Is there a Case for Exchange Rate Induced Productivity Changes?

Richard G. Harris

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ABSTRACT

Is there a Case for Exchange Rate Induced Productivity Changes?

Richard G. Harris

This paper examines the linkages between globalization, regional trade agreements, and the New Economy growth paradigm. The 'New Economy' is characterized as a technological transformation driven by a General Purpose Technologies (or GPT's) based on widespread application within an economy of computers, information and telecommunications technology (ICT). Within the GPT framework the 'New Economy' is thought to have originated within the United States where the middle phase of a major technological transition is underway induced by the convergence of computers and IT. A major issue is how the technological changes which have given rise to the U.S. based New Economy will be transmitted globally through trade and factor movements. The paper is uses two trade theory models to examine the trade and factor price impact of the New Economy transition on regional trade areas consisting of small countries which are manufacturing exporters. Questions examined include (a) How will this economic boom which thus far has been concentrated both by sector and on particular occupations such as IT workers impact on these type of regional trade areas; (b) How does trade liberalization and regional trading agreements impact upon income distribution and pattern of New Economy activity globally? (c) Will globalization or localization tend to be promoted as the New Economy diffuses internationally; and (d) Do small open economies which have traditionally been manufacturing exports stand to gain or lose the most as the New Economy matures and diffuses?

Keywords: globalization, new economy, economic development and technical change

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1. Introduction

In "traditional" open economy macroeconomic theory productivity growth is taken as exogenous relative to changes in the nominal exchange rate, or the exchange rate regime. The idea however is frequently raised that movements in the exchange rate can have an impact on productivity. One mechanism which focuses on demand side effects, often referred to as the competitiveness approach, emphasizes the export growth impact of an exchange rate depreciation and the productivity consequences of that growth.\(^1\) Another heterodox stream of literature focuses on the supply side consequences of a sustained real exchange rate depreciation arguing that it can contribute to lower productivity growth and a larger productivity gap between the depreciating country and the leading countries. This is actually quite an old idea among policy makers, central bankers and businessmen and was one of the reasons a nation would prefer to have a 'hard currency'. Porter(1990) in his well known book on global competitiveness and growth made the point that depreciations can reduce growth and at times an overvalued exchange rate can contribute to productivity growth by forcing productivity increases in the tradables sector. Occasionally this idea finds it way into official policy. In the case of Singapore for example it for a long period had a policy of deliberate appreciation of the exchange rate with a stated intention of forcing competitive productivity increases.\(^2\)

The productivity case has become central to the debate within Canada over recent years on the causes and consequences of the significant real depreciation of the Canadian dollar over the 1990's. Part of this paper will look at the Canadian productivity issue and ask whether it casts some light on the link between productivity and the exchange rate. Courchene and Harris(1999) and Grubel(1999), among others, have argued that the substantial depreciation of the Canadian dollar during the 1990's contributed to the well

\(^1\) Boltho(1998) discusses the history of the competitiveness view of the exchange rate and the important role it has played in economic policy discussions on economic growth in Europe.

\(^2\) For a discussion see Lu and Yu(1999).
documented widening productivity gap between Canada and the United States.\(^3\) The proximate and ultimate sources of the productivity gap have been widely discussed in the Canadian economic policy literature. Figure 1 and Table 1 present alternative perspectives. In Figure 1 using aggregate GDP as an output measure there is a clear indication of the dramatic decline in Canadian productivity performance relative to the U.S. A slightly less alarmist perspective is provided in Table 1 from Gu and Ho(2000) on comparisons of the Canada-U.S. manufacturing sectors.

![Table 1](image)

### Table 1  
Productivity and Output Growth Comparisons

<table>
<thead>
<tr>
<th></th>
<th>Manufacturing in Canada and U.S.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Canada</td>
</tr>
<tr>
<td>Gross Output</td>
<td>3.48</td>
</tr>
<tr>
<td>Capital Stock</td>
<td></td>
</tr>
<tr>
<td>Contribution</td>
<td>0.22</td>
</tr>
<tr>
<td>TFP</td>
<td>0.55</td>
</tr>
<tr>
<td>Labour Prod</td>
<td></td>
</tr>
<tr>
<td>(Value Added)</td>
<td>2.55</td>
</tr>
<tr>
<td>Labour Prod</td>
<td></td>
</tr>
<tr>
<td>(Gross Output)</td>
<td>2.75</td>
</tr>
</tbody>
</table>

Source: Gu and Ho(2000). Note capital and labour inputs are quality adjusted.

This table indicates a substantial gap opening up between Canadian and U.S. productivity over the '79-'95 period, particularly on a value added basis. The gap in TFP growth is also significant but not as dramatic. This suggests other than TFP determinates may have been responsible for the differences in Labour productivity growth, including greater

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\(^3\) This paper does not discuss what may have the causes of the real depreciation of the Canadian dollar. This remains an active and unresolved debate.
outsourcing in the U.S., larger quality changes in the inputs and stronger growth in capital.

It is traditional to argue that productivity changes cause real exchange rate changes. This is the well known Balassa-Samuelson hypothesis which states that higher productivity growth in the tradables sector should lead to a long run increase in the real exchange rate. LaFrance and Schembri (2000) in their recent review of the Canadian case argue that there is no evidence to suggest a link running from exchange rate depreciation to a widening productivity gap between Canada and the U.S., but suggest the Balassa-Samuelson mechanism may be evident in the data. That is Canada's lagging productivity performance in the manufacturing sector relative to the U.S. may be a contributing cause of the observed real exchange rate depreciation relative to the U.S. dollar.

In Harris (2000) it is argued that there are good reasons to treat productivity as endogenous within a macroeconomic framework in which the exchange rate regime is either fixed or floating. The motivation for these observations is drawn from endogenous growth theory, including the recent on General Purpose Technologies or large scale systemic technological revolutions, and recent business cycle theory. The competitiveness approach emphasizes that real exchange rate depreciations accelerate productivity growth in certain circumstances. This would be consistent with a substantial theoretical literature on the pro-cyclical productivity effects of demand shocks. For example in many macro models of the New Keynesian variety with nominal rigidities a positive demand shock can increase measured productivity growth through increased factor utilization, learning-by-doing effects (the Verdoon hypothesis), or increasing returns to scale. A real exchange rate depreciation, which increases the demand for tradables, would tend to exhibit similar effects in that sector. There is an active empirical debate as to how permanent the productivity consequences of demand shocks are. There is a related literature arguing the opposite link between cycles and productivity.

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4 Strauss (1999) provides recent evidence on the Balassa-Samuelson hypothesis based on a time series multi-country approach. He finds no evidence for causality running from productivity to real exchange rates, but some evidence of the reverse.

