Ten Productivity Puzzles Facing Researchers

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PUZZLES INTRIGUE AND MOTIVATE researchers and focus research effort. The field of productivity research is fortunate in having many unresolved puzzles. The purpose of this article is to highlight what I feel are the most important puzzles facing empirical productivity researchers. Ten is an arbitrary number inspired more by Letttermen's well known top ten list than a belief that there are only ten puzzles worthy of identification and study. Indeed, there are tens if not hundreds of interesting questions in the productivity field that await investigation. I have listed the seven general puzzles in terms of my perception of their importance. The three Canada-specific puzzles follow.

Puzzle 1: The Sources of the Post-1973 Productivity Slowdown

The grand daddy of productivity puzzles is of course the post-1973 productivity slowdown. It has intrigued productivity researchers for over 25 years. A definitive consensus on the causes of the slowdown has still not been achieved, although one may be emerging.

The post-1973 productivity slowdown was pervasive across developed countries. Out of 21 OECD countries only one escaped the trend – Ireland, which experienced no change. According to the Groningen productivity database, the average annual growth rate of total economy output per hour in OECD countries in 1950-73 was 4.64 per cent, compared to 2.15 per cent in 1973-2003, a slowdown or deceleration of 2.49 percentage points.[2] Portugal and Japan had the largest productivity slowdowns at 4.9 points and 4.7 points respectively because of the very rapid productivity growth these countries enjoyed in the 1950-73 period (around 7 per cent per year), due in part to their low initial productivity level. The smallest slowdowns were in Australia (0.8 points) and the United Kingdom (0.6 points). The magnitude of the productivity slowdown in Canada and the United States was slightly below average at 1.6 points and 1.7 points respectively.

Many explanations for the post-1973 labour productivity slowdown have been advanced, including energy price shocks, slower demand growth, measurement problems, slower capital intensity growth, negative productivity effects of the welfare state, and changing demographic structures. But the most promising explanation in my view lies in the historical perspective that

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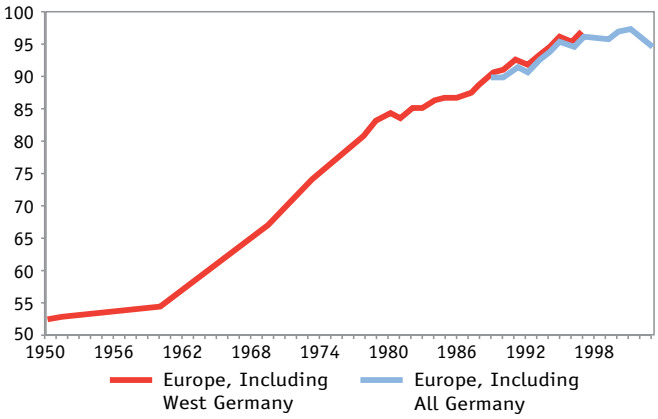
2 See Appendix Table 1 for data on output per hour growth in OECD countries. The appendix tables are posted with this article at www.csls.ca under the *International Productivity Monitor*.

Chart 1:
Output per Hour in Europe, as a Proportion of the United States, 1950-2003
(United States=100)



Source: Calculated by CSLS based on the Groningen Growth and Developoment Centre and the Conference Board Total Economy Database, February 2004, http://www.ggdc.net. Europe is the simple average of Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

sees the 1950-73 period as one of extraordinary productivity growth, a golden age so to speak, and the post-1973 period as a return to normalcy. The roots of the golden age resided in a number of influences (e.g. the development of mass production and mass markets, technological innovations such as the jet engine, transisters, and plastics) that came together to spur productivity growth in the immediate post-war period. Technological convergence also accounted for rapid productivity growth in countries that had a low productivity level relative to the United States in 1950. By the mid-1970s, the productivity-augmenting effect of these factors was beginning to wither away and productivity growth in North America returned to its long-run growth rate of 1.5-2.0 per cent. A definitive treatment of what I call the historical/technological perspective that integrates in a comprehensive manner the different explanations of the post-1973 productivity slowdown is badly needed.

