Is There a Case for Exchange-Rate-Induced Productivity Changes?

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Introduction

In “traditional” open economy macroeconomic theory, productivity growth is taken as exogenous relative to changes in the nominal exchange rate or in the exchange rate regime. The idea, however, is frequently raised that movements in the exchange rate can have an impact on productivity. One mechanism that focuses on demand-side effects, often referred to as the competitiveness approach, emphasizes the export growth effect of an exchange rate depreciation and the productivity consequences of that growth.[1] Another heterodox stream of literature, which focuses on the supply-side consequences of a sustained real exchange rate depreciation, argues 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 a “hard currency.” Porter (1990), in his well-known book on global competitiveness and growth, pointed out that depreciations can reduce growth, and an overvalued exchange rate can sometimes contribute to productivity growth

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.

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by forcing productivity increases in the tradables sector. This idea occasionally finds its way into official policy. Singapore, for example, had a long period of deliberate appreciation of the exchange rate with a stated intention of forcing competitive productivity increases (see Lu and Yu 1999).

Over recent years, the productivity case has become central to the debate in Canada on the causes and consequences of the significant real depreciation of the Canadian dollar in the 1990s. 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 1990s contributed to the well-documented widening productivity gap between Canada and the United States.[2] The proximate and ultimate sources of the productivity gap have been widely discussed in Canadian economic policy literature. Figure 1 and Table 1 present alternative perspectives. Figure 1 uses aggregate GDP as an output measure and clearly indicates the dramatic decline in Canadian productivity performance relative to that of the United States. A slightly less alarmist perspective is provided in Table 1 from Gu and Ho (2000) on comparisons of the Canada-U.S. manufacturing sectors.

This table indicates a substantial gap opening up between Canadian and U.S. productivity over the 1979–95 period, particularly on a value-added basis. The gap in total factor productivity (TFP) growth is also significant but not as dramatic. This suggests determinates other than TFP may have been responsible for the differences in labour productivity growth, including greater outsourcing in the United States, 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.[3] 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 United States, but they suggest that the Balassa-Samuelson mechanism may be evident in the data. That is, Canada's lagging productivity performance in the manufacturing sector may

2. This paper does not discuss possible causes of the real depreciation of the Canadian dollar. This remains an active and unresolved debate.

3. 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.

Figure 1
Relative labour productivity: Canada vs. the United States

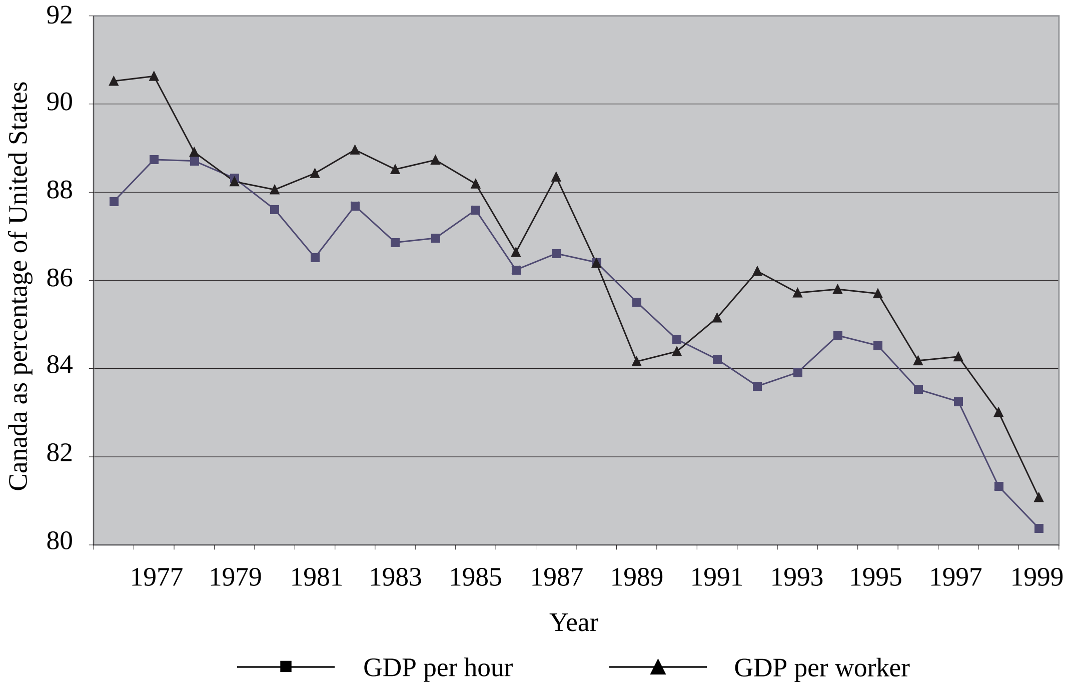

Table 1
Productivity and output growth comparisons
Manufacturing in Canada and the United States

	Canada		United States	
Period	**1961–95**	**1979–95**	**1961–95**	**1979–95**
Gross output	3.48	1.97	2.79	1.73
Capital stock contribution	0.22	0.143	0.24	0.17
TFP	0.55	0.28	0.86	0.80
Labour productivity (value-added)	2.55	1.83	3.17	3.00
Labour productivity (gross output)	2.75	2.28	2.37	2.32

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

be contributing to the observed real exchange rate depreciation relative to the U.S. dollar.

Harris (2000) 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 this observation is drawn from endogenous-growth theory, including the recent work on general purpose technologies (GPTs) 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 substantial theoretical literature on the procyclical 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 (see Basu 1998 and references) regarding how permanent the productivity consequences of demand shocks are. There is a related literature arguing the opposite link between cycles and productivity. Reorganization or "cleansing recession" are cited as reasons that a cyclical downturn could lead to productivity increases, although again, the evidence appears mixed.[4] One could also apply these types of theories to real exchange rate shocks.

The Canada-U.S. experience of the 1990s suggests another causal channel that is of current policy interest and may be 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 its major trading partner has forged ahead on its own major technological transition. If the United States is in the midst of a major technological transition driven by a convergence of computers and information technology—the IT revolution—the pace and manner in which Canada adapts to this major GPT[5] is critical for its longer-term growth performance. It is widely acknowledged that the United States leads the IT transition,[6] while Canada has lagged and continues to export and specialize in more traditional Old Economy sectors.

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4. Some of the recent literature includes Hall (1991), Caballero and Hammour (1992), and Saint-Paul (1993).

5. For a discussion of GPTs, see Helpman (1999); for a broad historical discussion, see the survey by Lipsey, Bekar, and Carlaw in that volume.

