Relative Price Movements and Labour Productivity in Canada: A VAR Analysis

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Abstract:
Over the recent years, the Canadian economy has been marked by a strong improvement in terms of trade brought about by a surge in energy and commodity prices, with significant implications for the exchange rate and the allocation of resources across Canadian sectors and regions. While the energy and mining industries and sectors with low exposure to international trade have benefited from these shocks, the pressure on the manufacturing sector has intensified as many manufacturers were already dealing with growing competition from China. The adjustments undertaken within the Canadian economy are readily noticeable through investment decisions, as well as through production and employment reallocation. Using VAR techniques, the aim of this paper is to broaden the analytical Corden and Neary (1982) framework, and examine how the relative price shocks described above and subsequent reallocation of resources across sectors will affect the (aggregate and sectoral) labour productivity growth in Canada. Results suggest that the impact of a positive relative price shock will in the adjustment process lower productivity growth in the primary and the non-tradable sectors, increase it somewhat in the manufacturing sector. The overall impact appears to be slightly negative on aggregate labour productivity growth although it is not statistically significant.

The views expressed in this paper are those of the authors.
No responsibility for them should be attributed to the Bank of Canada.
1. Introduction

Over the recent years, the Canadian economy has experienced strong improvements in the terms of trade. Terms of trade, defined as the ratio of export prices relative to import prices, have changed largely in response to the surge in energy prices. Contributing to the rise in energy prices was the robustness of growth in the global economy, increased demand from emerging-market countries such as China, the apparent bottlenecks in supply, and a series of geopolitical quandaries. Driven by the strong world demand, non-energy commodity prices also contributed to the improvement in the terms of trade since Canada is a net exporter of these products.

These changes in the terms of trade have had significant implications for the exchange rate and the allocation of resources across sectors and regions. After reaching its lowest level in January 2002, the Canadian dollar has appreciated 46% over the last five years. This exchange rate shock, combined with the energy price shock, have lead to major adjustments in the Canadian economy. While the energy and mining industries and sectors with low exposure to international trade have benefited from these shocks, the pressure on the manufacturing sector have intensified as many manufacturers were already dealing with growing competition from China. The adjustments undertaken within the Canadian economy are readily noticeable through investment decisions and shifts in employment, with related effect on sector and aggregate productivity growth.

The aim of this research project is to examine how the relative price shocks described above and the reallocation of resources across sectors will affect the aggregate labour productivity in Canada. The Bank of Canada is interested in productivity growth as it is a key determinant of potential output growth, and therefore instrumental to monetary policy decisions. Since various economic sectors may be affected differently by relative price shocks - some adversely and others positively – the effect on labour productivity growth will likely vary between sectors, depending on the required adjustments. In such an environment, examining productivity by sector is key to better understand the aggregate.

The paper is organized as follows. In the next section we describe the 3-sector model developed by Corden and Neary (1982). It represents a good starting point to analyze the current adjustments in the Canadian economy. The literature review is pursued with some extensions. In section 3, we present an analysis of the data where output and employment flows are weighed against the prediction of the 3-sector model presented in section 2, and we introduce some insight regarding sectoral productivity. Section 4, briefly describes the proposed empirical approach and describes the results. Some concluding remarks follow in section 5.

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1 The authors would like to thank Frédérick Demers, Richard Dion, Sharon Kozicki, Thérèse Laflèche and Danny Leung for their comments and Étienne Gaudette for his research assistance.

2 Canadian terms of trade improved by 20% between 2002 and 2007.

3 See for example remarks by Pierre Duguay to the Canadian Association for Business Economics, entitled « Productivity, Terms of Trade, and Economic Adjustment. », 28 August 2006.
2. Literature Review

2.1 Description of Corden and Neary (1982) 3-sector model

The seminal work of Corden and Neary (1982) and Corden (1984) on booming sector suggests that an important relative price movement will trigger important reallocation of resources amongst the sectors of an economy.\(^4\) Corden’s **Core model** depicts three sectors, the booming sector (B), the lagging sector (L) and the non-tradable sector (N). The first two sectors are price takers producing tradables. Output in each sector is produced by sector specific capital and non-sector specific labour, which is mobile between all three sectors in order to equalize wages between sectors.

According to Corden and Neary’s work, a boom can be brought about by a one-time technical improvement in a specific sector, a windfall discovery of new resources, or a rise in the price of the sector’s particular product on the world market. In the case where the boom is brought about by a run up in oil prices for example, the newfound revenues of the oil sector (the booming sector) will trickle down to the non-tradable (N) sector. Then, increased demand for goods and services produced in the N sector will lead to price increases in non-tradable relative to the price of tradables. This implies real appreciation of the national currency (as defined by the ratio of non-tradable prices to tradable prices) and will trigger resources reallocation from the booming and lagging sectors to the non-tradable sector.\(^5\) This phenomenon is what Corden and Neary (1982) call the **Spending Effect.**

In addition, as a result of the boom, the marginal product of and demand for labour rises in B, inducing movement of labour out of L and out of N. This is what Corden (1984) calls the **Resource Movement Effect.** This phenomenon has two parts.

