are expected to rise and fall pro-cyclically with the world business cycle, while manufacturing prices are not expected to be much affected by either the domestic or world business cycle. Further, productivity in mining is expected to have a non-linear relation with the world business cycle, moving pro-cyclically near the bottom of the cycle and counter-cyclically near the top of the cycle. In contrast, manufacturing productivity is expected to be pro-cyclical with domestic business cycles regardless of the phase of the cycle.

Data from Australia and Canada are used to illustrate the cyclical movements in prices and productivity. In each country, the price of mine products is found to move directly with the world business cycle, while manufacturing prices have no clear relationship to either domestic or global business conditions. As a result, the ratio of the price of mine products to manufactures is pro-cyclical with global economic conditions. Multi-factor productivity in the manufacturing sectors of both Australia and Canada appears to move pro-cyclically with domestic economic conditions. Productivity in the mining sector is clearly counter-cyclical with world economic conditions during the high part of the business cycle, but appears pro-cyclical when world industrial production is below trend growth.

The cyclical movements in prices and productivity have important implications for countries such as Australia and Canada, which are substantial exporters of mine products and have substantial manufacturing sectors. The opposing cyclical movements in productivity for mining and manufacturing during booms are at least partially offsetting, meaning that the cyclical behaviour of aggregate productivity will

[16] If this explanation holds for the current boom, the implication is that declining productivity in mining can be expected to continue for some years to come. There is not yet clear evidence of dissipation of the positive demand shock due to rapid growth in China, India, Brazil and Russia.

diverge from the positive reaction to demand shocks that is expected for industrialized countries without large mining sectors. More importantly, the cyclical movement of relative prices of mine products and manufactures creates pressures to reallocate resources in the domestic economy, which leads to difficulties for domestic policy makers trying to use monetary and fiscal instruments to control inflation and unemployment.

For the world economy, the pro-cyclical movement in mine product prices leads to a cyclical pattern for the terms of trade, favouring countries exporting mining products in boom times, and importing countries in downturns. This creates imbalances in trade flows and capital accounts. Further, the structural imbalance caused by changes in the terms of trade contributes to global inflationary pressures during worldwide booms (see Bloch, et al, 2007).

Understanding the impact of demand shocks on productivity is also important for interpreting long-run trends in resource exhaustion. The recent drop in mining productivity is illustrative. The pattern shown in Figures 3 and 4 suggests this is a counter-cyclical reaction to a period of abnormally high growth in world industrial production stimulated by the unexpected growth in China, India, Russia and Brazil. On this interpretation, productivity will recover (and mine product prices decline relative to prices of manufactures) once the positive demand shock abates. Alternatively, the fall in productivity (and increase in relative price) could be interpreted as a sign of the adverse effect of depletion of mining resources, with the implication that relative price increase is permanent. While some commentators seem convinced of the latter interpretation, historical experience for Australia and Canada over the past half century is more consistent with the former.

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Data Appendix

Australia

Prices (1968/69 – 2005/06)

Mining

Derived aggregate output price index for 8 mining sectors produced by the Productivity Commission in reply to a special request for data. The 8 sectors are coal mining, oil and gas extraction, iron ore mining, other metal ores (including bauxite), copper ore mining, mineral sand mining, and silver-lead-zinc ore mining. Base year – aligned with manufacturing to 1989/90 = 100.

Manufacturing

ABS Cat. 6427.0 Producer Price Indexes, Australia, Index numbers – manufacturing division. Quarterly data adjusted to annual fiscal year. Base year 1989/90 = 100.

The resulting price index is a ratio of Mining/Manufacturing.

Productivity (1968/69 – 2006/07)

Mining

Productivity Commission 1999, 'Statistical Annex to Supplement to Inquiry Report: Modelling the Regional Impacts of National Competition Policy Reforms', *Impact of Competition Policy Reforms on Rural and Regional Australia*, Canberra, September.

Table B.10. Index of total factor productivity growth by mining industry, 1968/69 to 1989/90 (1989/90 = 100). Index for total mining is estimated by aggregating the output weighted measures of productivity growth by industry. Average relative output weights are adopted.

This series is combined with the following:

ABS Cat. 5260.0.55.002 Experimental Estimates of Industry Multifactor Productivity. Table 1 - Gross Value Added Based Multifactor Productivity indexes, Mining, 1989/90 to 2006/07 (Base year aligned with Table B.10) (1989/90 = 100).

Manufacturing

Productivity Commission, Manufacturing Industry Productivity Estimates (online) http://www.pc.gov.au/research/productivity/estimates-trends/manufacturing Multifactor Productivity, 1968/69 to 1989/90 (1989/90 = 100).

This series is combined with the following:

ABS Cat. 5260.0.55.002 Experimental Estimates of Industry Multifactor Productivity. Table 1 - Gross Value Added Based Multifactor Productivity indexes, Manufacturing, 1989/90 to 2006/07 (Base year aligned with Productivity Commission estimates (1989/90 = 100).

Canada

Prices (1961 – 2007)

Mining

Natural Resources Canada. Metal Price Index (1997 = 100) based on prices and volumes of six minerals – copper, nickel, zinc, lead, gold and silver (domestic production only) developed by Natural Resources Canada. Special request made on 17/4/2008, 1961 – 2007. Online http://www.nrcan.gc.ca/mms/hm_e.htm.
(Base year aligned with productivity indices, 2002 = 100).

Manufacturing

Statistics Canada, v3822562, Table 329-0038: Industry price indexes, by NAICS; Canada; All manufacturing (index, 1997=100) [P6253].
(Base year aligned with productivity indices, 2002 = 100).

The resulting price index is a ratio of Mining/Manufacturing.

Productivity (1961 - 2006)

Mining

Statistics Canada, v41712883, Table 383-0021: Multifactor productivity in the aggregate business sector and major sub-sectors; Canada; Multifactor productivity; Mining and oil and gas extraction [21] (index, 2002=100).

Manufacturing

Statistics Canada, v41712886, Table 383-0021: Multifactor productivity in the aggregate business sector and major sub-sectors; Canada; Multifactor productivity; Manufacturing [31-33] (index, 2002=100).