Puzzle 2: Explanations for the Post-2000 U.S. Productivity Growth Acceleration

It is widely known that the United States experienced a post-1995 acceleration in productivity growth, but it is less well recognized that a second pick-up has taken place since 2000. Equally, increased investment in information and communication technologies (ICTs) has been identified as the driving force behind the post-1995 acceleration, both through capital deepening effects and through higher multifactor productivity growth. But the fall-off in ICT investment in recent years means this factor cannot have been responsible for the post-2000 improvement in productivity growth. The factors behind the post-2000 productivity acceleration are thus very poorly understood.

Business sector output per hour in the United States advanced at a 3.8 per cent average annual rate in the 2000-2003 period registering record back-to-back increases of 4.3 per cent in 2002 and 4.5 per cent in 2003. This represents a 1.1 point acceleration from the robust 2.7 per cent productivity growth in the 1995-2000 period. The macroeconomic environment was much more favourable to productivity growth in the second half of the 1990s than in the first years of the current decade. Business sector real output grew at a 4.8 per cent rate between 1995 and 2000, compared to only 2.0 per cent between 2000 and 2003.

One implication of the post-2000 acceleration of productivity growth in the United States has been the replacement in OECD countries of productivity convergence toward the higher U.S. level with productivity divergence away from the U.S. level.

Throughout the post-war period OECD countries excluding the United States have enjoyed faster productivity growth than the United States due to technological catch-up to

the world technology leader. Productivity levels in these countries converged toward the U.S. labour productivity level (Chart 1 and Appendix Table 2). In 1950, the unweighted average of the output per hour level in OECD countries excluding the United States was 53.9 per cent of the U.S. level. By 1995, this relative level had risen to 93.1 per cent of the U.S. level, and by 2000 to 94.4 per cent. This trend ended in 2000 and has been replaced by productivity divergence with productivity growth faster in the United States and the OECD productivity relative falling to 92.2 per cent by 2003.

The U.S. Bureau of Economic Analysis (BEA) has recently released GDP by industry estimates for 2002 and 2003 so it is now possible to analyze the industry contributions to the post-2000 acceleration. The BEA has now switched to the North American Industry Classification System (NAICS), which is overall a very positive development. Unfortunately, however, NAICS estimates of GDP by industry at this time only go back to 1998. This means analysis of the post-2000 industry contributions to aggregate productivity growth can only be compared to the 1998-2000 period, not the more appropriate 1995-2000 period. But since productivity growth was very similar in the 1998-2000 and 1995-2000 periods, the results are still likely indicative of the change in the industry composition of productivity growth between the second half of the 1990s and the early years of this decade.

In the 1998-2000 period manufacturing was responsible for 47 per cent total economy labour productivity growth despite accounting for only 14 per cent of output because of its very rapid productivity growth rate (Appendix Table 3). Services was responsible for 56 per cent of productivity growth. In the 2000-2003 period the contribution of manufacturing dropped to 31 per cent while that of services rose to 71 per cent. Output per hour growth in manufacturing was unchanged between 1998-2000 and 2000-2003, registering 6.6 per cent average annual growth in both periods, while that of services rose 1.6 points between periods from 1.7 per cent per year to 3.3 per cent per year. This means that services accounted for all the post-2000 productivity growth acceleration, with professional and business services accounting for 48 per cent, information services 37 per cent, wholesale trade 34 per cent, and retail trade 30 per cent.

A basic growth accounting decomposition of labour productivity growth in the 1995-2000 and 2000-2003 periods into capital intensity and total factor productivity components reveals that all the post-2000 acceleration was due to capital deepening (Appendix Table 4) as the rate of growth of the capital-labour ratio increased from 1.2 per cent per year in 1995-2000 to 3.0 per cent in 2000-2003. Total factor productivity growth actually fell 0.4 points between 1995-2000 and 2000-2003, although this development likely has a very large cyclical component because of lower capacity utilization during the 2001 recession. The increased pace of capital intensity growth did not in fact reflect a pick-up in capital accumulation, but rather a fall in labour input. Capital stock growth actually fell from 3.1 per cent per year in 1995-2000 to 2.0 per cent in 2000-2003, while total hours worked growth plummeted from 2.0 per cent to -1.0 per cent.