1. The movement of labour out of L into B lowers output in L. This can be called **direct de-industrialization** since it does not involve the market for N and thus does not require an appreciation of the real exchange rate.
2. There is also a movement of labour out of N into B at constant real exchange rate which contracts the supply of N and creates excess demand in addition to that created by the **Spending Effect**, bringing about another round of real appreciation. This appreciation will lead to additional movement of labour out of L and into N, reinforcing the de-industrialization resulting from the spending effect. Hence, the spending and resource movement effects combine, leading to a movement of labour from L to N called **indirect de-industrialization.**

Hence, unambiguously, according to the Core model the output of L must decline and the output of B must rise following a boom in the energy sector triggered by a shock in relative prices. However, output of N could in the end be higher or lower than initially, as the spending effect tends to make it higher, and the resource movement effect lower.

Given that capital is not mobile within the Core model, the above conclusions can be considered as a good approximation of an economy’s short term responses to a given relative price movement. Once the relative price shock is considered to display a certain degree of persistence, it is possible

\(^4\) The Corden and Neary model was popularized as the “Dutch Disease” model.

\(^5\) This is not the net effect.
to relax a number of assumptions within the Core model and develop what Corden (1984) calls the **Paradox model**. In this model, capital is mobile between the two non-boom industries, L and N. These two sectors will therefore employ labour and capital in varying proportion with one industry being capital-intensive and the other labour-intensive. The Paradox model owes its name to the fact that at a constant real exchange rate the resource movement effect will cause the output of the capital-intensive industry to expand in accordance with Rybczynski (1955) theorem. Thus, if L is the capital-intensive industry, the economy will experience a *pro-industrialization* movement as a result of the resource movement effect. Hutchison (1994) actually shows that the economy of the Netherlands displayed very little systematic and long-run net adverse consequences of the natural gas development on the manufacturing sector, in fact, the volume of manufacturing output recovered quickly surpassing its pre-downturn high by close to 30% six years later. Evidently, this can be offset by the spending effect which would move both capital and labour out of L and into N through the real appreciation of the currency. It can also be shown that if N happens to be the capital-intensive industry in the Paradox model, the boom could cause a real depreciation.

Thus, when capital is allowed to move freely between two or more sectors, detailed knowledge of the relative sectoral factor intensity is crucial to determine, within Corden and Neary (1982)’s framework, the outcome of a relative price movement on sectoral prices, wages, employment and output. Although the results are more ambiguous within such a framework, the authors nevertheless conclude that their model offer a weak presumption in favour of de-industrialization, because the direct impact on output of the resource movement effect always tends to reduce the lagging sector’s output.

### 2.2 Applications and extensions

Corden and Neary do not bridge the gap between the expected movement in output and employment from a boom in the resource sector and productivity. However, an extension to their work in that direction is the two-sector model developed by van Wijnbergen (1984). van Wijnbergen introduces learning by doing induced by technological progress to the traded goods sector. According to this model, a decline in the traded goods sector, as described in the Corden and Neary framework, means less learning by doing which leads to lower productivity in the future, and thus may permanently lower income per capita.

Many researchers have noted the disappointing performance of resource-abundant economies in the 1970’s and 1980’s. They suggest, without testing their hypothesis, several economic and political factors such as trade policy, investment rates and the effectiveness of the bureaucracy, among others, that could explain the failure of resource-led growth. Sachs and Warner (1995) were the first to rely on econometric analysis to do so. Using cross-country growth equations described in Barro and Sala-i-Martin (1995), they show that resource abundance, measured as the share of primary exports, has adverse effects on growth. This result is robust to the inclusion of variables that control for the factors cited by the other studies as important in explaining cross-country growth.

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6 The assumption is made that the booming sector employs sector specific capital.

7 The real depreciation is brought about by the increase in output within the non-tradable sector which leads to a decline in the ratio of non-tradable to tradable prices.
Gylfason et al. (1999) develop a simple stochastic endogenous growth model with two sectors to analyze the symptoms of the Dutch Disease. The primary sector and the secondary sector have different types of production technology and, hence, different processes for productivity. In the secondary sector there is learning-by-training while no training is required in the primary sector. According to this model, a productive primary sector leads to an appreciation of the exchange rate which makes it difficult for other potential export industries to prosper. This result is very similar to the implications derived from the model developed by van Wijnbergen (1984), where resource abundance shifts factors of production away from sectors generating learning by doing (human capital accumulation). Gylfason et al. (1999) extends their work to the empirical analysis. Using cross sectional and panel regressions based on data for 125 countries in the period 1960-1992, they confirm Sachs and Warner (1995)'s results by finding a statistically significant inverse relationship between the size of the primary sector and economic growth.