6. 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, acceleration in the growth of U.S. labour productivity remains intact.

The 1990s were also characterized by a significant decline in resource prices (the Old Economy, if there ever was one). Canada was thus hit with two simultaneous shocks in the 1990s: (i) a decline in Old Economy prices or resource prices and (ii) the arrival of a new major GPT. If the exchange rate *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, or necessarily the most important, means by which a sustained depreciation may raise or lower long-term growth. Section 1 reviews three potential and now standard explanations for the Canada-U.S. productivity gap in light of the sustained real exchange rate depreciation of the Canadian 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, with statistical methods, that these factors are the main reasons for the Canada-U.S. productivity gap, but they currently stand as the best explanations we have.

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 that results in 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 1980s, which was largely a response to the dramatic swings in the U.S. dollar over that decade.[7] From a theoretical perspective, therefore, a trend depreciation that 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 and exchange rates, the 1990s depreciation of the Canadian dollar will not prove or disprove the general hypothesis that persistent exchange rate depreciations contribute to productivity gaps. For this reason,

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7. The trade effects of misalignment is the subject of a fairly extensive literature—both theoretical and empirical. An overview from the Canadian perspective is provided in Harris (1993).

it is useful to go beyond the Canadian 1990s experience and use international cross-country evidence to determine whether there is any evidence for the hypothesis in the wide range of productivity-growth experiences of industrial countries. Section 2 presents a panel study of productivity growth in manufacturing industries in the Organisation for Economic Co-operation and Development (OECD). 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 possible effects of sustained exchange rate misalignment on productivity growth at the country and industry levels. The measure of exchange rate misalignment is a conventional and easily measurable one defined by purchasing-power parity (PPP) 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 through dynamic scale economies. This alternative "competitiveness" view of the exchange rate and productivity link is also examined. In general, the evidence supports 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. The final section offers concluding comments.

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

That a change in the real exchange rate could have productivity effects is consistent with a wide range of endogenous-growth models. The direction of the effect, however, will vary with the model used. This paper does not provide a comprehensive general-equilibrium theory of the co-movements in the exchange rate and productivity growth. That would require a specific theory of exchange rate determination and, as is well known, there is no consensus on what that theory might be. The focus is on the more limited question of whether there is a causal link between real exchange rate movements to medium-term productivity growth. It is entirely possible that this structural link is consistent with a long-run growth model in which the causality runs in both directions.

The focus here is on three explanations for a weak productivity growth performance—the three smoking guns that have emerged from the Canadian productivity debate—and their links to the exchange rate. Each of these explanations is consistent with at least one class of endogenous productivity growth models. The smoking guns are the factor-cost effect, the innovation-gap hypothesis, and the slowdown in creative destruction.

1.1 The relative factor-cost hypothesis

Canada's investment in machinery and equipment (M&E) has lagged behind that of the United States in recent years, in 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 per cent below its share of GDP, in comparison with the United States over the same period. From 1980 to 1996, Canada ranked fourth from bottom amongst the OECD in terms of its M&E spending relative to GDP.[8] This has direct and indirect effects on productivity. Important evidence to emerge from the Canadian productivity debate is provided by the work on TFP growth versus labour productivity in Canada. U.S. studies by Sharpe (1999), Gu and Ho (2000), and Lee and Tang (1999) show clearly that the labour productivity gap between Canada and the United States is due, in part, to a fall in the rate of capital formation in Canada relative to the United States and, to some extent, to a TFP gap. In 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 Kaptein-Russell (2000). There is substantial evidence, for example, that TFP growth is directly related to investment in M&E.[9] In the Canadian manufacturing sector over the 1991–97 period, the level of investment in M&E per hour worked (referred to as the investment intensity) fell significantly behind that of the United States after being at comparable levels in the late 1980s. By 1997, the Canadian-U.S. manufacturing investment intensity gap was 40 per cent. This dramatic deterioration in Canadian M&E investment contributes significantly to Canada's lagging productivity growth. The obvious 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 rental/wage (r/w) ratio in the two countries over the last decade. This comparison points to dramatically

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

9. There is substantial literature on investment and productivity growth. The standard reference is De Long and Summers (1991).

different trends. In Figure 2, (r/w) for Canada is drawn relative to that of the United States. From the end of 1991 to the end of 1999, the Canadian (r/w) ratio rose by 30 per cent 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 that of the United States, where, from 1991 to 1999, the r/w ratio fell by 36 per cent. Since approximately 80 per cent of Canadian M&E is imported—and the bulk of that from the United States—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 use labour 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, comes from Lee (1996); it features 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, and this supports earlier findings of De Long and Summers (1991).

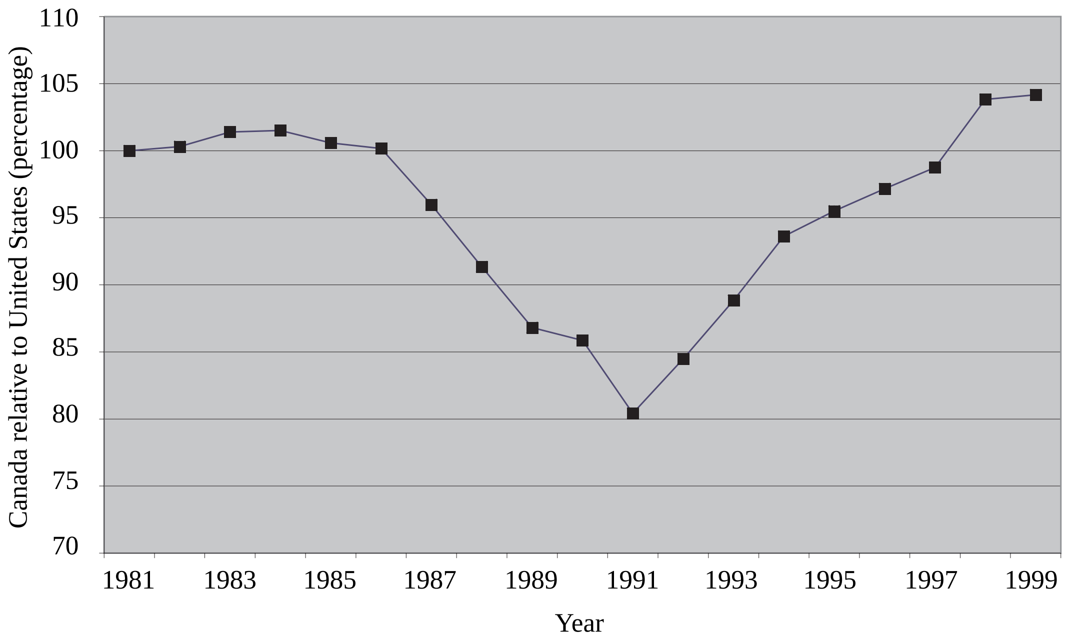
A different perspective on the factor-cost hypothesis is provided by recent evidence in an International Monetary Fund (IMF) report on Canada (see Dunaway et al. 2000) and in work by Carlaw and Kosempel (2000). These studies use the methods of Greenwood, Hercowitz, and Krussel (1997) to decompose TFP growth into investment-specific technological (IST) change and conventional residual-neutral technological (RNT) change. The studies argue that IST accounts for improvements in the quality of capital, since it captures technological advancements embodied in new M&E, such as innovations in information and communications. This perspective has quite a dramatic effect on the interpretation of Canadian TFP numbers. Table 2 summarizes the Carlaw-Kosempel measures of IST and RNT relative to TFP over selected periods.