5 See Basu (1998) and references.
Reorganization or 'cleansing recession', are cited as reasons that a cyclical downtown could lead to productivity increases although again the evidence appears to be mixed\textsuperscript{6} One could also apply these type of theories to real exchange rate 'shocks'.

The Canada-U.S. experience of the 1990's suggests another causal channel which is of current policy interest and may be relatively unique in the historical sense--the arrival of the New Economy. A small open economy under a floating exchange rate may face a structural transition problem when it's major trading partner has forged ahead on it's own major technological transition. If the U.S. is in the midst of a major technological transition being driven by a convergence of computers and information technology--the IT revolution--then the pace and manner in which Canada adapts to this major General Purpose Technology\textsuperscript{7} is critical for its longer term growth performance. It is widely acknowledged that the U.S. on the IT transition\textsuperscript{8} while Canada on the other hand has lagged in these areas, and continues to export and specialize in more traditional Old Economy sectors. The 1990's were also characterized by a decline in resource prices (the Old Economy if there ever was one) declined significantly. Canada was thus hit with two simultaneous shocks in the 1990's: (1) a decline in old economy prices or resource prices; and (2) the arrival of a new major GPT. If the exchange rate \textit{buffers} the Old Economy through an accommodating real depreciation this may lead to a slower rate of economic growth and possibly a permanently lower level of real income relative to a non-buffered exchange rate path. In effect there is a slowdown in creative destruction in the Old Economy due to the exchange rate depreciation.

These explanations are not the only, nor necessarily the most important, means by which a sustained depreciation may raise or lower long term growth. In section 2 of the paper three potential and now standard explanations for the Canada-U.S. productive gap are reviewed in light of the sustained real exchange rate depreciation of the Canadian

\textsuperscript{6} Some of the recent literature includes Hall(1991), Burnside and Hammour(1992), and Saint-Paul(1993).
\textsuperscript{7} For a discussion of GPT's see the collection of papers in Helpman(1999) and in particular for a broad historical discussion see the survey in that volume by Lipsey, Bekar and Carlaw.
\textsuperscript{8} Robert Gordon(1999) surveys this evidence as of mid 1999, and is a well known critic of the New Economy hypothesis. As of mid 2000 the acceleration in the growth of U.S. labour productivity remains intact.
dollar over the last decade. These are three 'smoking guns' in the productivity-exchange rate debate. In each case there are good a priori reasons to link the productivity driver to the exchange rate depreciation. It has admittedly been impossible to conclusively prove via statistical methods these three factors are the main reasons for Canada-U.S. productivity gap, but they currently stand as the best explanations we have.

More generally one can imagine other mechanisms through which a serious and persistent exchange rate undervaluation might raise productivity growth. For example if there is a persistent real undervaluation which results in sustained a sustained cost advantage to the country in question this could lead to a relatively long period of superior export performance. A variety of dynamic theories familiar from the infant industry literature can be used to link this superior export performance to a superior productivity performance. This argument was made in the context of the misalignment literature of the 1980's which was largely a response to the dramatic swings in the U.S. dollar over that decade. From a theoretical perspective therefore a trend depreciation which gives rise to a sustained undervalued exchange rate as measured by some index of misalignment may have positive or negative productivity consequences.

Given the multiplicity of factors and theoretical ambiguity relating productivity growth productivity and exchange rates the 1990's depreciation of the Canadian dollar will not to prove or disprove the general hypothesis that persistent exchange rate depreciations contribute to productivity gaps. For these reasons it is useful to go beyond the Canadian 1990's experience and use international cross-country evidence to see if there is any evidence for the hypothesis in the wide range of productivity growth experiences of the industrial countries. In section 3 of the paper a panel study of productivity growth in manufacturing industries in the OECD is presented. The basic empirical framework starts with a well known conditional convergence productivity growth equation used in many studies. This equation, motivated by endogenous growth in open economies, states that productivity growth is related to a convergence term, openness, and investment. Within this framework we look for any possible effects of

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9 The trade effects of misalignment is a fairly extensive literature-both theoretical and empirical. An overview from the Canadian perspective is provided in Harris(1993).
sustained exchange rate misalignment on productivity growth at the country and industry level. The measure of exchange rate misalignment is a conventional and easily measurable one defined by Purchasing Power Parity benchmarks for the equilibrium exchange rate. In traditional models exchange rate depreciations boost exports and import competing output. These short run output effects can also have positive productivity consequences through increased capacity utilization of fixed inputs, and dynamic scale economies. This alternative 'competitiveness' view of the exchange rate and productivity link is also examined. In general the evidence is supportive of both transmission channels for open economies, but the positive competitiveness effects from a depreciation are transitory while the misalignment effects tend to be much longer lasting and negative. Section 4 offers some concluding comments.

2. Depreciations and the Canada-U.S. Productivity Gap: Three Smoking Guns

In this section three, now conventional, explanations of the Canada-US productivity gap are reviewed--the 'smoking guns', and the link between these and the exchange rate. That a change in the real exchange rate could potentially have productivity effects is consistent with a wide range of endogenous growth models. The direction of the effect however will vary with the precise model used. This paper does not provide a comprehensive general equilibrium theory of the co-movements in the exchange rate and productivity growth. This would require a specific theory of exchange rate determination and as is well known there is little consensus on what that theory might be. The focus is on the more limited question of whether there is a causal link running from real exchange rate movements to medium term productivity growth. It is entirely possible this is structural link is consistent with a long run growth model in which the causality runs in both directions.

The focus here is on three particular explanations for a weak productivity growth performance-the 'three smoking guns' that have emerged out of the Canadian productivity debate--and the link each of these in turn to the exchange rate. Each of these explanations is consistent with at least one class of endogenous productivity growth
models and are referred to respectively as the factor cost effect, the innovation gap hypothesis, and the slowdown in creative destruction.

The Relative Factor Cost Hypothesis

Canada's investment in M&E has lagged that of the U.S. in recent years measure both as the nominal spending share relative to GDP and in real terms. The spending share of nominal M&E investment relative to GDP has averaged 11% below its share of GDP in comparison with the U.S. over the period. From 1980 to 1996 Canada ranked fourth worst amongst the OECD in terms of its M&E spending relative to GDP. 10 This has direct and indirect effects on productivity. One of the important pieces of evidence to come out of the Canadian productivity debate is that provided by the work on Total Factor Productivity growth versus Labour Productivity in Canada and the U.S.. Work by Sharpe(1999), Gu and Ho(1999), Lee and Tang(1999) shows clearly that the labour productivity gap between Canada and the U.S. is due in part to a fall in the rate of capital formation in Canada relative to the U.S. and to some extent a TFP gap. In those sectors where a TFP gap has persisted there are strong reasons to believe this may be related to a difference in the investment intensity of Canadian versus U.S. industries as discussed by Rao, Ahmad and Russell(2000). There is substantial evidence for example that TFP growth is directly related to investment in M&E. 11 In the Canadian manufacturing sector over the 1991-1997 period the level of investment in machinery and equipment per hour worked (referred to as the investment intensity) fell significantly behind the U.S. after being at comparable levels in the late 80's. By 1997 the Canadian-U.S. manufacturing investment intensity gap was 40 percent. This dramatic deterioration in Canadian M&E investment is a major contributor to Canada's lagging productivity growth. The obvious

10 An alternative explanation may hinge on tax differences between the two countries. A recent OECD study Gordon and Tchilinguirian (1998) notes that the effective subsidy to M&E in the US is equivalent to a reduction in the required rate of return on these investments of 4.4 percent. In contrast Canada the effective tax rate on M&E investments raise the required rate of return about 1.4 percent.