2.3 Labour reallocation, adjustment costs, and productivity

Very little has been said until now on the effects of the terms of trade shock on productivity. The main result of the Corden and Neary (1982) model described previously is that there is a resource reallocation across economic sectors, but the implications for productivity are not derived. There seems to be two types of effects on productivity: i) an accounting effect and ii) the effect of adjustment costs.

In the first case, aggregate productivity level might change following labour reallocation because workers move to sectors with different productivity levels. In other words, some of the movements in aggregate productivity, measured as a weighted average of sectoral productivities, simply result from a change in the sectoral composition. For example, as implied by equation 1 in Faruqui et al. (2003), aggregate productivity growth might increase if workers are moving towards high productivity level sectors even though productivity growth is negative for all sectors.

In terms of the effect of adjustment costs, there is a consensus in the literature regarding the existence of these costs which might reduce productivity. For example, Hamermesh and Pfann (1996), Gaisford and Leger (2000), and Bernstein, Mamuneas and Pashardes (2004) all agree that intersectoral labor transfers lead to some disruption of regular work both in declining and expanding sectors. In the former, remaining workers have to take over unfamiliar tasks when colleagues leave, and the work has to be reorganized while in the latter, new workers have to be trained. Even the experienced workers in the expanding sectors will see their productivity declining since they will have to contribute to the integration of new employees. The overall effect of such adjustment costs on aggregate productivity will depend on their size and their persistence. These costs are very difficult to measure and, although some have included adjustment costs in general equilibrium models, there is no indication about how long it takes to reach the efficient pace of production after a period of reallocation.
3. Canadian Stylized Facts

3.1 Relative price movements and sector adjustments

Responding to buoyant growth in world economic activity, commodity prices started their ascent late in 2001 and rose nearly 130% in the 22 quarters ending in 2007Q2 (see Graph 1). Given Canada’s position as a net exporter of base commodities, increased world demand for our products translated into real appreciation of the Canadian dollar. From an historical low of 62.7 US cents reached in 2002Q1, the Canadian dollar appreciated over 50% in value, trading at 94.9 US cents by 2007Q3 (see Graph 2). The change in relative prices that ensued triggered structural adjustments or Resource Movements within the Canadian economy.

Graph 1: Commodity Prices ($US terms)        Graph 2: Canada-US Bilateral Exchange Rate

First, the relative price change led to a rapid expansion in the mineral, oil, and gas extraction industries. In the eight quarters following 2001Q4 price shock, real GDP in the sector rose by 15% to just over $40 billion, while investment jumped 30% between 2001 and 2005 based on the Statistics Canada Public and Private Investment Survey. Employment in the sector increased by some 35% over the period 2001Q4 – 2007Q2 and labour shortages quickly became apparent, particularly in Alberta where wages increased sharply – on average by 6.7% annually between 2004 and 2006 compared to the national average of 3.3% (see Chart 3). To take advantage of the buoyant Alberta labour market and to help alleviate pressures on production capacities, net inter-provincial migration to Alberta accrued to 100,000 people between 2002 and 2005, with Saskatchewan, Ontario and British Columbia being the source of more than 60% of net inter-provincial migrants. Worth noting is the fact that net migration from manufacturing Central Canada is nowhere near the peak reached in the early 1980’s following the oil shocks of 1973 and 1979,

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8 Unless otherwise specified, all figures presented in this section are at annual rate.
9 It is clear that the rise in commodity prices is not the sole reason behind the appreciation of the Canadian dollar; other factors such as the depreciation of the US dollar are at play.
10 Structural adjustments are clearly multifaceted and given the geographical concentration of the different Canadian industries, the adjustments currently undergoing by the economy also features important regional aspects that will be discussed throughout the paper.
11 Based on the labour force survey, wages of employees by job permanence union coverage sex and age group, average hourly wage rate, Statistics Canada.
which suggests that direct de-industrialization (labour employed in the lagging manufacturing sector moving to the booming oil sector) remains a contained phenomenon in Canada at this point.\textsuperscript{12}

![Chart 3: Average Hourly Wage Growth by Province – Labour Force Survey Estimates](image)