Consequently, it is misleading to attribute the post-2000 productivity growth acceleration to faster capital intensity growth. More likely explanations may include outsourcing of low productivity activities to low-wage countries, and increased competitive pressures from national and international sources to cut costs by improving productivity performance (which leads to outsourcing). But in my view the most probable factor behind the acceleration is the more effective use of ICT investments. The full productivity impact of ICT investment has

taken time. It has required changes in organizational structures and a higher level of workforce computer literary. These developments have now happened and the productivity payoff from ICT is now being realized. The post-2000 productivity growth pick-up in the ICT-using industries of the service sector provides support for this view. Further research is needed to verify this hypothesis.

A related question to the explanation of the post-2000 productivity acceleration is the sustainability of this trend. A productivity growth world of 4 per cent means living standards double in 17 years compared to 35 years in a 2 per cent productivity world. Many economic problems such as the U.S. budget deficit and the costs of an aging population, including the issue of social security sustainability, disappear if productivity growth remains at 4 per cent or even 3 per cent for 20 years. The answer to this issue largely depends on the sources of the acceleration.

Puzzle 3: Higher European Labour Productivity Levels

Given the well-known fact that the United States is the richest county in the world and the link between income and productivity, it is perhaps surprising to many observers that a number of European countries actually have higher levels of output per hour than the United States. According to the Groningen productivity database (Appendix Table 2), eight western European countries in 2003 had output per hour levels higher than that of the United States: Luxembourg (122.5 per cent of the U.S. level), Norway (119.7 per cent), Belgium (109.0 per cent), Ireland (107.6 per cent), Netherlands (105.2 per cent), France (104.9 per cent), Germany (103.9 per cent), and Denmark (100.2 per cent).

The explanation for why Europeans have lower incomes than Americans despite higher productivity levels is straightforward. Both the employment rate (reflecting lower labour force participation and higher unemployment) and average annual hours worked are on average lower in Europe than in the United States, reducing the average income level. The reason why labour productivity is higher is more puzzling, especially since it is well recognized that the United States is the world technological leader in most industries.

Cette (2004) argues that the higher European productivity actually is an outcome of the low employment rate and low annual hours worked. High minimum wages and other labour market regulations mean that poorly educated, low productivity European workers have fewer employment opportunities than their U.S. counterparts and therefore do not drag down the average productivity level through a composition effect. Equally, shorter work hours increases output produced measured on an hours worked basis because workers are on average fresher and less tired and hence more productive. Just as two part-time workers each working 20 hour per week will in general produce more than one worker working 40 hours, a worker working 35 hours per week is likely to produce more on a per hour basis than a worker labouring 40 hours. However, these research results are not definitive and more work is needed to explore the reasons for the superior European labour productivity levels.

Puzzle 4: The Absence of a Post-1995 Productivity Growth Acceleration in Europe

In contrast to the United States (and Canada and Australia), most European countries have not experienced faster labour productivity growth since 1995. Comparing the 1973-1995 and 1995-2003 periods, the unweighted average output per hour growth for the total economy was 1.77 per cent per year in 1995-2003, down

0.62 percentage points from 2.39 per cent in 1973-95.[3] The United States enjoyed a 0.8 percentage point per year acceleration in productivity growth between the same periods from 1.12 per cent to 1.87 per cent. Eleven of 16 European countries experienced slower output per hour growth in the second period than in the first period (Appendix Table 5). The exceptions were small countries such as Finland, Switzerland, Greece, Sweden, and Ireland. The four major European countries (the United Kingdom, France, Italy, and Germany) all saw significant labour productivity growth decelerations after 1995.