11 There is a substantial literature on investment and productivity growth. The standard reference is DeLong and Summers(1991).
question is why? One answer is almost certainly the relative rise in the price of new M&E that has accompanied the depreciation of the Canadian dollar.

One way to illustrate this is to compare the wage-rental ratio in the two countries over the last decade. These show dramatically different trends. In figure 2 (r/w) for Canada is drawn relative to that of the U.S. From the end of 1991 to the end of 1999 the Canadian (r/w) ratio rose by 30 percent relative to the United States. With the global fall in M&E prices the r/w ratio fell in both countries. But Canada's modest decline pales next to the U.S. where from 1991 to 1999 the r/w ratio fell by 36 percent. Since approximately 80 percent of Canadian M&E is imported, and the bulk of that from the U.S. a substantial portion of this difference is directly attributable to the fall in the Canadian dollar over the same period.

The 'factor cost' hypothesis is broadly consistent with both exogenous and endogenous growth theories. In an open economy Solow type model if capital goods are imported a rise in the price of those imports will induce labor for capital substitution and lead to slower growth in average labour productivity even if there is no impact on TFP growth. In a wide range of open economy endogenous growth models there is the potential for an additional effect of slowing investment on TFP growth. One theory which is perhaps the simplest is due to Lee(1997), an open extension of the A-K type model in which capital goods are imported. Lee finds strong evidence of changes in equipment prices on growth rates of per capita GDP, supporting the earlier findings of DeLong and Summers(1991).

A different perspective on the factor cost hypothesis is provided by some recent evidence given in an IMF report on Canada12 and by Carlaw and Kosempel(2000). These studies use the methods of Greenwood and Hercowitz(1992) to decompose TFP growth into Investment Specific Technological Change (IST) and conventional Harrod-Neutral Technological Change(RNT). They argue that IST accounts for improvements in the quality of capital, as it captures technological advancements embodied in new machinery and equipment such as innovations in information and communications. This perspective has quite a dramatic effect on the interpretation of Canadian TFP numbers.

12 See Dunnaway(2000).
Table 2 summarizes the Carlaw-Kosempel measures of IST and RNT relative to TFP over selected periods.

<table>
<thead>
<tr>
<th>Table 2. Average Annual Growth Rates: Productivity and Technology</th>
</tr>
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<tbody>
<tr>
<td><strong>Canada 1961-1996</strong></td>
</tr>
<tr>
<td>Total Factor Productivity</td>
</tr>
<tr>
<td>Investment-Specific Technology</td>
</tr>
<tr>
<td>Residual-Neutral Technology</td>
</tr>
</tbody>
</table>

Source: Carlaw and Kosempel(2000)

The average annual rate of IST accelerated from 1.29 percent over the 1961-1973 period to 5.12 percent over the 1974-1996 period. In comparison, the average annual rate of RNT declined from 1.80 percent over the 1961-1973 period to -0.07 percent over the 1974-1996 period. Carlaw and Kosempel(2000) quantify the individual contributions of IST and RNT to the rate of TFP growth in Canada using a calibrated aggregate growth model. They find that IST accounted for approximately 20 percent of the growth in TFP over the entire 1961-1996 period, zero percent over the pre-1974 period and 100 percent over the post-1974 period. RNT accounted for the remainder in each period. Since IST is strictly driven by investment in M&E any factor which would cause that investment to slow would have a strong and direct effect on productivity growth. In an open economy which imports the bulk of its capital goods the supply side consequence of a sustained rise in the prices of imported investment goods would be considerable. Moreover the effects of differing investment intensities across countries, as in the Canada-U.S. case, will ultimately show up in the form of differential TFP levels. The recent poor investment performance of Canada in this regard does not bode well for future TFP level comparisons with the U.S. even if current comparisons do not indicate a problem.
The Innovation Gap Hypothesis

The Canada-U.S. productivity gap has been attributed by a number of observers to the existence of an "innovation gap" between Canada and the United States. The OECD(1999), Industry Canada(1999), Treffler(1999), Fortin(1999) and Trajtenberg(2000) all suggest that a poor R&D and innovation performance are explanations for Canada's lagging productivity growth. Again proving this is easier said than done. But the smoking gun is evident.\(^{13}\) Trajtenberg(2000) makes the following points.

a) Canada stands well below the other G7 (except for Italy) in terms of the relative amount of resources devoted to innovation, with a R&D/GDP ratio of 1.5%, as opposed to 2.0-2.8% for Germany, Japan and the US.

b) The “rate of success” of Canadian patent applications in the US is low relative both to the other G7 and to smaller technology leaders such as Finland, Israel, and Korea.

c) The technological composition of Canadian patents is out of step with the rest of the world particularly in the fields of Computers and Communications, and Electrical and Electronics.

d) The patterns of ownership of Canadian patents are also troubling: less than half of Canadian patents are owned by Canadian assignees. Half of Canadian inventions may not fully benefit the Canadian economy, either because they are done by individuals that have a hard time commercializing them, or because they are owned by foreign assignees.

e) There is a significant gap of about 20% in the “quality” or “importance” of Canadian patents versus patents of US inventors, as measured by the number of citations received. The quality gap resides first and foremost in Computers.

Related evidence on the innovation gap hypothesis is the slow TFP growth of the two high-tech industries --Industrial Machinery and Electrical Equipment. Gu and Ho(2000, Table 8) estimate that in Canada these two sectors account for 90% of the TFP growth gap between Canadian and U.S. manufacturing for the 1979-1995 period reinforcing the similar conclusions of Sharpe(1999). Obviously the source of this innovation gap is due to a number of causes, of which the exchange rate depreciation may

\(^{13}\) This is a summary of the argument as presented in Trajtenberg(1999).
only have been a partial or complementary factor. The large depreciation however could have been a contributing cause through at least three channels.

1. A great deal of technology is imported from the U.S. including notably computer equipment. As in the case of the factor price hypothesis to the extent these costs are in U.S. dollars the depreciation raised the absolute Canadian dollar cost of innovation in Canada in both the service and manufacturing sectors.