Although one cannot deny the power of attraction vested upon the Alberta economy, wage pressure spillover to other parts of the country appears to be contained, as can be seen from Chart 3. While wages have been growing at 6.7\% (annual average) in Alberta over the 2004-2006 period, the next two provinces which experienced the biggest wage gains were Nova Scotia and Saskatchewan where wages grew over the period near the Canadian average of 3.3\%. On a sectoral basis, wage growth in the mineral, oil, and gas extraction sector has reached a pace of 4.4\% (annual average) per year in 2004-2006 compared to an annual average of 2.3\% over the 1991 – 2003 period (see Chart 4).\textsuperscript{13} Although wage growth has also accelerated in the construction and services producing sector in the last three years, it nevertheless remains contained at a pace between 2.5 and 3.0\%. A fair assessment of the data at this point suggests that wage pressures are contained within Alberta and/or within the mineral, oil, and gas extraction industries.

As expected from Corden and Neary’s theoretical framework, new income and wealth from the mineral, oil, and gas extraction industries fed demand for non-tradables.\textsuperscript{14} Indeed, over the 2001Q4 – 2007Q2 period, output in the non-tradable sector has increased by 21.0\%, while

\textsuperscript{12} While the current spike in energy prices is mostly believed to be driven by buoyant global demand, the 1970’s energy price shocks were the result of supply constraints that led to a generalized economic slowdown. High unemployment throughout the Canadian economy therefore created the incentive for Central and Eastern Canada labourers to move to Western provinces to acquire a job in the vibrant energy sector. This is not the case in Central Canada today were final domestic demand remains strong.

\textsuperscript{13} Based on average weekly earnings (SEPH) seasonally adjusted for all employees by selected industries (NAICS), Statistics Canada Table 281-0028.

\textsuperscript{14} This sector includes all services and construction.
employment progressed by 14.7%. Gains have been particularly important in the construction sector, FIRE, wholesale and retail trade, as well as the health services sector. Although resource reallocation has been important over the recent period, as revealed by recent population movements, shift in the labour markets and investment flows, the evidence suggests that the Spending Effect, as defined by Corden and Neary, is more important than the Resource Movement Effect in the Canadian economy at this point.15

Chart 4: Average Weekly Wage Growth for Selected Sector
(average annual growth rate)

Over the recent period, the manufacturing sector faced rapid appreciation of the Canadian dollar, in addition to increased competition from Asian countries, especially China. From its peak reached in 2000, employment in the Lagging sector had declined some 12.5% by the mid-2007. Manufacturing output managed to grow on average by 0.7% a year over the last 3-year period, a much slower pace than the 6.3% annual average posted over the 1996-2001 period. In line with these developments, wages in the manufacturing sector have continued to grow, over the recent period, close to the decade long average of 2.3%. The level of investment in the sector has declined substantially since its peak reached in 2000, while growth rates which averaged 4.5% over the 1991-2000 period slowed down markedly to 0.2% over the 2001-2005 period. Evidence suggests that the slowdown has been more important in the segments with high exposure to the international trade. On a regional basis, it would appear that the manufacturing sector has fared somewhat better outside Central Canada, particularly in Alberta, Manitoba and New Brunswick, where employment has recently recaptured 2004 levels. A lesser degree of exposure to international competition and trade, proximity from primary sector wealth and a distinct manufacturing sector structure where production is intended for the extraction industries may have in part cushioned the blow from the rapid change in relative prices. Nevertheless, 74% of the Canadian manufacturing sector operates out of Quebec or Ontario where the spillover from the Spending Effect is of lesser magnitude.16

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15 Recall that the spending effect tends to increase the production of non-tradables while the resource movement effect tends to lower it.

16 It is interesting to note that the share of Central Canada in Canadian manufacturing sector declined from 77% to 74% over the last two years.
All things considered, the sectors of the Canadian economy are currently experiencing the theory-predicted adjustments with related effects at the regional level. As the Paradox model suggests, if the energy sector uses relatively few resources that can be drawn from elsewhere in the economy the resource movement effect will be negligible and the major impact of the boom will come through the spending effect. In other words, there will be very little direct de-industrialization, only indirect de-industrialization brought about by real appreciation of the currency. This appears to be the case within the Canadian economy. For example, the manufacturing sector has shed 150,000 jobs since the beginning of this episode, while the mineral, oil and gas extraction industry has gained 45,000 new jobs. Considering the skills set required to fill primary sector jobs, general population movements and shifts in sectoral employment, it appears unlikely that the bulk of the new jobs in the mineral, oil and gas extraction industry have been filled by workers moving out of the Ontario/Quebec manufacturing sector. In addition, given sectoral and regional trends in wages, which have been increasing in the primary sector and that throughout Canada, it is more likely that these positions were filled by Eastern Canadians, particularly Newfoundlanders with working experience in the primary sector. Other evidences supporting this view is that Alberta firms are courting Atlantic Canadian workers through a recrudescence of job fairs, while Albertan authorities are trying to partner-up Alberta firms with Central Canada firms in an effort to alleviate constraints on production capacities.