Table 2
Average annual growth rates: Productivity and technology Canada 1961–96

Period	1961–73	1974–96	1961–96
Total-factor productivity	1.75%	0.17%	0.71%
Investment-specific technology	1.29%	5.12%	3.81%
Residual-neutral technology	1.80%	–0.07%	0.57%

Source: Carlaw and Kosempel (2000).

Figure 2
Relative factor prices
Price of machinery and equipment/wage rate
Canada vs. the United States: 1981–99



The average annual rate of IST accelerated from 1.29 per cent over the 1961–73 period to 5.12 per cent over the 1974–96 period. In comparison, the average annual rate of RNT declined from 1.80 per cent over the 1961–73 period to –0.07 per cent over the 1974–96 period. Carlaw and Kosempel 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 per cent of the growth in TFP over the entire 1961–96 period, zero per cent over the pre-1974 period, and 100 per cent 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 that would cause that investment to slow would have a strong and direct effect on productivity growth. In an open economy that 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 United States, even if current comparisons do not indicate a problem.

1.2 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 (1998), Trefler (1999), Fortin (1999), and Trajtenberg (1999) all suggest that a poor R&D and innovation performance can explain Canada's lagging productivity growth. Again, proving this is easier said than done. But the smoking gun is evident. Trajtenberg makes the following points.[10]

(i) Canada stands well below the other G-7 countries (except for Italy) in terms of the relative amount of resources devoted to innovation, with a R&D/GDP ratio of 1.5 per cent, as opposed to 2.0–2.8 per cent for Germany, Japan, and the United States.

(ii) The "rate of success" of Canadian patent applications in the United States is low relative both to the other G-7 countries and to smaller technology leaders such as Finland, Israel, and Korea.

(iii) 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 equipment and electronics.

(iv) The patterns of ownership of Canadian patents are also troubling: less than one-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 who have a difficult time commercializing them, or because they are owned by foreign assignees.

(v) There is a significant gap of about 20 per cent in the "quality" or "importance" of Canadian patents versus patents of U.S. 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 per cent of the TFP growth gap between Canadian and U.S. manufacturing for the 1979–95 period, reinforcing similar conclusions from Sharpe (1999). Obviously, the source of this innovation gap is due to a number of causes, of which the exchange rate depreciation may only have been a partial or complementary factor. The large depreciation, however, could have been a contributing cause through at least three channels.

10. This is a summary of the argument as presented in Trajtenberg (1999).

(i) A great deal of technology is imported from the United States 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.

(ii) The IT boom in the United States, 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 the United States. This may have contributed to the "brain drain." And the brain drain, in turn, could have (a) slowed down the rate at which new technology was absorbed in Canada and (b) 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 one.

(iii) The depreciation may have led 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 thought 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 sectors where product innovation is a more important competitive strategy. As discussed by Trefler (1999), the export and output data for Canada show a clear pattern of growth in the traditional sectors—including resources—relative to sectors where innovation has been more important.

1.3 A slowdown in creative destruction

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

A large number of U.S. studies have identified firm-level heterogeneity in productivity and the entry and exit process as major sources of productivity growth. Foster, Haltiwanger, and Krizan (1998) claim that 40 to 50 per cent of all productivity growth in some industries is due to entry and exit effects. In contrast to the United States, however, the distribution of employment by firm size in Canada has shifted substantially towards 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 from that of the United States, with a much larger fraction of output accounted for by small firms. A series of studies reviewed by Daly, Helfinger, and Sharwood (2000) suggest that the persistence of these small firms may have contributed to Canada's productivity gap vis-à-vis the United States.[11] The orders of magnitude are considerable. Daly, Helfinger, and Sharwood 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 are striking.

Table 3
Relative productivity of Canadian vs. U.S. plants by size class

Plant size (no. of workers)	1977	1987	1999
500+	108	105	114
1–100	69	58	57
All plants	90	79.6	82.4

Source: Daly, Helfinger, and Sharwood (2000).

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

(i) Small firms are often constrained in the capital market and heavily affected by changes in cash flow. An exchange rate depreciation that 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

11. This evidence is reviewed in Harris (1999).

growth by shifting output growth from high to low productivity sectors.[12]

(ii) 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, since more output is accounted for by plants with low productivity levels.

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

When the pace of creative destruction is potentially uneven across sectors, an additional source of productivity growth is the ability to shift resources from slow- to fast-growing sectors. The 1990s may have been unique in that the decade witnessed a period of larger scale technological change at a global level, brought about by 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 a managed or flexible exchange rate regime, such a shock results in a trend real depreciation, this may tend to delay technological adoption and encourage output growth in 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.[13]

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12. Grubel (1999) has raised this argument in the case of the resource sectors in Canada.
13. A theoretical model of this process is described in Harris (2000).

2 An Econometric Model of Exchange Rate Misalignment and Productivity

The simultaneous increase in the Canada-U.S. productivity gap and the trend depreciation of the Canadian dollar do not prove that the exchange rate depreciation contributed to the productivity gap.[14] Other country case studies would be useful to see whether 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 (e.g., Norway or Finland). In this section, however, we look to cross-country/ cross-industry data for evidence consistent with the hypothesis that large depreciations slow productivity growth. To do this, one needs a benchmark model of productivity growth that has support in the literature. One widely used model is the conditional productivity convergence model, which has been used at both the aggregate and industrial levels in a large number of international and industry comparison studies. Examples include Bernard and 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 examine a range of issues that include 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:

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

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 right-hand side of the equation. β is the (positive) coefficient of the conditional convergence coefficient that reflects the extent to which international catch-up contributes to an industry's productivity growth. Catch-up is relative to the average productivity across all countries for that

14. McCallum (1999) notes 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 a single event: the depreciation of the 1990s. Statistical inferences from these types of aggregate correlations in single-country time series are notoriously fragile.

industry defined by A_i^*. This equation is viewed as being broadly consistent with a number of endogenous productivity-growth theories. Explanatory variables that 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.