2. The IT boom in the U.S. coupled with a fall in the Canadian dollar lowered the U.S. dollar wages of IT and other high tech workers in Canada relative to what they are paid in Canada. This may have contributed to the 'Brain Drain'. This in turn could have (i) slowed down the rate at which new technology was absorbed in Canada, and (ii) in the case of creative brains who migrated, the drain may have led to innovations occurring within a U.S. based firm as opposed to a Canadian based firm.

3. The depreciation may have led to firms to shift resources from productivity enhancement to output expansion. Saint-Paul(1993) has developed a model of endogenous productivity growth in which firms in the short run must substitute between productivity-enhancing activities (process and product innovation) and output expanding activities. This theory would imply that a series of exchange rate depreciations, all of which were though to be temporary, would cause profit maximizing firms to expand output in response to the depreciation at the expense of R&D etc. This intertemporal substitution effect would have been most pronounced in those export and import competing sectors that could build market share through price competition rather than in those sectors where product innovation is a more important competitive strategy. As discussed by Treffler(1999) the export and output data for Canada show a clear pattern of growth in the traditional sectors, including notably resources, relative to sectors where innovation has been more important.

A Slowdown in Creative Destruction

The emerging ‘New Economy’ paradigm in the U.S. suggests that we are in the midst of a major technological transition being driven by a convergence of computer technology, the Internet, and a wide range of innovations in information technology. The acceleration in the U.S. productivity data after 1995 is the principal macro evidence
supporting the hypothesis that a major new General Purpose Technology (the IT revolution of the New Economy) is driving economic activity in the U.S. From 1972 to 1995 output per hour in the U.S. Business sector grew at 1.27 percent. From 1995 through the end of 1999 it grew at 2.65 percent. This acceleration, and the lack thereof in Canada, suggests the process of creative destruction may have been thwarted to some extent in Canada. There are two avenues here worth thinking about—the small firm problem, and the declining industry problem.

There are a large number of U.S. studies that have identified firm level heterogeneity in productivity and the entry and exit process as a major source of productivity growth. Foster et. al. (1998) claim that 40 to 50% of all productivity growth in some industries is due to entry and exit effects. In contrast to the U.S. however the distribution of employment by firm size in Canada has shifted substantially toward small and medium size firms. The productivity debate in Canada has consistently identified the prevalence of 'small firms' in Canada as a proximate contributing factor to the Canada-U.S. productivity gap. Canada has a size distribution of firms much different than the U.S. with a much larger fraction of output accounted for by small firms. A series of studies by John Baldwin and co-authors and Daly et. al (2000) suggest the persistence of these small firms may have contributed to Canada's productivity gap vis-a-vis the U.S.\textsuperscript{14} The orders of magnitude are considerable. Daly et.al.(2000) present the following data (Table 3) using value added per production worker as the measure of productivity in both countries. The Canada-U.S. differences in plants with less than 100 employees is striking.

\textsuperscript{14} This evidence is reviewed in Harris(1999).
Table 3

Relative Productivity of Canadian vs. US Plants by Size Class

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>500+</td>
<td>108</td>
<td>105</td>
<td>114</td>
</tr>
<tr>
<td>1-100</td>
<td>69</td>
<td>58</td>
<td>57</td>
</tr>
<tr>
<td>All Plants</td>
<td>90</td>
<td>79.6</td>
<td>82.4</td>
</tr>
</tbody>
</table>

Source: Daly et. al. (2000)

The persistence of a Canadian size distribution heavily waited toward small firms awaits a coherent theoretical explanation, but a large (possibly unanticipated) exchange rate depreciation almost certainly contributed toward a slowdown in of creative destruction in the small firm sector. Two channels are possible.

(a) Small firms are often constrained in the capital market and heavily impacted by changes in cash flow. An exchange rate depreciation which raises profits will tend to reduce the rate of exit of cash constrained incumbents. At the same time the depreciation raises the cost of entry to firms that need either new technology and or have large fixed costs based on imported inputs. This can slow the overall rate of productivity growth by shifting output growth from high to low productivity sectors.15

(b) Grubel (1999) has noted that previously marginal entrants in contestable industries (easy entry and exit) find it profitable to enter with an exchange rate depreciation driving down productivity growth in the industry as more output is accounted for by plants with low productivity levels.

c) Entrepreneurship and human capital can respond to exchange rate changes. A real depreciation can reduce the returns to skilled labor via Stolper-Samuelson effects if the tradables sector is human capital intensive relative to the non-tradables sector; it can induce entrepreneurial or skilled labor out-migration if factors are sufficiently mobile and responsive to exchange rate induced real income decreases.

15 Grubel (1999) has raised this argument specifically in the case of the resource sectors in Canada.
When the pace of creative destruction is potentially uneven across sectors an additional source of productivity growth is the ability to shift resources from low to fast growing sectors. The 1990's may have been unique in that it was a period of larger scale technological change is occurring globally due to the arrival of what has become known as the New Economy. Creative destruction in the Old Economy is an important and necessary feature of the technological transition induced by a major new GPT. In the case of Canada the negative shock to the Old Economy was exacerbated by the decline in natural resource prices. If under managed or flexible exchange rates such a shock produces a trend exchange rate depreciation this may tend both to delay technological adoption, and encourage output growth in the Old Economy sectors, reinforcing old patterns of comparative advantage, and lowering growth rates. This raises the troubling scenario that while the initial depreciation appears to be a temporary equilibrium response to the Old Economy shock, it induces a permanently lower equilibrium exchange rate due to reduced productivity growth that initial depreciation gives rise to. The ‘misalignment’ is thus temporary but the real depreciation becomes permanent.16

3. An Econometric Model of Exchange Rate Misalignment and Productivity

The simultaneous increased in the Canada-U.S. productivity gap and the trend depreciation of the Canadian dollar does not prove the exchange rate depreciation was a contributing cause of the productivity gap.17 Other country case studies would be useful to see if similar factors are at work. The cases of New Zealand and Australia might be instructive in this regard, particularly if contrasted with other resource exporters who were either on fixed rates or had a long run trend real exchange rate appreciation (Norway, Finland). In this section however we take the route of looking to cross-country/cross industry data for evidence consistent with the hypothesis that large depreciations slow productivity growth. In order to do this one needs a benchmark model

16 A theoretical model of this process is laid out in Harris(2000).
17 McCallum(1999) notes the correlation between the correlation between productivity growth in Canadian manufacturing and lagged quarterly changes in the Canada-U.S. exchange rate. This correlation is however almost entirely dependent on the single event which was the 1990's depreciation. Statistical inferences from these type of aggregate correlation's in single country time series are notoriously fragile.
of productivity growth which has found some support in the literature. One widely used model is the conditional productivity convergence model which has been used at both the aggregate and industrial level in a large number of international and industry comparison studies. Some examples include Bernard Jones (1996). Bernard and Jensen (1999), Cameron, Proudman, and Redding, (1998), Carree, Klomp and Thurik (2000), and Harris and Kherfi (2000). The model has been used to look at a range of issues from the speed of convergence, trade specialization, human capital and Foreign Direct Investment spillovers, and export concentration.