3.2 Recent and expected movements in labour productivity growth

Labour productivity growth in the booming sector has averaged 0.4% per annum over the 1997-2006 period. However, before the significant increase in commodity prices in 2001, productivity growth averaged 2.4% per year in that sector (1997-2001). Although productivity experienced rapid growth during the 2002 expansion (a little over 6% annually) the average annual productivity growth for the 2002-2006 period slumped to an average of -3.3% per year, as hours worked growth caught up (and overtook) output growth in the industry (see Graph 7). This caused labour productivity in the oil and mining sector to fall back to its 2001 level after having reached a

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17 Labour productivity is defined as output by hours worked.
18 Hours worked are only available for the forestry, fishing, and mineral, oil, and gas extraction industries, productivity in the booming sector is therefore proxied by this aggregate.
peak in mid-2003. The level of productivity is however still relatively high, largely due to the capital intensity of this industry which is among the highest in the economy.

In contrast, the relatively rapid decline in labour input has allowed the manufacturing sector to maintain its labour productivity. Over the 1997-2001 period productivity has averaged 2.2% per year and accelerated only slightly to 2.3% per year on average over the 2002-2006 period, as the rapid appreciation of the Canadian dollar and increased competition from Asian countries force the manufacturing sector to shed labour in search of efficiency gains. While the sector experienced a cycle downturn in 2001-2002 as the US economy went through a short economic slump, it nevertheless posted average productivity growth rate of 1.8% per year over the 1997-2006 period.

Productivity in the non-tradable sector averaged just below 2% in the last decade, with its strongest performance between 2001-2003, when growth in hours worked was minimal. Over the 2002-2006 period, labour productivity growth in the non-traded sector fell to an average of 1% per year, with hours worked growth accelerating considerably since 2002.

All these observations are in-line with anecdotal evidence which suggests that the lagging sector as a result of shedding least productive labour and firms will, at least in the short-run, increase labour productivity growth. This would be further accentuated by the increased capital-labour ratio in the sector resulting from decreased labour input and high investment rates due to relatively lower price of capital. While investment in construction has declined substantially in the manufacturing sector in response to the appreciation in the Canadian dollar, investment in machinery and equipment (M&E) has risen by an average of 5.7% per annum between 2002 and 2005 compared to an annual average of 4.7% over the 1991-2000 period. Conversely, due to substantial increases in labour input (and assuming diminishing marginal product of labour) and diminishing return on the available resources, labour productivity in the booming sector is expected to recede below that of its baseline growth rate, before returning to its long-run trend which should follow trends in technological growth. Lastly, the non-traded sector, subject to increased demand due to the
Spending Effect may also exhibit a slowdown in its productivity growth due to important resource reallocation effects. However, given the wide variety in the composition of the non-tradable sector, assumption about relative price movements effects on the sectors’ productivity are sketchy at best.

Nevertheless, one way to explain these cyclical movements in productivity is through the costs of adjustment theory. Broadly stated, adjustment costs will temporarily reduce output to the extent that productive resources are diverted to the process of job searching, hiring and retraining, and capital accumulation. Therefore, adjustment costs within an economy will dampen productivity growth for a time, before returning to its long-run trend, which should follow trends in technological growth, as adjustments unfold.

4. Empirical Analysis

4.1 Methodology

The econometric approach we follow is based on a vector autoregression (VAR) model. The usual structural VAR (SVAR) assumes the following general form:

\[ Ay_t = \Gamma_0 + \sum_{i=1}^{p} \Gamma_i y_{t-i} + \epsilon_t \]

where \( y_t \) is a \((n x 1)\) vector of endogenous variables, \( A \) is an invertible \((n x n)\) matrix of contemporaneous coefficient, \( \Gamma_0 \) is the \((n x 1)\) intercept vector, \( \Gamma_i \) is the \(i\)th \((n x n)\) matrix of autoregressive coefficients for \(i = 1, 2, ..., p\), and \( \epsilon_t \) is the \((n x 1)\) vector structural innovations.

The structural innovations \( \epsilon_t \) can then be recovered from the observed residuals \( \epsilon_t \) through the following relationship \( \epsilon_t = Ae_t \). However, given this estimation scheme, the structural model is underidentified and need to be restricted in order to be recovered from the reduced form. A number of methods can be applied to the system in order to achieve this goal. However, following Sims (1986) and Bernanke (1986), economic theory is applied to identify the underlying structural shocks from the reduced-form model. In other words, in this structural VAR approach the \( A \) matrix will be constrained on the basis of economic priors.