2.1 Two exchange rate effects: Misalignment and competitiveness

In line with the discussion of the last section, two explanatory variables are included that reflect exchange rate channels. To implement them, we define an exchange rate misalignment variable using a trade-weighted PPP benchmark to measure the divergence of the current exchange rate from its long-run equilibrium value based on economic fundamentals.

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

The second set of effects emanates 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 a long-run equilibrium real exchange rate. As discussed in the previous section, a range of supply-side effects come into play from a seriously misaligned exchange rate that could have a negative or positive effect on productivity growth. As in 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 Fundamental Equilibrium Exchange Rate 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, using bilateral PPPs and trade weighting them as the model. While much maligned, PPP remains one of our most durable exchange rate models. A permanent misalignment, therefore, occurs when the value of the exchange rate departs for a sustained period of time from its trade-weighted bilateral PPP value.[15] In line with the theories discussed earlier, one can assume that a sustained undervaluation or overvaluation distorts relative prices in a manner that affects supply and demand determinants of productivity and in a way that feeds in with an appropriate lag on measured productivity outcomes.[16]

The data for the study consist of a panel of annual observations on 18 industries in 14 countries, from 1970 to 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 International Standard Industrial Classification (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 these industries are listed in the appendix.

2.2 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 are from the STAN database and are PPP adjusted, then divided by the number of engaged to give a real valued per worker definition of average labour productivity. While definition of labour productivity based on hours worked would have been desirable, this was not possible with the STAN data. The “number engaged” includes the 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 because of problems of international comparability in capital stock data and because labour productivity is the focus of interest here.

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15. This corrects for cases when either all countries are either under- or overvalued vis-à-vis some other currency such as the U.S. dollar, but do not trade much with the United States, or other cases where there may be a lot of bilateral trade (e.g., Britain-Germany), but one country (Germany) is undervalued against the U.S. dollar and the other country (Britain) is not.

16. This paper does not deal with the feedback mechanism from productivity to long-run equilibrium real exchange rates. Among other things, this would involve correcting the measure of misalignment itself for long-term changes in productivity levels. The cross-sectional variation in the misalignment index is unlikely to be seriously affected by ignoring this factor.

2.2.1 Misalignment index and competitiveness

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

$$MIS_i = \sum_{n=1}^{N} \omega_{in}\left[\left(\frac{E_i^{nom} - PPP_i}{PPP_i}\right) - \left(\frac{E_n^{nom} - PPP_n}{PPP_n}\right)\right].$$

For countries $i = 1, \ldots, N$, where ω_{in} is country *n*'s share of country *i*'s trade:

$$\omega_{in} = \frac{X_{in} + M_{in}}{\sum_{n=1}^{N}(X_{in} + M_{in})}.$$

Note that misalignment is defined in a relative sense, using OECD PPPs as the benchmark. Thus, even if a country's exchange rate is at the PPP value, if all other countries are undervalued, its index of misalignment will be recorded as an overvaluation or as a 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 to reconcile some anomalous cases, probably reflecting price-level-comparison problems, where 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-U.S. real exchange rate over the past 15 years, because of the growing role of the United States as Canada's largest trading partner. Bilateral trade flows are from the OECD Monthly Statistics of International Trade, Series A. The misalignment indexes suffer from all the usual problems that any PPP-based theory of equilibrium exchange rates does.[17] It would have been desirable to have used industry trade shares to construct industry-specific misalignment indexes. This was not done, however, because trade data are not available on an industry-by-industry basis.