The basic productivity growth equation for industry i in country c is as follows:

$$\Delta A_{ic}(t)/A_{ic}(t) = \alpha_{ic} + \gamma X_{ic}(t) + \beta \frac{(A^*_{ic}(t-1) - A_{ic}(t-1))}{A_{ic}(t-1)}$$

The dependent variable is the change in productivity in industry i in country c in time period t. This is dependent on some fixed effects (both country and industry) and some general effects as measured by the set of variables X. The convergence effect is reflected by the productivity gap term on the end of the RHS of the equation. \( \beta \) is the (positive) conditional convergence coefficient reflecting the extent to international catch-up contributes to an individual industry's productivity growth. Catch-up is relative to the average productivity across all countries for that that industry defined by \( A^*_{ic} \). This equation is viewed as broadly consistent with a number of endogenous productivity growth theories. Explanatory variables which are presumed to cause productivity growth (the X's) include R&D, investment, openness, human capital intensity, and trade specialization. The benchmark model used in this paper includes investment and openness.

**Two Exchange Rate Effects: Misalignment and Competitiveness**

In line with the discussion in the last section, two explanatory variables are included which reflect exchange rate channels. In order to implement these we define an exchange rate misalignment variable using a trade-weighted Purchasing Power Parity benchmark to measure the divergence of the current exchange rate from it's long run equilibrium value based on economic fundamentals.

The first productivity-exchange rate link is competitiveness hypothesis. In its crudest terms that model simply focuses on the idea that the major source of productivity
is output growth or increases in market shares. To the extent both of these are driven by price competition the theory would predict that exchange rate depreciation contributes to an increase in 'international price competitiveness' and this increases output growth and with this comes productivity improvements. The competitiveness effect is captured empirically by the most recent one year change in the degree of misalignment. Since PPP benchmarks move relative slowly this will largely reflect the most recent change in the nominal and real exchange rate.

The second set of effects are those that emanate from a relatively permanent or long lived departure of the exchange rate from its equilibrium value as measured by the level of the exchange rate relative to some long run equilibrium real exchange rate. As discussed in the previous section there are a range of supply side effects which comes into play from a seriously misaligned exchange rate which could potentially have either a negative or a positive effect on productivity growth. Consistent with the misalignment literature one needs some measure of an equilibrium exchange rate in order to measure the divergence of the actual exchange rate from the equilibrium rate--the degree of misalignment. There has been no unique resolution in the misalignment literature as to how this should be done. Concepts such as the FEER or other structural models of the real exchange rate have been used as benchmarks. In this case data constraints limit the choice for what can be used to identify the equilibrium exchange rate. In light of these problems a much simpler approach is taken of simply using bilateral PPP's and trade weighting them as the model. PPP while much aligned remains one of the most durable exchange rate models we have. A permanent misalignment therefore a situation in which the actual value of the exchange rate departs for a sustained period of time from its trade weighted bilateral PPP value.\footnote{Note that this corrects for cases when either all countries are either under or overvalued vis-a-vis some other currency, such as the U.S. dollar but do not trade much with the U.S., or other cases where there may be a lot of bilateral trade (eg. Britain-Germany) but one country (Germany)is undervalued against the U.S. dollar but the other country(Britain) is not.} The interpretation in line with the theories discussed earlier is that a sustained under or overvaluation distorts relative prices in a manner which
affect supply and demand determinants of productivity and feed in with an appropriate lag on measured productivity outcomes.19

The data for the study consists of a panel of annual observations on 18 industries in 14 countries, over the period 1970-1997. All data used in this study were published by the OECD. We obtained industry-specific data from the OECD STAN Database (1998). The STAN Database was constructed to enable international, inter-industry comparisons. The database focuses on manufacturing activities and is organized according to the two and three-digit ISIC. Our study considers STAN industries at the two-digit level of aggregation. For non-industry-specific data, we use the OECD Monthly Foreign Trade Statistics, Series A, OECD Main Economic Indicators, and OECD National Accounts. The choice of industries was limited by the availability of data and listed in the appendix.

**Labour Productivity**

Labour Productivity is calculated on an industry-specific basis, as the real value added in a given industry per number engaged in that industry. Real value added data is from the STAN data base and PPP adjusted, then divided by the number of engaged to give a real valued per worker definition of average labour productivity. While an hours definition of labour productivity would have been desirable it was not possible with the STAN data. Number engaged includes number of employees as well as self employed, owner-proprietors and unpaid family workers. Note that this study uses average labour productivity rather than total factor productivity. This was done both because of problems of international comparability in capital stock data, and also because labour productivity itself is the ultimate object of interest here.

**Misalignment Index and Competitiveness**

For each country $i$, the misalignment is expressed as:

\[ MIS_i = \sum_{n=1}^{N} \omega_n \left[ \left( \frac{E_{i}^{nom} - PPP_i}{PPP_i} \right) - \left( \frac{E_{n}^{nom} - PPP_n}{PPP_n} \right) \right] \]

19 The paper does not deal with the feedback mechanism from productivity to long run equilibrium real exchange rates. This would involve among other things correcting the measure of misalignment itself for
For countries \( n=1,\ldots,N \). Where \( \omega_n \) is country-\( n \)'s share of country-\( i \)'s trade:

\[
\omega_n = \frac{X_{in} + M_{in}}{\sum_{n=1}^{N} (X_{in} + M_{in})}
\]

Note that misalignment is defined in a relative sense using OECD PPP's as the benchmark. Thus even if a country's own exchange rate is at the PPP value, if all other countries are undervalued, it's own index of misalignment will be recorded as an overvaluation or positive number. A negative value of the index implies an undervaluation relative to the currencies of a country’s trading partners. A positive value implies a relative overvaluation. Finally the index was adjusted so that over the entire period the average misalignment was zero. This was done in order to reconcile some anomalous cases, probably reflecting price level comparison problems, in which countries were always over or undervalued. Figure 3 depicts the misalignment index for the 14 countries. In the case of Canada, the Misalignment Index increasingly resembles the Canada-US real exchange rate over the past fifteen years, due to the growing role of the US as Canada’s largest trading partner. Bilateral trade flows are from the OECD Monthly Foreign Trade Statistics, Series ‘A’. The misalignment indexes suffer from all the usual problems that any PPP based theory of equilibrium exchange rates does.\(^{20}\) It would in general have been desirable to have used industry trade shares to construct industry specific misalignment indexes this was not done because of a lack of trade data on an industry basis.