We explore two related specifications in order to determine the role of relative price movements on productivity. First, eliminating the sector issue brought forth by the literature cited above, we investigate the effect of relative price movements on aggregate productivity using a simple three-variable VAR which includes the U.S. GDP as a proxy for global activity \( y^{gw} \), the Canadian terms of trade as a measure of relative prices \( tot \), and aggregate labour productivity \( LP_{agg} \) - measured as the ratio of output to hours worked\(^\text{19} \). As exposed previously, we assume that changes in global activity, as proxied by U.S. GDP, will affect relative prices which in turn will trigger reallocation in output and employment, and therefore changes in labour productivity. Although the U.S. GDP may

\(^{19} \text{The analysis was also conducted using labour productivity measured as the ratio of output to employment. The results were similar.} \)
not be the best proxy for global activity in the recent past, as relative price movements have been mostly driven by increased Asian presence in global activity, it is often considered to be one of the most relevant measure in the Canadian context\(^{20}\), and certainly one of the most consistent over the sample period under investigation.\(^{21}\) Nevertheless, we robust-tested our framework with other proxies for global activity, such as the OECD world gap estimate and obtained comparable qualitative results. We choose to approximate relative prices with terms of trade (the ratio of export prices to import prices) despite similar results obtained with the real Canada-U.S. bilateral exchange rate (the ratio of non-tradable prices to tradable prices). One of the reasons behind this choice is given by the Balassa-Samuelson framework in which, according to theory, causality runs from productivity towards real-exchange rate and not the other way around. As we need to identify a causal relationship that runs from relative prices towards productivity, we thought that the use of terms of trade would help us circumvent this potential problem.

Therefore, in this particular VAR framework, we implicitly assume that output is a function of land, technology, capital, labour and other production material inputs, while the underlying choice of factor inputs (including labour) is assumed to be a function of relative factor prices. This being said, we do not explicitly model for the production function. What we are interested in is to identify a relative price shock that, through its influence on relative factor prices, will ultimately affect output, hours worked, and productivity.

Once the overall impact is estimated on aggregate productivity, a second model is built with sectoral labour productivity in place of aggregate labour productivity with the aim of identifying idiosyncratic responses of sector productivity to a movement in relative prices.\(^{22}\) We define our sector along the Corden and Neary (1982) framework. Hence, labour productivity growth will be partitioned between the primary or booming sector \((LP_{pri})\), manufacturing or lagging sector \((LP_{mfg})\) and the non-tradable sector \((LP_{nt})\) which leads us to construct a six-variable SVAR.

In the case of the three-variable SVAR we use economic theory to single out various interactions amongst the system variables. Once again, the growth in U.S. GDP is used as a proxy for global activity. Given the Canadian economy status of “small and open” it is easy to justify the exogenous character of U.S. GDP. In VAR language, this implies that the only structural innovation that should contemporaneously affect U.S. GDP growth is its own. In this sectoral framework, it is believed that a movement in the terms of trade can affect productivity growth through two main “channels”: the exchange rate (or spending effect), and the reallocation of resources across sector.\(^{23}\) For one, the currency appreciation, brought about by the improvement in terms of trade, lowers the relative price of capital and encourages the substitution of capital for labour which should

\(^{20}\) Recall that the Canadian economy exports some 40% of its production, 80% of which is going to the United States.

\(^{21}\) In addition, questions remain concerning the quality of Chinese and Indian data.

\(^{22}\) As a first step, we chose to look at the sectoral aspect (as opposed to the regional aspect) of the adjustment in order to be consistent with Corden and Neary’s 3-sector model. Data on productivity are often considered more reliable and informative at the sectoral level while regional data would probably not be very helpful in better understanding aggregate productivity since the differences in trend productivity growth are rather sectoral. The only comparative advantage of a regional analysis is the availability of inter-provincial migration data. No such data exists on inter-sectoral labour movements.

\(^{23}\) For a more formal discussion of the two « channels » see: Duguay, P. “Productivity, Terms of Trade, and Economic Adjustment,” Remarks before the Canadian Association for Business Economics, 28 August 2006.
contribute to higher labour productivity growth over time. In addition, the important reallocation of resources away from manufacturing toward the primary sector should raise the overall level of productivity, since productivity level tends to be higher in the more capital-intensive primary sector. However, the accompanying shift from tradables to non-tradables would tend to lower overall productivity, as the non-tradable sector tends to be less productive. The net effect is not clear from an analytical standpoint. In the VAR framework it means that we need to identify a structural terms of trade shock that would have a contemporaneous impact on productivity (sector or aggregate).  