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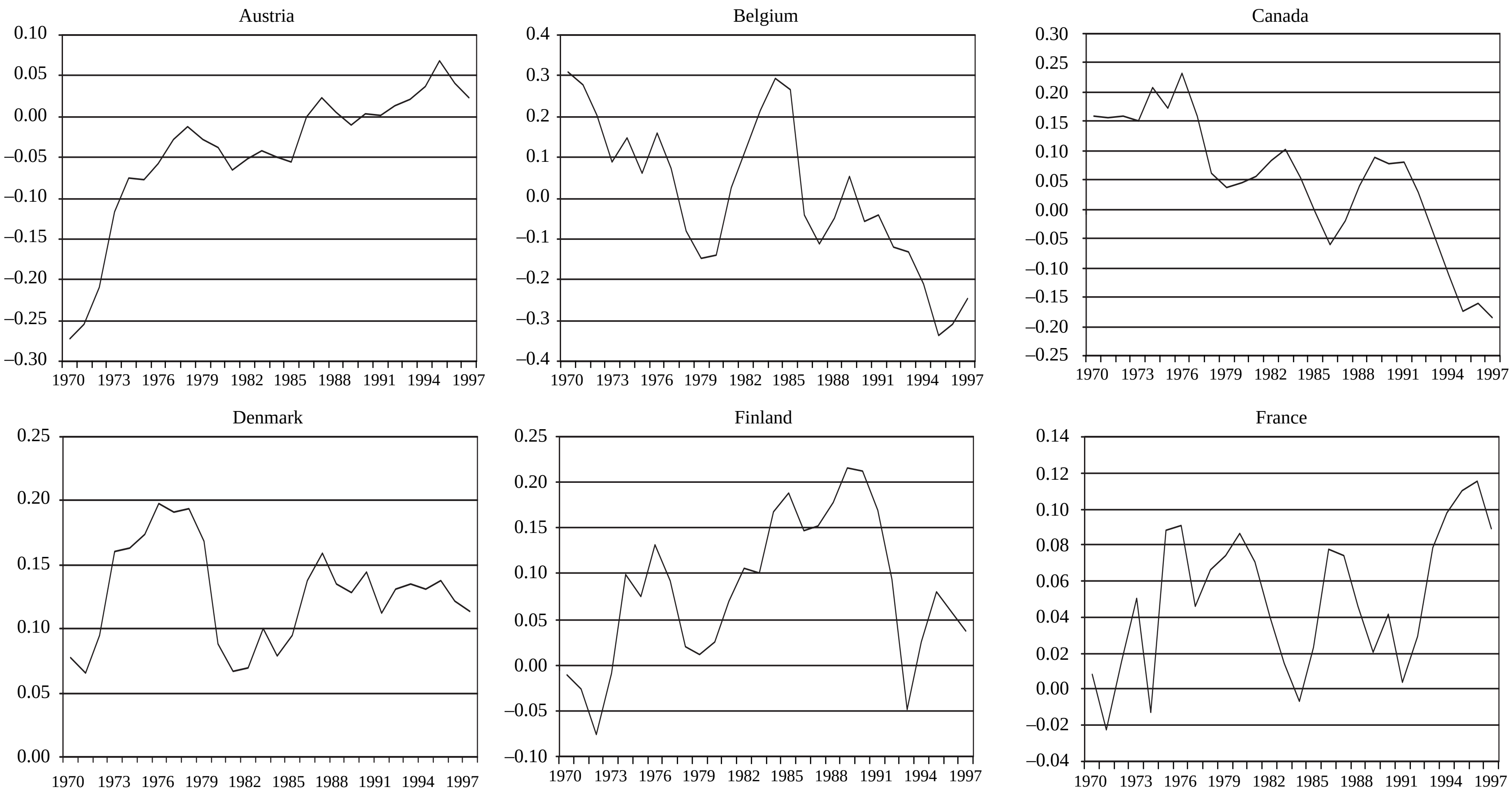
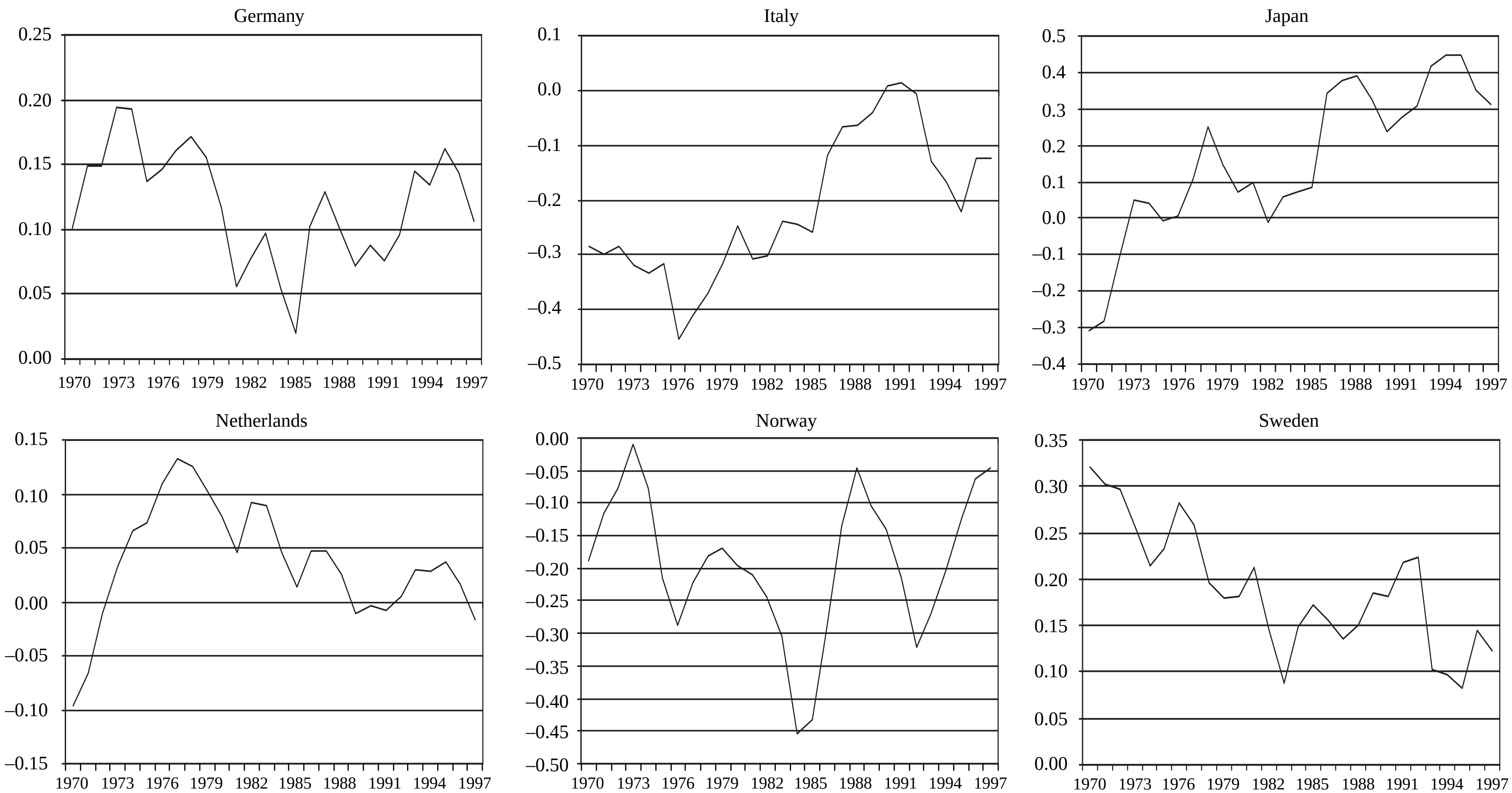
17. The evidence on PPP is reviewed in Lothian (1997). There is strong evidence that nominal exchange rates converge back to their PPP values, but with substantial lags. It would clearly be desirable to use other indexes of misalignment based on alternative theories of equilibrium exchange rate to check for robustness.

Figure 3
A graphical representation of the misalignment index



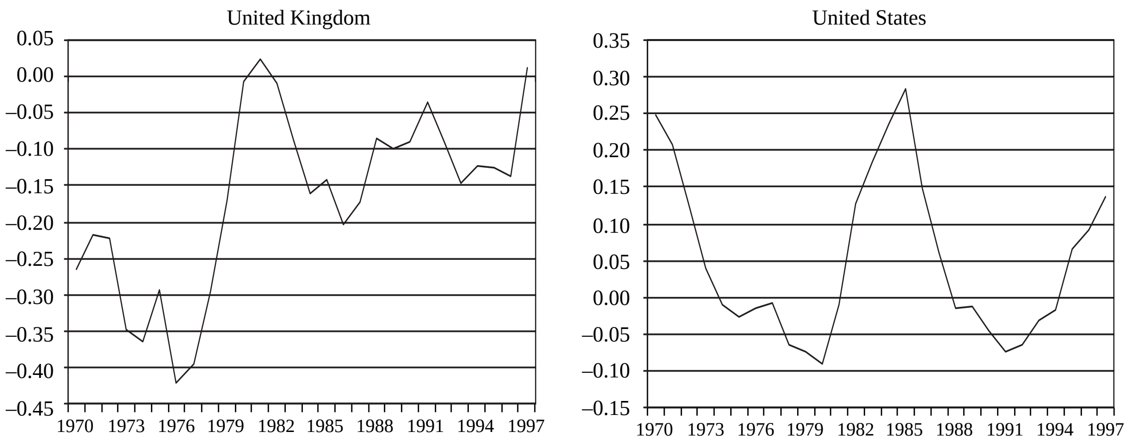
(continued)

Figure 3 (continued)
A graphical representation of the misalignment index



(continued)

Figure 3 (continued)
A graphical representation of the misalignment index



2.2.2 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 preferable to gross output, since it (i) is consistent with the productivity numbers used and (ii) eliminates some of the effects 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 three 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.