**Investment-Output Ratio**

The investment-output ratio is calculated on an industry-by-industry basis. We use STAN data on Gross Fixed Capital Formation, adjusted by OECD investment deflators, to represent investment. We GDP-deflate and PPP-adjust STAN value added data to obtain an industry-specific value added output measure. Value added is thought to be long term changes in productivity levels. The cross sectional variation in the misalignment index is unlikely to be impacted seriously by ignoring this factor.

\(^{20}\) The evidence on PPP is reviewed in Lothian(1996). There is strong evidence that nominal exchange rates converge back to their PPP values but with substantial lags. It would clearly be desirable to use other indexes of misalignment based on alternative theories of equilibrium exchange rate to check for robustness.
preferable to gross output since it is a) consistent with the productivity numbers used and 
b) eliminates some of the impacts of different degrees in outsourcing across different 
countries in the same industry. The investment variable in the regression model AVIO, is 
the average of the investment output ratio over the preceding 3 periods. This is consistent 
with other studies of productivity dynamics in which the medium term impact of past 
investment is the mechanism by which productivity growth is affected.

**Openness**

Openness is defined on a country basis. Openness (OPEN) is measured on a country-
specific, but not industry-specific level. For this paper, openness is defined as the ratio of 
exports plus imports to squared GDP. This variable is multiplied by 1,000,000 for ease in 
examining the coefficient. The use of the non-linear openness variable was used rather 
than use of an explicit country size variable. Generally convergence theory predicts that 
the larger the country the less significant openness should be as a growth determinant. 
Given the presence of a number of large countries in the OECD data set making this 
correction is important.

**Average Productivity**

We include an average productivity variable to control for convergence or catch-up 
effects. The average productivity gap  is expressed as the difference between own 
country, current period labour productivity, and the average labour productivity obtained 
in the last period, for a particular industry.

\[
AVLP_{GAP_{i(t)}} = \frac{AVLP_{(i(t-1))} - LP_{i(t-1)}}{LP_{i(t-1)}}
\]

AVLP refers to the average labour productivity level across countries. A large positive 
number for this measure would imply that, for a particular industry, the labour 
productivity in the country in question was well behind the world average labour.

**Estimation**

The following is the basic panel regression model which is estimated.

\[
DLP_{i(t)} = \alpha_{ij} + \beta_1 DMIS_{i(t-1)} + \beta_2 LRMISS_{i(t-1)} + \beta_3 AVIO_{i(t)} + \beta_4 OPEN_{i(t)} + \beta_5 AVLP_{GAP_{i(t-1)}} + \mu_{ij}
\]
for $i=1,...,I$ countries and $j=1,...,J$ industries. All variables in the panel, with the exception of the misalignment index and openness, are industry and country specific. The dependent variable is the change in labour productivity over the previous year. The misalignment index is common across industries within any specific country. There are two exchange rate variables. Last period's change in misalignment, $DMIS_{t-1}$, and a long run measure of the level of misalignment $LRMIS_{t-1}$ which is intended to capture the effect of misalignment in periods $t-1$ and back. This is measured by a linearly declining 5-year average of the previous MIS terms, with weights of 5/15 on the first lagged period, declining to 1/15 in the final lagged period.

A positive coefficient on the DMIS variables would imply that a exchange rate appreciation would yield positive productivity growth. A positive coefficient on the permanent misalignment index, $LRMIS$, implies that an increase in the degree of overvaluation or a decrease in the degree of undervaluation increases productivity growth. OPEN is the Openness variable, AVLPGAP is the average labour productivity gap of the industry form the world average for that industry, and AVIO is the average investment-output ratio defined as Gross Fixed Capital Formation divided by Value Added. The AVIO variable is country-industry specific to the two-digit ISIC level. In the estimation, we use an unweighted average of lagged investment-output ratio (averaged over lags of -3, -4 and -5) so as to capture the long term effects of investment on productivity and to eliminate any problems with simultaneity.

The econometric estimation model is a fixed-effects model allowing the intercept to vary for each industry-country observation. The estimation method is iterative GLS, using the Heteroskedasticity-Consistent Variance-Covariance Matrix proposed by White (1980). Although the coefficient estimates using pooled least squares were almost identical to the GLS estimates, cross section weights substantially improved the statistical significance of those estimates. A correction for autocorrelation in the errors was tried but there appears to be no evidence of autocorrelation in the errors.

**Baseline Results**

The basic convergence model is reported in the Table 4. Both Openness and the productivity gap have the expected signs and are significant. A 10 percent productivity gap relative to the average implies that annual productivity growth is higher by about 1
percent than without the gap. One should note that Bernard and Jones (1996) and others found that the convergence effect in the OECD on aggregate manufacturing data was substantially weaker after the mid 1980's. This model is estimated however without allowance for a mid 80's structural break. The average investment to output ratio is also positive and significant. The coefficient estimates imply that a permanent 10 percent increase in the investment ratio corresponds to an increase of annual productivity growth of 1 percent. This coefficient seems somewhat high and some of the literature suggests it may interact with the openness variable considerably.

**Misalignment and Exchange Rate Effects: Results**

The results for the misalignment model are reported in Table 5 in columns 1 through 3 for a variety of specifications. The competitiveness effect as measured by the coefficient on DMIS is always significant and as expected negative. In the first column for example which is the basic model a one percent real depreciation below the equilibrium level of the exchange rate in the previous year would increase labour productivity growth over the current year by about 0.8 percent. In contrast the LRMIS variables captures the effect of a sustained misalignment. The positive and significant coefficient on LRMIS implies that the empirically estimated effect of an undervalued exchange rate is to reduce productivity growth. The orders of magnitude are illustrated in figure 4. Here the model in column 1 issued to simulate the effects of an undervalued exchange rate which goes from equilibrium level to being 25 percent undervalued over a two year period and then staying undervalued. As indicated in figure 4 the effects on productivity growth are a short but sharp increase in productivity growth, and then a subsequent and long run fall productivity growth by 0.66 percent.

A number of alternative specifications were tried with variations in the way in which the basic misalignment variable was measured with similar conclusions. The model in all cases without investment performs substantially worse than the model with investment. Simultaneity on LRMIS and investment is an issue that requires further investigation. When the model is estimated without fixed effects it performs substantially worse (Table 5 column 3) and the LRMIS variable becomes insignificant. Given the importance of fixed effects in the model it would be desirable to identify other
proximate determinants of productivity and to examine how exchange rates influence each of these.