The reasons for the lack of a post-1995 productivity growth acceleration in Europe are poorly understood. European firms have certainly invested in ICTs, but not as heavily as American firms. The productivity payoff from ICT investments may be less in Europe than in the United Stares for structural or institutional reasons or just may be slower in coming. A more aggressive approach on the part of U.S. statistical agencies relative to their European counterparts to the measurement of quality improvements in high-tech products, with implications for prices and real output, may also be a factor.

Of course, despite the lack of productivity growth acceleration in Europre and the acceleration in the United States, European total economy labour productivity growth in absolute terms in the post-1995 period has been roughly comparable to U.S. growth.

Puzzle 5: Productivity Effects of the Internet

The internet represents one of the greatest technological advances in the history of the modern world, but its productivity-enhancing effects are underappreciated and underresearched. It has cut the costs of communication and of obtaining information dramatically. Email communication is extremely efficient and cheap. It fosters the development of networks throughout the world and the exchange of information through file transfer. The world wide web has made libraries redundant. Reports, journals, and books can be posted at virtually no cost on the web for download throughout the world. This in particular represents a boon for developing countries that now have access to much of the stock of world knowledge at minimal cost. Both email and the world wide web thus contribute to much wider, faster, and cheaper dissemination of knowledge. Since the availability of knowledge is an important driver of productivity, the internet is a crucial tool of productivity advance. It is important for economists to attempt to measure the impact on potential aggregate productivity growth of this technological revolution in communications and information diffusion.

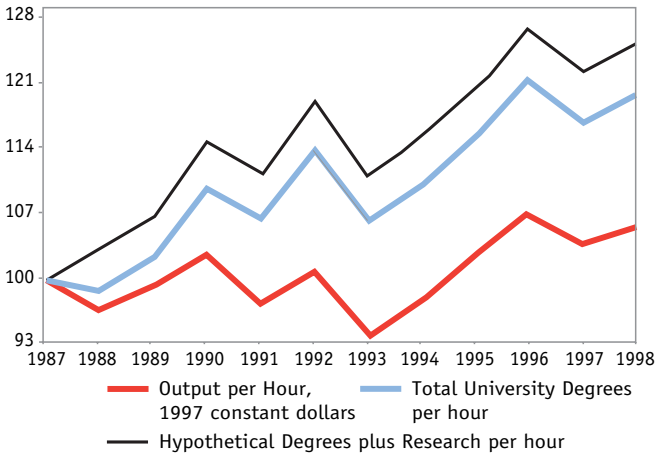
Puzzle 6: Productivity Growth in the University Sector

The measurement of real output and hence productivity in the non-market sector of the economy is problematic. Real output is often not measured independently of input, resulting in zero measured productivity growth. This is currently the case in the university sector where real output is based on nominal labour compensation (plus depreciation) deflated by the rate of wage increase. According to Statistics Canada data, real output of the university sector in Canada increased at a 1.1 per cent average annual rate over the 1987-2003 period (Chart 2 and Appendix Table 6). Total hours worked rose at a 1.2 per cent average annual rate, resulting in a 0.1 per cent decline in labour productivity growth.

This negative productivity growth is inconsistent with the large increase in the number of

3 These data are from the Groningen Growth and Development Centre productivity data base. See Appendix Table 5.

Chart 2
Conventional versus Alternative Measures of Productivity in the University Sector in Canada, 1987-1998
(1987=100)



Source: Appendix Table 6. Data on university degrees are only available to 1998.

graduates, the main output of the sector, produced by Canadian universities over the period. Indeed, total university degrees granted rose at a 1.9 per cent average annual rate over the 1987-1998 period (the most recent data currently available only go to 1998). Degrees can be substitued for deflated labour compensation as an output measure to produce an alternative productivity measure for the university sector. This results in a more realistic labour productivity growth rate of 1.8 per cent for 1987-1998, well above the conventionally measured rate of 0.5 per cent per year for the same period and roughly comparable to overall labour productivity growth (Chart 2).