2.2.3 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 non-linear openness variable was used rather than an explicit country-size variable. Convergence theory usually 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.

2.2.4 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.

$$AVLPGAP_{ic(t)} = \frac{AVLP_{(i,t-1)} - LP_{ic(t-1)}}{LP_{ic(t-1)}}$$

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.

2.2.5 Estimation

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

$$\Delta A_{ic(t)}/A_{ic(t-1)} = \alpha_{ij} + \beta_1 DMIS_{i(t-1)} + \beta_2 LRMIS_{i(t-1)} + \beta_3 AVIO_{ij(t)} + \beta_4 OPEN_{it} + \beta_5 AVLPGAP_{ij(t-1)} + \mu_{ij}$$

for $i = 1, \ldots, I$ countries and $j = 1, \ldots, J$ 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 are intended to capture the effect of misalignment in periods $t-1$ and back. This is measured by a linearly declining five-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 an exchange rate appreciation would yield positive productivity growth. A positive coefficient on the long-run 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 from 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-ouput ratio (averaged over lags of –3, –4, and –5) 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 that allows the intercept to vary for each industry-country observation. The estimation method is iterative generalized least squares (GLS), using the White heteroscedasticity-consistent variance-covariance matrix. 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 attempted, but there appears to be no evidence of autocorrelation in the errors.

2.2.6 Baseline results

The basic convergence model is reported in Table 4. Both openness and the productivity gap have the expected signs and are significant. A 10 per cent productivity gap relative to the average implies that annual productivity growth is higher by about 1 per cent, 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-1980s. This model is estimated, however, without allowing for a mid-1980s structural break. The average investment-to-output ratio is also positive and significant. The coefficient estimates imply that a permanent 10 per cent increase in the investment ratio corresponds to an increase of annual productivity growth of 1 per cent. This coefficient seems somewhat high, and some literature suggests that it may considerably interact with the openness variable.

2.2.7 Misalignment and exchange rate effects: Results

The results for the misalignment model for a variety of specifications are reported in Table 5 in columns 1 through 3. 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 1 per cent 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 per cent. In contrast, the *LRMIS* variable 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 is used to simulate the effects of an undervalued exchange rate, which goes from equilibrium level to being 25 per cent undervalued over a two-year period and then stays undervalued. As indicated in Figure 4, the effects on productivity growth are a short but sharp increase in productivity growth, and a subsequent and long-run fall in productivity growth by 0.40 per cent, which persists for about a decade.

Alternative specifications were tried with variations in the way the basic misalignment variable was measured. The conclusions were similar. The model in all cases without investment performs substantially worse than the model with investment. Simultaneity on *LRMIS* and investment 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

Table 4
Baseline productivity model: Estimation results
Dependent variable: Change in labour productivity

Variable	Estimation method * GLS	
	Baseline W/O investment	Baseline W/ investment
AVIO		0.119
		(4.979)
$AVLPGAP_{(t-1)}$	0.103	0.091
	(21.654)	(16.778)
OPEN	–0.008	0.007
	(–5.063)	(5.959)
Sample	1976–96	1976–96
No. of observations	5,849	4,780
R^2	0.173	0.173
Adjusted R^2	0.130	0.130
D-W statistic	1.937	1.915

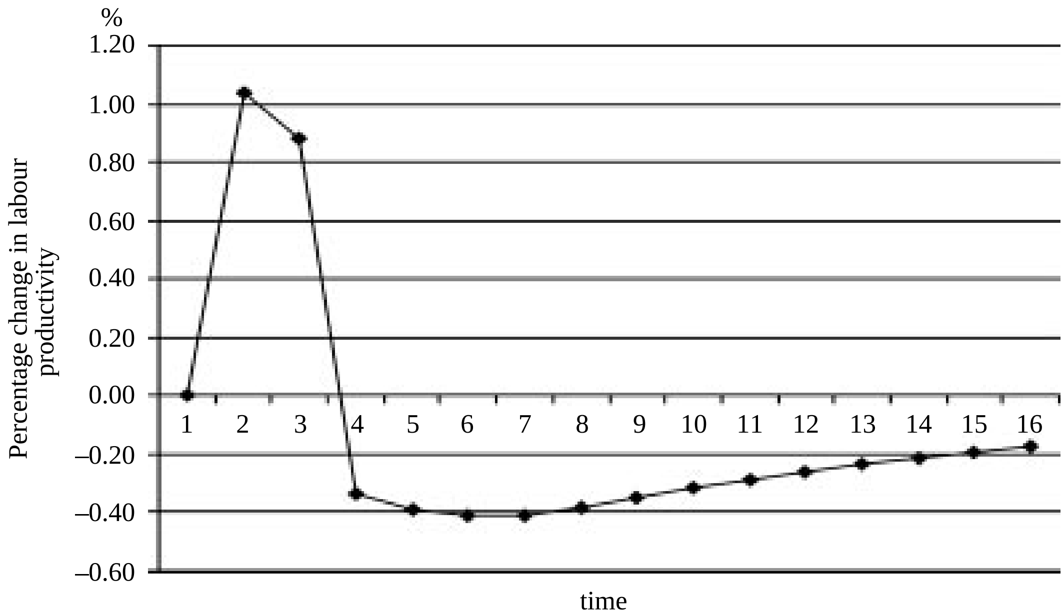
Notes: *t*-statistic in parentheses.

Table 5
Misalignment models estimation results

Variable	Investment	W/O investment	Common intercept (no fixed effects)	Large exchange rate effect model (+/–0.15)
Constant			0.0007	
			(15.206)	
DMIS	–0.083	–0.074	–0.0604	–0.096
	(–8.958)	(–9.571)	(–2.879)	(–10.495)
LRMIS	0.014	–0.001	–0.0096	
	(2.321)	(–0.157)	(–0.709)	
UNDER				–0.002
				(–1.067)
OVER				–0.018
				(–7.962)
AVIO	0.106			0.103
	(4.242)			(4.143)
$AVLPGAP_{(t-1)}$	0.093	0.103	0.0194	0.091
	(17.055)	(21.518)	(4.829)	(16.871)
OPEN	0.043	–0.008	–0.060	0.038
	(5.935)	(0.002)	(–3.313)	(5.281)
Sample	1976–96	1975–95	1975–95	1975–95
No. of observations	4,780	5,849	5,849	4,780
R^2	0.184	0.180	0.020	0.190
Adjusted R^2	0.141	0.138	0.019	0.147
D-W statistic	1.913	1.878	1.959	1.921

Notes: *t*-statistic in parentheses.