**Large Exchange Rate Misalignments**

The literature on trade hysteresis produced a number of models and some evidence that changes in trade patterns would occur with 'large' exchange rate changes which lasted for a sufficient period. Many of those sorts of arguments might well apply to the type of investments needed to bring about productivity change. For example it may be the case that many of the supply side factors are possibly only going to respond to a major exchange rate change, in particular if exchange rate expectations are quite inelastic in the short run. Short term volatility of exchange rates in a number of models is predicted to reduce the impact of relatively small changes in the exchange rate. To investigate this effect an alternative index of misalignment is used. The index UNDER is defined as dummy variables which take the value 1 when the long term misalignment index, LRMIS, says the exchange rate is under (or over) valued by at least 15 percent or more lasting at least two years. Over is defined as an overvaluation of the misalignment index by 15 percent or more for at least the preceding two years. This model is reported in the last column of Table 5. Both coefficients are significant. The undervaluation coefficient is insignificant although negative. The overvaluation coefficient is negative and significant. Interesting is appears that very large overvaluations may lead to lower productivity growth. These results are in contrast with the other misalignment models based on continuous indexes. They also appear to be somewhat unstable with respect to alternative cut-off values used to define "large" misalignments. It may be that there are some strong non-linear effects here. For example a very severely overvalued exchange rate in levels may lead to a continuing loss of export markets. These negative effects on output may ultimately swamp any of the productivity-push effects that a mildly overvalued exchange rates lead to, which in turn would give rise to a highly non-linear effect of LRMIS on productivity growth.

**Interaction Effects**

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The basic model identifies assumes three basic determinants of productivity growth—investment, openness and the productivity gap relative to the world average. Exchange rates channels on productivity growth may occur by either by enhancing or diminishing the effect each of these variables, rather than through an independent effect. The potential for interaction is even greater when one realizes that the three measured 'determinants' are themselves proxies for a variety of influences on the unmeasured processes which drive productivity change. For example in general one would expect the exchange rate effect to be stronger in more open economies for a number of reasons. Misalignment might enhance the investment effect for example if a low exchange rate contributes to growth of output in sectors which investment has been high. The 'catch-up' effect is generally thought to come through international spillovers of knowledge from high to low productivity countries. An exchange rate misalignment might enhance these spillovers for example if it affects either trade of investment flows through which spillovers are sometimes mediated.

To check for the possible significance of interaction the model is re-estimated with LRMIS interacted with each of the three basic variables of the convergence model. These results are reported in Table 6. Three models are reported. The long term misalignment variable is interacted with respectively openness, investment and the productivity gap variable. Of these three models the only one which does not performance worse and in which the interaction is significant is that between openness and misalignment. In this case the exchange rate misalignment variable is highly significant and has a sign is consistent with the basic thrust of supply side effects of exchange rate depreciation. For industries which are open to international trade, exchange rate misalignment is more consequential, and in a direction consistent with the long term supply side view of misalignment. The investment interaction effect does not appear to work; this may not be too surprising. In countries that are exporters of M&E or are relatively closed one would not expect the factor cost effect of an exchange rate change to be very important.

**Panel Results: Summary**
The evidence from panel model supports the competitiveness view of the positive short run effects of exchange rate depreciation on productivity, and the long term negative supply consequences of undervalued exchange rates on productivity growth. There is no evidence of that a sustained undervalued exchange rate leads to longer term superior productivity growth. This type of empirical approach forces common parameters across all industries and countries. There is little doubt this is assumption is unjustified and especially so in the case of the exchange rate variables. Time series approaches may be an alternative, or better structural models. In general we need more evidence on how differences across countries affect the productivity-exchange rate link.
Table 4: Baseline Productivity Model: Estimation Results
Dependent Variable: Change in Labour Productivity

<table>
<thead>
<tr>
<th>Variable</th>
<th>Estimation Method – GLS</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Baseline W/O investment</td>
<td>Baseline W/ investment</td>
<td></td>
</tr>
<tr>
<td>AVIO</td>
<td></td>
<td></td>
<td>0.119</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(4.979)</td>
</tr>
<tr>
<td>AVLPGAP(t-1)</td>
<td>0.103</td>
<td></td>
<td>0.091</td>
</tr>
<tr>
<td></td>
<td>(21.654)</td>
<td></td>
<td>(16.778)</td>
</tr>
<tr>
<td>OPEN</td>
<td>-0.008</td>
<td>0.007</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(-5.063)</td>
<td>(5.959)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5894</td>
<td>4780</td>
<td></td>
</tr>
<tr>
<td>R²</td>
<td>0.173</td>
<td>0.173</td>
<td></td>
</tr>
<tr>
<td>Adj. R²</td>
<td>0.130</td>
<td>0.130</td>
<td></td>
</tr>
<tr>
<td>D – W Statistic</td>
<td>1.937</td>
<td>1.915</td>
<td></td>
</tr>
</tbody>
</table>

Notes: t – Statistic in parentheses
Table 5: Misalignment Models Estimation Results

<table>
<thead>
<tr>
<th>Variable</th>
<th>Investment</th>
<th>W/O Investment</th>
<th>Common Intercept (No fixed effects)</th>
<th>Large Exchange Rate Effect Model (+/-.15)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td></td>
<td></td>
<td>0.0007 (15.206)</td>
<td></td>
</tr>
<tr>
<td>DMIS</td>
<td>-0.083 (-8.958)</td>
<td>-0.074 (-9.571)</td>
<td>-0.0604 (-2.879)</td>
<td>-0.096 (-10.495)</td>
</tr>
<tr>
<td>LRMIS</td>
<td>0.014 (2.321)</td>
<td>-0.001 (-0.157)</td>
<td>-0.0096 (-0.709)</td>
<td></td>
</tr>
<tr>
<td>UNDER</td>
<td></td>
<td></td>
<td></td>
<td>-0.002 (-1.067)</td>
</tr>
<tr>
<td>OVER</td>
<td></td>
<td></td>
<td></td>
<td>-0.018 (-7.962)</td>
</tr>
<tr>
<td>AVIO</td>
<td>0.106 (4.242)</td>
<td></td>
<td></td>
<td>0.103 (4.143)</td>
</tr>
<tr>
<td>AVLPGAP(-1)</td>
<td>0.093 (17.055)</td>
<td>0.103 (21.518)</td>
<td>0.0194 (4.829)</td>
<td>0.091 (16.871)</td>
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<tr>
<td>OPEN</td>
<td>0.043 (5.935)</td>
<td>-0.008 (0.002)</td>
<td>-0.060 (-3.313)</td>
<td>0.038 (5.281)</td>
</tr>
<tr>
<td>Obs.</td>
<td>4780</td>
<td>5849</td>
<td>5849</td>
<td>4870</td>
</tr>
<tr>
<td>R²</td>
<td>0.184</td>
<td>0.180</td>
<td>0.020</td>
<td>0.190</td>
</tr>
<tr>
<td>Adj. R²</td>
<td>0.141</td>
<td>0.138</td>
<td>0.019</td>
<td>0.147</td>
</tr>
<tr>
<td>D-W</td>
<td>1.913</td>
<td>1.878</td>
<td>1.959</td>
<td>1.921</td>
</tr>
</tbody>
</table>