A second output of the university sector is research, generally in the form of publications. Anecdotal evidence suggests that the average research output of university researchers, measured for example by number of publications in refereed journals, has increased in recent years. If research output were included with degrees in the total output of the university sector, the output growth over the 1987-1998 period would be greater than 1.9 per cent per year, with a commensurate increase in productivity.

The BEA is currently undertaking a research project on the measurement of real output in the education sector, including university education (Fraumeni et al., 2004). This research will hopefully shed light on what is really happening to productivity growth in the university sector.

Puzzle 7: Negative Productivity Growth in the Construction Sector

The Achilles heel of productivity measurement in the United States is the construction industry. The Bureau of Labor Statistics, the agency responsible for productivity measurement, does not release productivity estimates for the construction sector because they believe that estimates based on existing data are unreliable. Productivity growth rates can be constructed from estimates of real value added and employment produced by the Bureau of Economic Analysis. The index of output per hour in the U.S. construction sector fell from 120.4 in 1977, the first year of the series, to 94.2 in 2003, an unprecendented 22 per cent decline (Chart 3 and Appendix Table 7). Statistics Canada, which does produce an official estimate of construction sector productivity growth, reports that output per hour worked in the construction sector was only 8 per cent higher in 2003 than in 1977, a quarter century earlier.

The reasons behind the long-term stagnation or even decline in construction productivity in North America have eluded researchers. A number of hypotheses have been advanced. These include the lack of technical progress in the sector (Sharpe, 2001) and mismeasurement of output prices due to the unique nature of much construction output (Hoss et al., 1999), and more stringent energy efficiency regulations whose effects

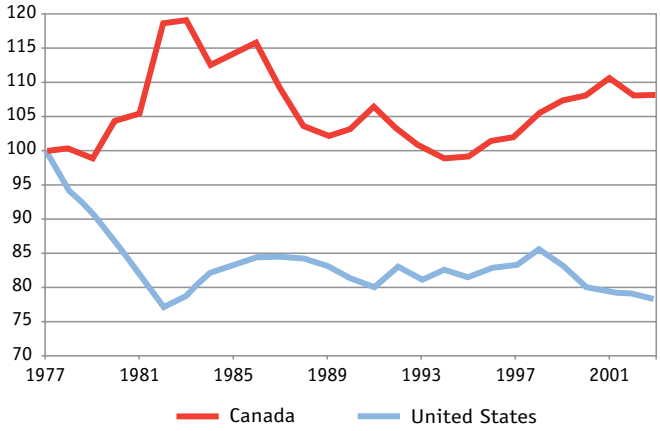
are not captured in output measures. More research is desperately needed on this topic.

Puzzle 8: Total Economy Versus Business Sector Canada-U.S. Labour Productivity Growth Comparisons

A comparison of aggregate labour productivity growth between Canada and the United States reveals a significantly different story depending on which measure of aggregate labour productivity is used. Business sector output per hour advanced at a 2.2 per cent average annual rate over the 1981-2003 period in the United States versus 1.5 per cent in Canada (Chart 4 and Appendix Table 8). The United States enjoyed a 0.7 percentage point advantage over Canada. Total economy output per hour grew 1.7 per cent per year in the United States compared to 1.4 per cent in Canada, a difference of 0.3 points, one half that registered for the business sector.

The better relative productivity performance for Canada with the total economy measure is explained by the measured productivity growth in the non-business sector: 1.1 per cent per year versus 0.1 per cent in the United States. The key issue is which of these two productivity growth rates better captures the true productivity performance of the non-business sector. Non-business sector output is generally proxied by labour inputs. But Statistics Canada attempts to capture productivity gains in certain non-business industries by using output measures that are independent of inputs. The United States appears more reticent in the use of this practice. This may introduce a non-comparability in the measurement of real GDP growth between the two countries for non-business sector output and for total output since the non-business sector is part of total output, and may explain the different trends in the two aggregate labour productivity growth rates. More work on the comparability of GDP per hour growth between Canada and the United States is needed.