Figure 4
Effect of a 25 per cent misalignment on the percentage change in labour productivity



would be desirable to identify other proximate determinants of productivity and to examine how exchange rates influence each of these.

2.2.8 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 that lasted for a sufficient period.[18] 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 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 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 per cent or more for at least two years. OVER is defined as an overvaluation of the misalignment index by 15 per cent or more for at least the preceding two years. This model is reported in the last

18. Harris (1993) op. cit. and Baldwin and Krugman (1989).

column of Table 5. Both coefficients are significant. The undervaluation coefficient is insignificant although negative. The overvaluation coefficient is negative and significant. It 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 somewhat unstable with respect to alternative cut-off values used to define "large" misalignments. There may be some strong non-linear effects here. A severely overvalued exchange rate in levels, for example, may lead to a continuing loss of export markets. These negative effects on output may ultimately swamp any of the productivity-push effects that mildly overvalued exchange rates lead to, which, in turn, would give rise to a highly non-linear effect of LRMIS on productivity growth.

2.2.9 Interaction effects

The basic model assumes three basic determinants of productivity growth: investment, openness, and the productivity gap relative to the world average. Exchange rate channels on productivity growth may occur by enhancing or diminishing the effect of 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 proxies for a variety of influences on the unmeasured processes that drive productivity change. For example, one would usually expect the exchange rate effect to be stronger in more open economies, for a number of reasons. Misalignment might enhance the investment effect if a low exchange rate contributes to growth of output in sectors where 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 if it affects either trade or 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 variables of the convergence model. These results are reported in Table 6. Three models are reported. The long-term misalignment variable is interacted with openness, investment, and the productivity gap variable, respectively. Of these models, the only one whose performance is not 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 that is consistent with the basic thrust of supply-side effects of exchange rate depreciation. For industries that 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-

Table 6
Interaction models estimation results

	Interaction between MIS and openness	Interaction between MIS and investment	Interaction between MIS and convergence
LRMIS*OPEN	0.0287		
	(3.546)		
LRMIS*AVIO		–0.054	
		(–1.479)	
LRMIS* $AVLPGAP_{(t-1)}$			–0.052
			(–1.831)
DMIS	–0.085	–0.091	–0.086
	(–9.229)	(–10.008)	(–9.093)
AVIO	0.115		0.227
	(4.665)		(8.924)
$AVLPGAP_{(t-1)}$	0.092	0.096	
	(16.942)	(17.828)	
OPEN		0.044	0.034
		(6.125)	(4.608)
Sample	1976–1996	1976–1996	1976–1996
No. of observations	4,780	4,780	4,780
R^2	0.181	0.183	0.157
Adjusted R^2	0.139	0.141	0.113
D-W statistic	1.911	1.911	1.966

Notes: *t*-statistic in parentheses.

interaction effect does not appear to work. This may not be too surprising, however. In countries that are exporters of M&E or that are relatively closed, one would not expect the factor-cost effect of an exchange rate change to be very important.

2.2.10 Panel results: Summary

Evidence from the 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 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 that this assumption is unjustified and particularly so in the case of the exchange rate variables. Time-series approaches or better structural models may be alternatives. We need more evidence on how differences across countries affect the productivity-exchange rate link.

Conclusions

The results of this paper support 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 could have negative consequences for long-term productivity growth. Two sorts of evidence are reviewed.

The sustained real depreciation of the Canadian dollar over the 1990s has led to an extensive examination 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 1990s contributed to factors that worsened the Canadian productivity performance relative to that of the United States. The paper discusses three major productivity channels: (i) the factor-cost effect of a depreciation that raises the cost of imported investment goods; (ii) 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. (iii) Exchange rate depreciations can reduce the forces of creative destruction. This can occur in two ways. First, they can affect the exit and entry process in a manner that sustains the existence and growth of small, inefficient firms longer than they would otherwise. Second, during a period of major technological change, capital and labour are sheltered in old slow-growth sectors, and this 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 and 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-term benefits in productivity growth but long-term costs in productivity performance. The evidence is consistent with theories suggesting 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. 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.

Appendix
The Panel

Industry	United States ISIC	Countries
Food, beverages, and tobacco	3,100	Austria
Textiles, apparel, and leather	3,200	Belgium
Wood products and furniture	3,300	Canada
Paper products and printing	3,400	Denmark
Industrial chemicals	3,510	Finland
Other chemicals	3,520	France
Petroleum refineries	3,530	Germany
Petroleum and coal products	3,540	Italy
Rubber products	3,550	Japan
Plastic products	3,560	Netherlands
Non-metallic mineral products	3,600	Norway
Basic metal industries	3,700	Sweden
Metal products	3,810	United Kingdom
Machinery	3,820	United States
Electrical machinery	3,830	
Transport equipment	3,840	
Professional goods	3,850	
Other manufacturing	3,900	

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Discussion

David Longworth

Rick Harris has provided us with a very interesting and timely paper on the relationship between exchange rate movements and productivity changes.

The case of the possibly exchange-rate-induced productivity changes. A case for Hercule Poirot? Perhaps. The dastardly deed is the poorer productivity performance in Canada than in the United States. There are apparently three smoking guns. Evidence is presented that each one of these has something to do with Canada's poorer productivity performance vis-à-vis the United States. The accused is Mr. Depreciation (henceforth, Mr. D.).[1] But did he pull the triggers of the three guns? And to make the case more exciting, new evidence has just come to light: an innovative model of exchange rate misalignment and productivity.

Mr. D. with the three smoking guns? Does he lurk at the Bank of Canada? Rick does not tell us for sure. But wherever he is, he certainly beats out old Colonel Mustard with the candlestick in the conservatory.[2] We're certainly given a lot of clues.

Let's examine each of the smoking guns in turn. As we consider each of them, I will tell you what Mr. D. and I would say, if I were Mr. D.'s defence attorney.