In the case of the three-variable system, it appears that we can justify the Choleski decomposition on the basis of theory and identify thus, a structural terms of trade shock in the system. The following restrictions therefore will be applied to the contemporaneous innovations:

\[
\begin{bmatrix}
1 & 0 & 0 \\
0 & 1 & 0 \\
0 & 0 & 1
\end{bmatrix} \begin{bmatrix}
\epsilon_{i,t}^{\text{tot}} \\
\epsilon_{i,t}^{\text{pri}} \\
\epsilon_{i,t}^{\text{mfg}}
\end{bmatrix} = \begin{bmatrix}
\epsilon_{i,t}^{\text{man}} \\
\epsilon_{i,t}^{\text{tot}} \\
\epsilon_{i,t}^{\text{yus}}
\end{bmatrix}
\]

In the case of the five-variable SVAR, in addition to the theoretical restrictions put forth in the three-variable case, we need to investigate the contemporaneous relationship between sector productivity. Arguably, the relative price shock we are investigating is likely to hit primary sector productivity first, as increases in commodity prices should initially stimulate employment in this sector. Subsequently, productivity in the manufacturing sector should be affected as the currency appreciates and the competitive environment in the sector becomes more difficult triggering resources reallocation. Lastly, as productivity adjustments in the non-tradable sector are difficult to derive analytically, we are tempted to argue it should appear last in the ordering. The variance decomposition appears to agree with our pre-selected ordering, as 20% of the variance in the non-tradable sector productivity is explained by productivity in other sectors compared with 9% for manufacturing and 2% for primary. Hence, the following restrictions will be applied to the contemporaneous innovations in the sector productivity model:

\[
\begin{bmatrix}
1 & 0 & 0 & 0 & 0 \\
0 & 1 & 0 & 0 & 0 \\
0 & 0 & 1 & 0 & 0 \\
0 & 0 & 0 & 1 & 0 \\
0 & 0 & 0 & 0 & 1
\end{bmatrix} \begin{bmatrix}
\epsilon_{i,t}^{\text{man}} \\
\epsilon_{i,t}^{\text{tot}} \\
\epsilon_{i,t}^{\text{pri}} \\
\epsilon_{i,t}^{\text{mfg}} \\
\epsilon_{i,t}^{\text{yus}}
\end{bmatrix} = \begin{bmatrix}
\epsilon_{i,t}^{\text{man}} \\
\epsilon_{i,t}^{\text{tot}} \\
\epsilon_{i,t}^{\text{yus}}
\end{bmatrix}
\]

Another possible link between terms of trade and productivity was offered by Balassa (1964) and Samuelson (1964). They proposed that a change in the growth rate of productivity would trigger changes in the relative prices of non-tradables with respect to tradables, and therefore a change in the real exchange rate (i.e.: a change in the terms of trade). This “channel” will not be investigated in the course of this exercise since we are mainly interested with the impact of relative prices onto productivity, not the other way around.

Changing the ordering of sector productivities does not alter this ordinal result.
Before estimating the models, a series of unit root test were applied on the series considered in the study in order to determine their order of integration. Specifically, the Augmented Dickey-Fuller (ADF) and the Phillips-Perron (PP) tests were performed and suggest that all variables are integrated of order 1. Hence, labour productivity and US output are used in logarithmic form, and all variables were first-differenced for the purposes of stationary. The sample covers the period 1987Q2 to 2007Q2.\(^{26}\)

### 4.2 Results

#### Aggregate Model Results

The order for the aggregate model was based on a SVAR(3) model. While contrary to the Akaike’s information criterion (AIC), which indicated the optimal lag length to be one, the likelihood ratio test indicated three lags to be the optimal order. Analysis of the impulse response function (IRF) for the relationship of interest in the study, between the terms-of-trade and labour productivity growth, suggests that a one standard deviation shock to the terms-of-trade has a slightly negative impact on labour productivity growth. However, the impact of this shock is at no point statistically different from zero at the four year horizon (see Chart 8) when using confidence intervals obtained through bootstrapping methods. The cumulative effect, interpreted as the impact of the terms-of-trade on labour productivity level, although negative is not significant at the 90% confidence level. One of the reason for which aggregate productivity is not responsive to a shock on relative prices could be that its underlying components, output and hours worked, react in a similar fashion to such a shock, leaving the consequential net effect on productivity to be nil. Upon further investigation, it appears that this is exactly what is happening, at least in the aggregate case.\(^{27}\)

![Chart 8: Structural and cumulative IRF of a terms-of-trade shock on aggregate labour productivity growth.](image)

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\(^{26}\) The starting date for the sample is constrained by hours.