Chart 3
Real Output per Hour Indexes in the Construction Industry in Canada and the United States, 1977-2003
(1977=100)



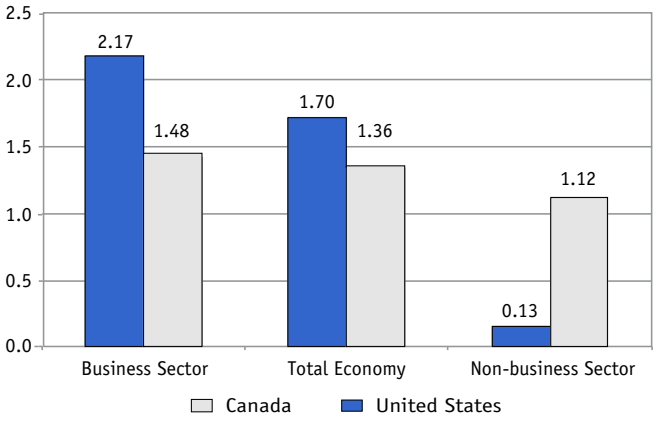
Source: Appendix Table 7.

Puzzle 9: Causes of the Canada-U.S. Labour Productivity Level Gap

In 2003, total economy output per hour in Canada was estimated to be 85.1 per cent of that of the United States (Chart 5 and Appendix Table 9). This was down from 89.0 per cent as recently as 2000. The level of aggregate labour productivity has always been lower in Canada than in the United States, but the gap between the countries has never been wider, as least in the post-1961 period for which comparable data are available. The reasons for this gap have been much studied, but no definitive conclusions have been reached.

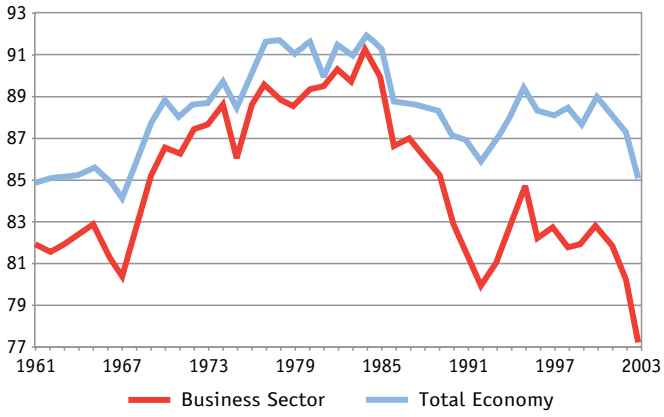
The choice of the hours series for the United States affects the relative productivity level. The productivity relative given above is based on hours data from an unpublished Bureau of Labor Statistics series constructed primarily from the U.S. Current Employment

Chart 4
Output per Hour in the Business Sector, Total Economy and Non-business Sector in Canada and the United States, 1981-2003
(compound average annual growth rates)



Source: Appendix Table 8.

Chart 5
Output per Hour in Canada as a Proportion of the United States, 1961-2003
(United States=100)



Source: Appendix Table 9.

Survey (CES), an establishment-based survey. When the Current Population Survey (CPS), a household survey, is used total hours worked are about 7 per cent higher and reduce the Canada-U.S. labour productivity gap by a commensurate amount (Sharpe, 2003 and Smith, 2004). The issue of which U.S. hours measure is more appropriate for international comparison of productivity levels needs further research.

Capital intensity is lower in Canada than in the United States and this situation contributes to the lower productivity level. According to Rao, Tang, and Wang (2004), in 1999 capital intensity in the Canadian business sector was 89 per cent of the U.S. level, and accounted for 4 percentage points or about one fifth of the business sector labour productivity gap of 18 points (82 per cent of the U.S. level). Other factors that may be contributing to the gap include the lower proportion of the workforce with a university education (but not post-secondary) relative to the United States (Rao, Tang and Wang, 2002); an innovation gap as evidenced by the lower incidence of R&D spending (Rao et al., 2001); low spending on machinery and equipment investment; the greater importance of the self-employed in the workforce, who tend to have below average productivity; and the smaller proportion of the Canadian population that lives in urban centres (Milway, 2004). Further research is needed to develop an expert consensus on the relative importance of these factors.