Note: t – Statistic in parentheses.
Table 6: Interaction Models Estimation Results

<table>
<thead>
<tr>
<th>Interaction Models</th>
<th>Interaction between Waver and Openness</th>
<th>Interaction between Waver and Investment</th>
<th>Interaction between Waver and Convergence</th>
</tr>
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<tbody>
<tr>
<td>LRMIS*OPEN</td>
<td>0.0287 (3.546)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LRMIS*AVIO</td>
<td></td>
<td>-0.054 (-1.479)</td>
<td>-0.052 (-1.831)</td>
</tr>
<tr>
<td>LRMIS*AVLPGAP_(t-1)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DMIS</td>
<td>-0.085 (-9.229)</td>
<td>-0.091 (-10.008)</td>
<td>-0.086 (-9.093)</td>
</tr>
<tr>
<td>AVIO</td>
<td>0.115 (4.665)</td>
<td></td>
<td>0.227 (8.924)</td>
</tr>
<tr>
<td>AVLPGAP_(t-1)</td>
<td>0.092 (16.942)</td>
<td>0.096 (17.828)</td>
<td></td>
</tr>
<tr>
<td>OPEN</td>
<td></td>
<td>0.044 (6.125)</td>
<td>0.034 (4.608)</td>
</tr>
<tr>
<td>Obs.</td>
<td>4780</td>
<td>4780</td>
<td>4780</td>
</tr>
<tr>
<td>R²</td>
<td>0.181</td>
<td>0.183</td>
<td>0.157</td>
</tr>
<tr>
<td>Adj. R²</td>
<td>0.139</td>
<td>0.141</td>
<td>0.113</td>
</tr>
<tr>
<td>D–W Statistic</td>
<td>1.911</td>
<td>1.911</td>
<td>1.966</td>
</tr>
</tbody>
</table>

Note: t – Statistic in parentheses.
4. Conclusions

The results of this paper lend support to the view that real exchange rates affect productivity growth in both the short and long term. In the short run the results are consistent with the competitiveness hypothesis which suggests that exchange rate depreciations boost productivity growth in the short run. However there is also evidence that a sustained real exchange rate depreciation have negative consequences for long term productivity growth. Two sorts of evidence are reviewed.

The sustained real depreciation of the Canadian dollar over the 1990's has proven to be a major case study of the long term productivity consequences of an undervalued exchange rate. The substantial literature on the Canada-U.S. productivity gap points to a number of causal mechanisms in which the Canadian dollar depreciation of the 1990's contributed to factors which worsened the Canadian productivity performance relative to that of the U.S. The paper discusses include three major productivity channels. One, the factor cost effect of a depreciation which raises the cost of imported investment goods. Two, the impact of a depreciation on innovation and R&D; sustained exchange rate depreciations raise the cost to imported technology and shift profit opportunities where price competition works relative to competition on new or improved product and process innovation. Three exchange rate depreciations can reduce the forces of creative destruction. This can occur in two ways. One, by affecting the exit and entry process in a manner which sustains the existence and growth of small, inefficient firms longer than they would otherwise. Secondly, during a period of major technological change, capital and labour are sheltered in old slow growth sectors, which in turn reduces the rate at which the New Economy high growth sectors can expand.

To what extent is the Canadian case indicative of a more general link between exchange rates productivity growth? The second part of the paper looks to international cross country-industry evidence on productivity dynamics using a conditional convergence framework in conjunction with a set of exchange rate misalignment measures. The results are consistent with a model in which for highly open economies exchange rate undervaluation carries short benefits in terms of productivity growth but long term costs in terms of productivity performance. The evidence is consistent with theories which suggest that sustained undervaluation appears to lead to deteriorating
productivity growth. Whether this will hold up under other approaches and with other
data sets should be an important item on the research agenda of both productivity
researchers and international economists concerned with the exchange rate as a
transmission mechanism in open economies. It also points to the need for further
research on the identification of the conditions under which a sustained misalignment is
likely to have strong productivity consequences. In summary productivity effects should
be added to the list of criteria and consequences used in the evaluation of flexible versus
fixed exchange rate regimes, the cost-benefit analysis of optimal currency areas, and the
ex-post historical evaluation of sustained real exchange rate misalignments.
Bibliography


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OECD STAN Database (1998), OECD DSI.

### Appendix Scope of the Panel

<table>
<thead>
<tr>
<th>Industry</th>
<th>United States ISIC</th>
<th>Countries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food Beverages &amp; Tobacco</td>
<td>3100</td>
<td>Austria</td>
</tr>
<tr>
<td>Textiles, Apparel &amp; Leather</td>
<td>3200</td>
<td>Belgium</td>
</tr>
<tr>
<td>Wood Products &amp; Furniture</td>
<td>3300</td>
<td>Canada</td>
</tr>
<tr>
<td>Paper Products &amp; Printing</td>
<td>3400</td>
<td>Denmark</td>
</tr>
<tr>
<td>Industrial Chemicals</td>
<td>3510</td>
<td>Finland</td>
</tr>
<tr>
<td>Other Chemicals</td>
<td>3520</td>
<td>France</td>
</tr>
<tr>
<td>Petroleum Refineries</td>
<td>3530</td>
<td>Germany</td>
</tr>
<tr>
<td>Petroleum and Coal Products</td>
<td>3540</td>
<td>Italy</td>
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</tr>
</tbody>
</table>
Figure 1
Relative Labour Productivity: Canada as percent of U.S.
1976-1999

Data source: csis web site/www.csis.ca

Notes: data for GDP per worker and GDP per hour for US recalculated from 1996$ into 1992$ with GDP price deflator ratio 1992/1996=0.917

Note: GDP per capita and GDP per hour for Canada recalculated into 1992 US $ with OECD bilateral 1992 PPP exchange rate estimate 1.23 $CAD/$US.
FIGURE 2

Relative Factor Prices
M&E/wages

Notes: US wages series from the DRI(Citibase) GAWS series on Wages and Salaries; US M&E price series from the DRI(Citibase) variable PWME, producer price index for Machinery and Equipment; Canadian wages series, CANSIM series D17023; and Canadian M&E prices, CANSIM series D15625, Chain Price Index for Business Capital Formation, Machinery and Equipment
FIGURE 3 – MISALIGNMENT INDEXES

AUSTRIA

BELGIUM

CANADA

DENMARK

FINLAND

FRANCE

GERMANY

ITALY
FIGURE 3 – MISALIGNMENT INDEX (CONT’D)
Figure 4

Effect of a 25% Misalignment on Labour Productivity Growth

Percentage Change in Labour Productivity Growth

1.20%
1.00%
0.80%
0.60%
0.40%
0.20%
0.00%
-0.20%
-0.40%
-0.60%

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16

time/years
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