At the outset, it is important to note that, if the movements in the Canadian dollar are largely reflecting fundamentals, as argued in the Djoudad et al. paper in this volume and in the strain of literature starting with Amano and

1. It is never entirely clear whether Mr. D. has "Nominal" or "Real" for his first name. The references to the exchange rate regime suggest "Nominal," but most of the arguments and empirical work relate to "Real." Below, I concentrate mostly on "Real."
2. With apologies to the creators of *Clue*™.

van Norden (1993), it is the fundamentals that are leading to any of the effects argued for by Harris, and not Mr. D. at all.[3]

First, the “relative factor-cost” gun. The Canadian rental-wage ratio has risen 30 per cent in Canada relative to that in the United States from 1991 to 1999. This is blamed on Mr. D. If I were Mr. D.’s defence attorney, I would first note that this rise was largely a reversal of the decline in the 1986–91 period (Figure 2 in Harris’s paper) that was associated with rising changes in Canadian unit labour costs and a real appreciation of the Canadian dollar. I would also grill the expert witness on how these aggregate data were constructed:

- Do they now include software in the United States (but not in Canada)?
- Does Statistics Canada assume the law of one price between Canada and the United States in constructing the data on the price of investment in computer equipment? (There is a lot of anecdotal evidence that, at least for personal computers and personal computer software, there is significant pricing to market.)

Second, the “innovation-gap” gun. This gun is evidently smoking quite a lot. It is not clear, however, whether Mr. D. was ever holding it. Pricing-to-market issues are at play for technology transfers as well as for investment. And Mr. D. would like to know for which period of time he is charged with the offence. Most of the data in the “court documents” are for the period ending in 1995 or 1996, a period over which there is little or no evidence of a significant brain drain.[4] It is only over the last two or three years, if at all, that the case can be made for the significance of this drain.

Third, the “slowdown in creative destruction” gun. Mr. D. protests that an increase in creative destruction did not seem to be required in the United States (at least after 1990–92). Indeed, the argument made for productivity gains in the United States has been exactly the opposite—the United States has been pushing against capacity limits, especially in the last five years or so, which has led to at least part of the productivity gains. Canada experienced a large real exchange rate appreciation through November 1991, but the creative destruction of that period did not seem to be helpful in increasing productivity. Indeed, some argued vehemently at the time that a real exchange rate appreciation was exactly the worst thing to have if one wanted to take advantage of the free trade agreement with the United States.

3. Moreover, if fundamentals are driving movements in the real exchange rate, it is difficult to see how changing the exchange rate regime would change the fundamentals and the real exchange rate movements.

4. See, for example, Helliwell (1999) and Human Resources Development Canada and Statistics Canada (1999).

Mr. D., when called to the stand, would also argue that increases in cash flow (which are probably negatively correlated with creative destruction) tend to promote investment.[5] Furthermore, the ratio of investment in machinery and equipment to GDP has picked up substantially in Canada in the last few years despite the low value of the Canadian dollar. Rising investment is exactly what most experts think is one of the major factors increasing productivity (based on regressions such as those reported in Tables 4 and 5 of Harris's paper).

Is the new evidence that has come to light the one thing that will really convince the jury? I think that the jury will be confused.

The equations estimated in the "court documents" are of the following type: the percentage change in labour productivity (*DLP*) in a given industry and country is a function of the change in real exchange rate misalignment (*DMIS*), a weighted moving average over five years of past exchange rate misalignments (*LRMIS*), several other explanatory variables (including investment in some equations but not others), and a term that captures the percentage difference between the average level of labour productivity across countries for a particular industry and the lagged level of labour productivity domestically in that industry.

A feature of the estimated specifications is that a misalignment arising from a real depreciation initially causes a rise in productivity. In specifications that include investment (e.g., the first column in Table 5 and the first column in Table 6), the coefficient of the past misalignment variable (*LRMIS*) indicates that a permanent real depreciation eventually leads to a permanent decline in productivity. On the other hand, in specifications that exclude investment, the coefficient of the past misalignment variable is of the opposite sign, indicating that a depreciation never leads to a decline in productivity. One plausible explanation for the differences in these results is that a depreciation, through its effect on net exports, could increase cash flow and/or expected future output, therefore having a tendency to increase investment. The specifications with investment would capture this effect through the investment variable, while the other specifications would capture this effect directly through the misalignment variable.

In any event, it is important to note that the lags between misalignment and the *level* of productivity are very long, with it taking at least eight years (in the case of the simulation in Figure 4, which is based on an equation with investment and with investment treated exogenously) for productivity to fall below its initial level.

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5. Because of asymmetric information, the cost of internal funds is likely lower than the cost of external funds.

As well, and perhaps most importantly, the specification with the highest adjusted R^2 has a significant negative effect of overvaluations on productivity, but no statistically significant effect of undervaluations on productivity (final column in Table 5).

Stepping out of my role as Mr. D.'s attorney, I now ask, "Who done it?"

First, it obviously has been "done." On average, over the last ten years, productivity performance in Canada has not been as good as it has in the United States.

Second, all three guns exist, but perhaps only the second one is smoking.

Third, it is not obvious that Mr. Depreciation, on his own, squeezed any of the triggers.

Fourth, given the differing stories across equations, the prosecution will have difficulty using its new evidence to convince the jury.

Fifth, three or four years from now, one might never think of charging Mr. D. There are some encouraging signs that productivity may be picking up, including the rise in the ratio of investment in machinery and equipment to GDP. It's too early to say for sure—and a central bank should not count on it—but it is too soon for other policy-makers to panic.

More importantly, putting Mr. D. on trial cannot be used as a way to determine whether the nominal exchange rate regime is guilty of reducing productivity growth. To convict the exchange rate regime, one has to show beyond a shadow of a doubt that the major movements in real exchange rates were not related to real fundamentals.

References

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General Discussion

David Laidler opened the discussion by asking whether the real depreciation that occurred in the 1990s could have been prevented by stabilizing the nominal exchange rate. He also questioned the use of purchasing-power parity (PPP) to determine the equilibrium exchange rate.

Richard Harris replied that PPP provides the best available approximation for the equilibrium real exchange rate for a wide range of countries.

Andrew Rose touched on the literature that seeks to link productivity to exchange rate regimes and, in particular, on his and Frankel's unsuccessful efforts to find such a link.

Eduard Hochreiter described the efforts of Austrian policy-makers in the 1970s to lower inflation and increase productivity. They adopted an appreciated value for the schilling relative to the German mark to encourage productivity growth, and this measure was accepted by the unions, who recognized it as a means to obtaining higher real wages. At the same time, Austria adopted supply-side measures to encourage investment. Since then, it has experienced higher productivity growth then Germany, but also more inflation.

Robert Lafrance noted that it is difficult to make productivity growth rate comparisons with the United States over short sample periods. Hence, it may be misleading to attribute Canada's recent productivity performance to a depreciating nominal exchange rate.