\(^{27}\) To get a clear picture of which between output and hours reacted to the relative price shock we estimated the same aggregate VAR with output and hours separately instead of productivity. In this case, we ordered output before hours as we believe firms’ employment needs to be driven by demand (hence output) for their product.
Sectoral Productivity Model

In the sector model, a fourth-order SVAR model was used, given that it minimized the serial correlation among residuals and rendered them normal. The response of primary sector labour productivity growth to a positive shock in the terms-of-trade is negative; reaching its maximum magnitude at four quarters after the shock took place, and dissipating almost entirely after eight quarters (see Chart 9). This finding is robust to VAR orders between one and five with the impacts being significantly different from zero at the 10% confidence level. Furthermore, the impact of a terms-of-trade shock on the primary sector level of labour productivity is significantly negative, reaching its lowest level about two years after the shock, and slowly recovering thereafter. It would appear that a large increase in the growth of hours worked, reaching a peak on average three quarters after the impact of the shock, would be responsible for the decline in labour productivity growth in the primary sector. The reason why extra hours worked do not initially generate output is twofold. First, newly hired workers would be expected to be less productive on the margin than experienced ones, and second, efforts devoted early in the base commodities production cycle often go towards less productive activities such as exploration and deposit appraisal expenditures.

Chart 9: Structural and cumulative IRF of a terms-of-trade shock on primary sector labour productivity growth.

The effect of a terms-of-trade shock on labour productivity growth in manufacturing seems less obvious, although overall marginally positive in the very short-run. The initial shock causes an increase in manufacturing labour productivity growth in the first quarter, followed by a sharp decline into negative territory at lag three and subsequent second spike after four quarters. The

28 Lag order was chosen to be between one and five, with VAR(4) exhibiting lowest autocorrelation and the lowest Jarque-Bera statistic (resulting in the highest p-value for the null hypothesis of normality).
impacts beginning at lag 2, however, are not significantly different from zero (see Chart 10), with the second spike disappearing completely when the VAR order is shortened to three or less. The initial positive spike is significant irrespective of the lag order. The impact on labour productivity level in manufacturing, although positive initially, declines substantially in the subsequent years, although never being statistically different from zero. This result could be interpreted as a positive impact on the manufacturing labour productivity growth that is very short-lived. After the first spike, driven by a sharp decline in hours worked, manufacturing labour productivity growth converges back to its long-run growth rate.

Chart 10: Structural and cumulative IRF of a terms-of-trade shock on a manufacturing sector labour productivity.

The terms-of-trade impact on the non-tradable sector labour productivity growth seems to be slightly negative, although with large standard errors, thereby rendering the impact not statistically different from zero (Chart 11). The cumulative impact, however, is marginally significant, implying a negative impact of a terms-of-trade shock on labour productivity level in the non-tradable sector. This result is mostly driven by an increase in hours worked, although this increase is not statistically significant either.
5. Conclusion

An important movement in the terms of trade, while leading to significant resource reallocations, could also affect sector or aggregate productivity growth during the adjustment process. For one, due to substantial increases in labour input, diminishing returns on the available resources and less productive activities early in the production cycle, labour productivity in the primary sector should experience subpar growth in the adjustment period. Second, the manufacturing sector, as a result of shedding least productive labour and plants, should experience faster labour productivity growth in the short-run. Lastly, given the wide variety in the composition of the non-tradable sector it is unclear what the effect of relative price movements will be on the sectors’ productivity growth rate. The overall impact on aggregate labour productivity growth remains difficult to identify analytically.

Our results tend to support the adjustment costs theory and reinforce the hypotheses that increases in the commodity prices, which subsequently improve Canadian terms-of-trade, have a detrimental impact on labour productivity growth in the primary sector, but a positive impact on manufacturing labour productivity growth in the very short-run. The impacts are not as strong as we expected for the manufacturing sector productivity growth which, as suggested by recent anecdotal evidence, rose slightly along with the terms-of-trade.

In the long-run, the improvement in terms of trade should lower the relative price of capital and encourage the substitution of capital for labour which should contribute to higher labour productivity levels. In addition, the important reallocation of resources away from manufacturing toward the primary sector should raise the overall level of productivity, since productivity level tends to be higher in the more capital-intensive primary sector. However, we also recognized that the accompanying shift from tradables to non-tradables would tend to lower overall productivity, as the non-tradable sector tends to be less productive. Our results suggest that the net level effect on
productivity is negative for all but the manufacturing sector, experiencing a negative impact most pronounced two to three years after the initial terms of trade shock. Nevertheless, the aggregate labour productivity level does not appear to be significantly affected by an important movement in relative prices -- although the cumulative effect is negative it is not statistically significant.
6. Bibliography