Puzzle 10: Cause of Lower M&E Capital Intensity in Canada

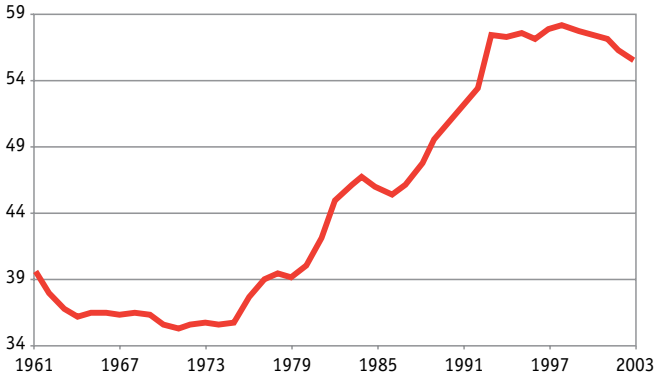
Given the many common characteristics of the Canadian and U.S. economies, it is surprising to find great dissimilarity between the two countries in the intensity with which machinery and equipment (M&E) is used in the production process. The ratio of M&E to hours worked in Canada in 2003 was 55 per cent of that in the United States (Chart 6 and Appendix Table 10) and the share of M&E investment in nominal GDP has been consistently lower in Canada than in the United States (Chart 7). The factors behind this situation are poorly understood.

Possible explanations for the lower M&E intensity in Canada include different depreciation patterns and service life assumptions used in the estimation of the Canadian and U.S. M&E capital stock; differences in the definitions of M&E and structures used by statistical agencies in the two countries; a higher corporate tax burden in Canada, discouraging M&E investment; a greater proportion of structures-intensive industries in Canada; a higher relative and absolute price of M&E in Canada; and less recognition of the importance of M&E for productivity advance by Canadian firms. Further research is needed to explain this stylized fact.

Conclusion

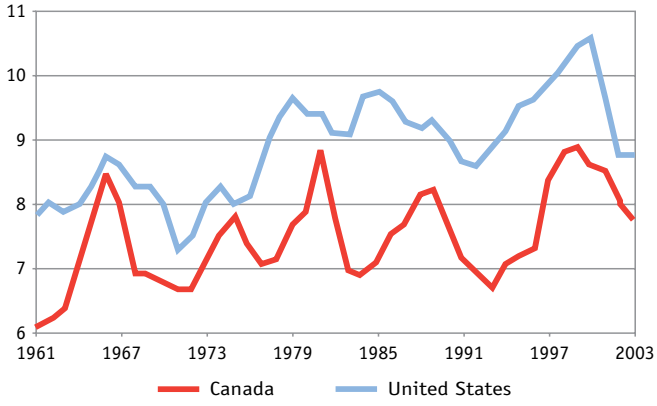
This article has highlighted what the author believes are important puzzles facing productivity researchers. There are many more. Indeed, there are more than enough important productivity questions to keep productivity researchers fully employed for the rest of their careers! Productivity growth is both an important and an intriguing subject. It is the driver of growth in living standards and a key contributor to improvements in economic well-being. It is hoped that this article will encourage researchers to take up some of the productivity puzzles outlined above. A better understanding of productivity issues can contribute to the development of more effective policies to improve productivity.

Chart 6
Machinery and Equipment Capital Intensity in the Total Economy in Canada as a Proportion of the United States, 1961-2003
(United States=100)



Source: Appendix Table 10.

Chart 7
Investment in Machinery and Equipment as a Percentage of Nominal GDP in Canada and the United States, 1961-2003



Source: Appendix Table 10.

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